Faculty of Science and Technology
Savitribai Phule Pune University
Maharashtra, India

http://unipune.ac.in

Curriculum

For

Fourth Year of Artificial Intelligence and Data Science (2020 Course)

(With effect from A.Y. 2023-24)

Final Year of Artificial Intelligence and Data Science Engineering
(2020 Course)
(With effect from 2023-24)

Prologue

B.E. (Artificial Intelligence and Data Science) course began in the Academic Year 2020-21 with 15 institutes taking part in this course in Savitribai Phule Pune University. It is a great privilege to design and share the syllabi for Fourth year of Artificial Intelligence and Data Science (2020 course) on the behalf of Board of Studies (Computer Engineering).

Honest and sincere efforts have been put in by us to frame the syllabus in accordance with NEP recommendations, AICTE, UGC and affiliated University (SPPU) and while taking in consideration the technological advancements and industrial requirements.

Our team of faculty members and several industry domain professionals have given their valuable time towards reviewing the work to gets its final shape. Nearly all courses have case studies and the course instructor has been recommended to discuss suitable current technology/ upgrades / case studies to encourage students to think about the developments /ongoing trends / issues /utilities in the real world and study the course from a scenario.

I am beholder to all the minds and hands who have worked adroitly to execute these tasks. I am highly appreciative of your contributions and suggestions given to this content.

Dr. Nilesh J. Uke
Chairman, Board of Studies (Computer Engineering), SPPU, Pune

Links to SE, TE (AIDS) Syllabus
SE : http://collegecirculars.unipune.ac.in/sites/documents/Syllabus2021/SE_AI-DS_Curriculam_2021_28.06.2021.pdf
TE : http://collegecirculars.unipune.ac.in/sites/documents/Syllabus2022/TE_17012023.zip

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** (With effect from Academic Year 2023-24)		
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Savitribai Phule Pune University Bachelor of Engineering in Artificial Intelligence and Data Science		
Program Outcomes (POs)		
Learners are expected to know and be able to–		
PO1	**Engineering knowledge**	Apply the knowledge of mathematics, science, Engineering fundamentals, and an Engineering specialization to the solution of complex Engineering problems.
PO2	**Problem analysis**	Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics natural sciences, and Engineering sciences.
PO3	**Design / Development of Solutions**	Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health andsafety, and the cultural, societal, and Environmental considerations.
PO4	**Conduct Investigations of Complex Problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage**	Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex Engineering activities with anunderstanding of the limitations.
PO6	**The Engineer and Society**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability**	Understand the impact of the professional Engineering solutions in societal and Environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
PO9	**Individual and Team Work**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication Skills**	Communicate effectively on complex Engineering activities with the Engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project Management and Finance**	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary Environments.
PO12	**Life-long Learning**	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
Program Specific Outcomes (PSO)		
PSO1	**Professional Skills**-The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexities.	
PSO2	**Problem-Solving Skills**- The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.	
PSO3	**Successful Career and Entrepreneurship**- The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a zest for higher studies.	

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) (With effect from Academic Year 2023-24)

Semester-VII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	In-Sem	End-Sem	Term work	Practical	Oral/ Presentation	Total	Lecture	Practical	Tutorial	Total
417521	Machine Learning	03	-	-	30	70	-	-	-	100	03	-	-	03
417522	Data Modeling & Visualization	03	-	-	30	70	-	-	-	100	03	-	-	03
417523	Elective III	03	-	-	30	70	-	-	-	100	03	-	-	03
417524	Elective IV	03	-	-	30	70	-	-	-	100	03	-	-	03
417525	Computer Laboratory I	-	04	-	-	-	50	25	-	75	-	02	-	02
417526	Computer Laboratory II	-	04	-	-	-	50	25	-	75	-	02	-	02
417527	Project Stage I	-	04	-	-	-	50	-	50	100	-	02	-	02
417528	MOOC	-	-	02	-	-	50	-	-	50	-	-	02	02
	Total	12	12	02	120	280	200	50	50	700	12	06	02	20
417529	Audit Course 7													
	Total Credits										12	06	02	20

Elective III:	Elective IV:
417523(A) Quantum Artificial Intelligence 417523(B) Industrial Internet of Things 417523(C) Enterprise Architecture and Components 417523(D) Bioinformatics	417524(A) GPU Programming and Architecture 417524(B) Information Retrieval 417524(C) UI/UX Design 417524(D) Optimization Algorithms
Computer Laboratory I:	**Computer Laboratory II:**
It is based on two compulsory subjects: • Machine Learning • Data Modeling & Visualization	It is based on two Elective subjects: • Elective III • Elective IV
Audit Course 7: AC7 – I Block Chain AC7 – II Entrepreneurship Development AC7 – III Botnet of Things AC7 – IV Foreign Language AC7 – V MOOC-Learn New Skills	

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	in-Sem	End-Sem	Term work	Practical	Oral/ Presentation	Total	Lecture	Practical	Tutorial	Total

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
(With effect from Academic Year 2023-24)

Semester-VIII

Course Code	Course Name	Lecture	Practical	Tutorial	in-Sem	End-Sem	Term work	Practical	Oral/ Presentation	Total	Lecture	Practical	Tutorial	Total
417530	Computational Intelligence	03	-	-	30	70	-	-	-	100	03	-	-	03
417531	Distributed Computing	03	-	-	30	70	-	-	-	100	03	-	-	03
417532	Elective V	03	-	-	30	70	-	-	-	100	03	-	-	03
417533	Elective VI	03	-	-	30	70	-	-	-	100	03	-	-	03
417534	Computer Laboratory III	-	02	-	-	-	50	25	-	75	-	01	-	01
417535	Computer Laboratory IV	-	02	-	-	-	50	25	-	75	-	01	-	01
417536	Project Stage II	-	12	-	-	-	100	-	50	150	-	06	-	06
	Total	**12**	**16**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**08**	**-**	**20**
417537	Audit Course 8													
	Total Credits										**12**	**08**	**-**	**20**

Elective V:	Elective VI:
417532(A) Virtual Reality and Game Development	417533(A) Augmented Reality
417532(B) Big Data analytics	417533(B) Business Intelligence
417532(C) Software Development for Portable Devices	417533(C) Information Systems Management
417532(D) Deep Learning	417533(D) Reinforcement Learning
Computer Laboratory III:	**Computer Laboratory IV:**
It is based on two compulsory subjects:	It is based on two Elective subjects:
• Computational Intelligence	• Elective V
• Distributed Computing	• Elective VI

Audit Course 8:
AC8 – I Usability Engineering
AC8 – II Conversational Interfaces
AC8 – III Social Media and Analytics
AC8 – IV Foreign Language
AC8 – V MOOC-Learn New Skills

General Guidelines

1. Every undergraduate program has its own objectives and educational outcomes. These objectives and outcomes arefurnished by considering various aspects and impacts of the curriculum. These **Program Outcomes (POs)** are categorically mentioned at the beginning of the curriculum (ref: NBA Manual). There should always be a rationale and a goal behind the inclusion of a course in the curriculum. Course Outcomes though highly rely on the contents of the course, many a times are generic and bundled. The **Course Objectives**, **Course Outcomes** and **CO-PO mappings matrix** justifies the motives, accomplishment and prospect behind learning the course. The Course Objectives, Course Outcomes and CO-PO Mapping Matrix are provided for reference and these are indicative only. The course instructor may modify them as per his or her perspective.

2. **CO and PO Mapping Matrix** (Course Objectives and Program Outcomes) attainment mapping matrix at end of course contents, indicates the correlation levels of 3, 2, 1 and _-_. The notation of 3, 2 and 1 denotes substantially (high), moderately (medium) and slightly (low). The mark _-_ indicates that there is no correlation between CO and PO.

3. For each course, contents are divided into six units-I, II, III, IV, V and VI.
    #Elaborated examples/Case Studies are included at each unit to explore how the learned topics apply to real world situations and need to be explored so as to assist students to increase their competencies, inculcating the specific skills, building the knowledge to be applicable in any given situation along with an articulation. One or two sample exemplarsor case studies are included for each unit; instructor may extend the same with more. Exemplar/Case Studies may be assigned as self-study by students and to be excluded from theory examinations.

4. *For each unit contents, the content attainment mapping is indicated with Course Outcome(s). Instructor may revise the same as per their viewpoint.

5. For laboratory courses, set of suggested assignments is provided for reference. Laboratory Instructors may design suitable set of assignments for respective course at their level. Beyond curriculum assignments and mini-project may be included as the part of laboratory work. Inclusion of it will be the value addition for the students and it will satisfy the intellectuals within the group of the learners and will add to the perspective of the learners.

6. For each laboratory assignment, it is essential for students to draw/write/generate flowchart, algorithm, test cases, mathematical model, Test data set and comparative/complexity analysis (as applicable). Batch size for practical and tutorial may be as per guidelines of authority.

7. For each course, irrespective of the examination head, the instructor should motivate students to read articles/research papers related to recent development and invention in the field.

8. For laboratory, instructions have been included about the conduction and assessment of laboratory work. These guidelines are to be strictly followed.

9. **Term Work –**Term work is continuous assessment that evaluates a student's progress throughout the semester. Term work assessment criteria specify the standards that must be met and the evidence that will be gathered to demonstrate the achievement of course outcomes. Categorical assessment criteria for the term work should establish unambiguous standards of achievement for each course outcome. They should describe what the learner is expected to perform in the laboratories or on the fields to show that the course outcomes have been achieved.

Students' work will be evaluated typically based on the criteria like attentiveness, proficiency

in execution of the task, regularity, punctuality, use of referencing, accuracy of language, use of supporting evidence in drawing conclusions, quality of critical thinking and similar performance measuring criteria.

10. **Program codes with sample output of all performed assignments are to be submitted as softcopy. Use of DVD or similar media containing students' programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints at Laboratory. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal may be avoided. <u>Submission of journal/ term work in the form of softcopy is desirable and appreciated. (In laboratory Practices the lab teachers can give different applications other than the indicated.)</u>**

Abbreviations

TW: Term Work	TH: Theory	PR: Practical
OR: Oral	Sem: Semester	TUT : Tutorial

Semester VII

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417521: Machine Learning		
Teaching Scheme: TH: **03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Data Science (317529), Artificial Neural Network (317531)

Course Objectives:

- Explain the learning paradigms, and models of machine learning
- Apply different regression techniques for making predictions in different applications
- Apply the classification algorithms to classify the data with appropriate labels
- Apply the clustering algorithms to divide the unlabeled data into the similar groups
- Introduce and integrate models in the form of advanced ensembles
- Explain reinforcement learning and its algorithms

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Describe and compare different models of machine learning

CO2: Design ML models to make predictions by using linear, non-linear and logistic regression techniques

CO3: Implement classification models for two class problems and multiclass problems

CO4: Implement clustering models for unlabeled data

CO5: Integrate multiple machine learning algorithms in the form of ensemble learning

CO6: Apply reinforcement learning and its algorithms for different applications

Course Contents		
Unit I	**Introduction to Machine Learning**	**06 Hours**

Introduction: What is Machine Learning, Definitions and Real-life applications, Comparison of Machine learning with traditional programming, ML vs AI vs Data Science.
Learning Paradigms: Learning Tasks- Descriptive and Predictive Tasks, Supervised, Unsupervised, Semi-supervised and Reinforcement Learnings.
Models of Machine learning: Geometric model, Probabilistic Models, Logical Models, Grouping and grading models, Parametric and non-parametric models.
Feature Transformation: Dimensionality reduction techniques- PCA and LDA

#Exemplar/Case Studies	**Explore the machine learning paradigms with its application:** This case study is about exploring three different machine learning paradigms that help to solve different problem categories in plain language and from a technical standpoint. **Reference URL:** https://www.analyticsvidhya.com/blog/2022/07/machine-learning-paradigms-with-example/
***Mapping of Course Outcomes for Unit I**	CO1

Unit II	**Regression**	**06 Hours**

Introduction- Regression, Need of Regression, Difference between Regression and Correlation, Types of Regression: Univariate vs. Multivariate, Linear vs. Nonlinear, Simple Linear vs. Multiple Linear, Bias-Variance tradeoff, Overfitting and Underfitting.

Regression Techniques - Polynomial Regression, Stepwise Regression, Decision Tree Regression, Random Forest Regression, Support Vector Regression, Ridge Regression, Lasso Regression, ElasticNet Regression, Bayesian Linear Regression.

Evaluation Metrics: Mean Squared Error (MSE), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE),R-squared ,Adjusted R-squared.

#Exemplar/Case Studies	**Comparison of different regression models:** Build and compare the Lasso, Ridge, and Elastic Net regression models, consider the big market sales to predict sales depending on features selected. This case study discusses regression models and how they can be used to solve prediction problems. **Reference URL:** https://www.analyticsvidhya.com/blog/2017/06/a-comprehensive-guide-for-linear-ridge-and-lasso-regression/
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Classification	06 Hours

Introduction: Need of Classification, Types of Classification (Binary and Multiclass), Binary-vs-Multiclass Classification, Balanced and Imbalanced Classification Problems.

Binary Classification: Linear Classification model, Performance Evaluation- Confusion Matrix, Accuracy, Precision, Recall, F measures.

Multiclass Classification: One-vs-One and One-vs-All classification techniques, Performance Evaluation- Confusion Matrix, Per Class Precision, Per Class Recall

Classification Algorithms: K Nearest Neighbor, Linear Support Vector Machines (SVM) – Introduction, Soft Margin SVM, Kernel functions– Radial Basis Kernel, Gaussian, Polynomial, Sigmoid.

#Exemplar/Case Studies	**Explore Multiclass Classification with imbalanced dataset:** This case study uses a "20 Newsgroups" data set that is converted into an imbalanced form. A multiclass classification algorithm is applied on an imbalanced dataset and its performance is compared with the model after applying undersampling/oversampling techniques. **Reference URL:** https://builtin.com/machine-learning/multiclass-classification
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Clustering	06 Hours

Introduction: What is clustering, Need of Clustering, Types of Clustering

Hierarchical clustering algorithms /connectivity-based clustering): Agglomerative Hierarchical Clustering (AHC) algorithm, Divisive Hierarchical Clustering (DHC) algorithm.

Centroid-based clustering algorithms / Partitioning clustering algorithms: K-Means clustering algorithm, Advantages and disadvantages of K-Means clustering algorithm, Elbow method, The Silhouette method, K-Medoids, K-Prototype.

Density-based clustering algorithms: DBSCAN algorithm, how it works, Advantages and disadvantages of DBSCAN.

Distribution-based clustering algorithms: Gaussian mixture model.

Application of Clustering Technique: Market Segmentation, Statistical data analysis, Social network analysis, Image segmentation, Anomaly detection.

#Exemplar/Case Studies	**Customer segmentation using clustering algorithms:** This case study demonstrates the concept of segmentation of a customer data set from an e-commerce site using k-means clustering in python. The data set contains the annual income of ~300 customers and their annual spend on an e-commerce site. The k-means clustering algorithm is applied to derive the optimum number of clusters and understand the underlying customer segments based on the data provided. **Reference URL:** https://towardsdatascience.com/clustering-algorithms-for-customer-segmentation-af637c6830ac
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Ensemble Learning	06 Hours

Ensemble Learning: Introduction to Ensemble Learning, Need of Ensemble Learning, Homogeneous and Heterogeneous ensemble methods, Advantages and Limitations of Ensemble methods, Applications of Ensemble Learning.

Basic Ensemble Learning Techniques: Voting Ensemble, Types of Voting: Max Voting, Averaging, Weighted Average.

Advanced Ensemble Learning Techniques:

Bagging: Bootstrapping, Aggregation.

Boosting: Adaptive Boosting (AdaBoost), Gradient Boosting, XGBoost .

Stacking: Variance Reduction, Blending, Random Forest Ensemble, Advantages of Random Forest.

#Exemplar/Case Studies	**Apply ensemble learning techniques:** This case study uses ensemble learning techniques on the Heart Attack dataset. It indicates that ensemble techniques, such as bagging and boosting, are effective in improving the prediction accuracy of weak classifiers and exhibit satisfactory performance in identifying risk of heart disease. **Reference URL:** https://www.sciencedirect.com/science/article/pii/S235291481830217X?via%3Dihub
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Reinforcement Learning	06 Hours

Reinforcement learning: What is Reinforcement Learning? Need for Reinforcement Learning, Supervised vs Unsupervised vs Reinforcement Learning, Types of Reinforcement, Elements of Reinforcement Learning, Real time applications of Reinforcement learning.

Markov's Decision Process: Markov property, Markov chain/process, Markov reward process (MRP), Markov decision process (MDP), Return, Policy, Value functions, Bellman equation

Q Learning: Introduction of Q-Learning, Important terms in Q learning, Q table, Q functions, Q learning algorithm.

#Exemplar/Case Studies	**Implement Tic Tac Toe Game using reinforcement Learning:** The case study explores the implementation of reinforcement learning techniques to create an agent capable of playing Tic-Tac-Toe. It discusses the use of Q-learning and the construction of a reward system to train the agent, resulting in a player that can learn and improve its gameplay over time. **Reference URL:**https://towardsdatascience.com/reinforcement-learning-implement-tictactoe-189582bea542
*Mapping of Course Outcomes for Unit VI	CO6

	Learning Resources	

Text Books:
1. Ethem Alpaydin, "Introduction to Machine Learning", Publisher: The MIT Press,2014
2. Peter Flach: "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, Edition 2012

Reference Books:
1. Ian H Witten, Eibe Frank, Mark A Hall, "Data Mining, Practical Machine Learning Tools and Techniques", Elsevier, 3rd Edition
2. Jiawei Han, Micheline Kamber, and Jian Pie, "Data Mining: Concepts and Techniques", Elsevier Publishers Third Edition, ISBN: 9780123814791, 9780123814807
3. Shalev-Shwartz, Shai, and Shai Ben-David, "Understanding machine learning: From theory to algorithms", Cambridge university press, 2014
4. McKinney, "Python for Data Analysis O' Reilly media, ISBN : 978-1-449- 31979-3

e-Resources:
1. https://timeseriesreasoning.com/
2. Reinforcement Learning: https://www.cs.toronto.edu/~urtasun/courses/CSC411_Fall16/19_rl.pdf
3. A brief introduction to machine learning for Engineers: https://arxiv.org/pdf/1709.02840.pdf
4. Introductory Machine Learning Nodes: http://lcsl.mit.edu/courses/ml/1718/MLNotes.pdf

MOOC Courses:
1. Introduction to Machine Learning(IIT kharagpur) : https://nptel.ac.in/courses/106105152
2. Introduction to Machine Learning (IIT Madras): https://onlinecourses.nptel.ac.in/noc22_cs29/prevew
3. Machine Learning A-Z™: AI, Python & R + ChatGPT Bonus [2023] https://www.udemy.com/course/machinelearning/
4. Machine Learning and Deep Learning A-Z: Hands-On Python https://www.udemy.com/course/machine-learning-and-deep-learning-a-z-hands-on-python/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	-	-	-	-	-	-	1	-	-	1
CO2	3	3	3	2	3	-	-	-	1	-	-	1
CO3	3	3	3	2	3	-	-	-	1	-	-	1
CO4	3	3	3	2	3	-	-	-	1	-	-	1
CO5	3	3	3	2	3	-	-	-	1	-	-	1
CO6	3	3	3	2	3	-	-	-	1	-	-	1

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417522: Data Modeling and Visualization

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Statistics (217528), Computer Graphics (210244), Database Management System (310241)

Course Objectives:
- Creating an emerging data model for the data to be stored in a database
- Conceptualized representation of Data objects
- Create associations between different data objects, and the rules
- Organize data description, data semantics, and consistency constraints of data
- Identifying data trends
- Incorporate data visualization tools and reap transformative benefits in their critical areas of operations

Course Outcomes:
After completion of the course, learners should be able to-
CO1: Summarize data analysis and visualization in the field of exploratory data science
CO2: Analyze the characteristics and requirements of data and select an appropriate data model
CO3: Describe to load, clean, transform, merge and reshape data
CO4: Design a probabilistic data modeling, interpretation, and analysis
CO5: Evaluate time series data
CO6: Integrate real world data analysis problems

Course Contents

Unit I	Introduction to Data Modelling	06 Hours

Basic probability:
Discrete and continuous random variables, independence, covariance, central limit theorem, Chebyshev inequality, diverse continuous and discrete distributions.
Statistics, Parameter Estimation, and Fitting a Distribution: Descriptive statistics, graphical statistics, method of moments, maximum likelihood estimation
Data Modeling Concepts • Understand and model subtypes and supertypes • Understand and model hierarchical data • Understand and model recursive relationships • Understand and model historical data

#Exemplar/Case Studies	Case study of sampling for any real-world problem like exit poll statistics
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Testing and Data Modeling	06 Hours

Random Numbers and Simulation: Sampling of continuous distributions, Monte Carlo methods
Hypothesis Testing: Type I and II errors, rejection regions; Z-test, T-test, F-test, Chi-Square test, Bayesian test
Stochastic Processes and Data Modeling: Markov process, Hidden Markov Models, Poisson Process, Gaussian Processes, Auto-Regressive and Moving average processes, Bayesian Network, Regression, Queuing systems

#Exemplar/Case Studies	Hypothesis Testing for examples like: Dieters lose more fat than the exercisers, New medicine testing

*Mapping of Course Outcomes for Unit II	CO2

Unit III	Basics of Data Visualization	06 Hours

Computational Statistics and Data Visualization, Types of Data Visualization, Presentation and Exploratory Graphics, Graphics and Computing, Statistical Historiography, Scientific
Design Choices in Data Visualization, Higher-dimensional Displays and Special Structures,
Static Graphics: Complete Plots, Customization, Extensibility,
Other Issues: 3-D Plots, Speed, Output Formats, Data Handling

#Exemplar/Case Studies	Use IRIS dataset from Scikit and plot 2D-3D views of the dataset

*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Data Visualization and Data Wrangling	06 Hours

Data Wrangling: Hierarchical Indexing, Combining and Merging Data Sets Reshaping and Pivoting. Data Visualization matplotlib: Basics of matplotlib, plotting with pandas and seaborn, other python visualization tools
Data Visualization   Through Their Graph Representations: Data and Graphs   Graph Layout Techniques, Force-directed Techniques Multidimensional Scaling, The Pulling Under Constraints Model, Bipartite Graphs

#Exemplar/Case Studies	Use data set of your choice from Open Data Portal (https://data.gov.in/) and apply data preprocessing methods

*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Data Aggregation and Analysis	06 Hours

Data Aggregation and Group operations: Group by Mechanics, Data aggregation, General split-apply-combine, Pivot tables and cross tabulation 67 Time Series
Data Analysis: Date and Time Data Types and Tools, Time series Basics, date Ranges, Frequencies and Shifting, Time Zone Handling, Periods and Periods Arithmetic, Resampling and Frequency conversion, Moving Window Functions.

#Exemplar/Case Studies	Study and analyse Weather records/economic indicator/ patient health evolution metrics

*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Data Analysis of Visualization and Modelling	06 Hours

Reconstruction, Visualization and Analysis of Medical Images
Introduction: - PET Images, Ultrasound Images, Magnetic Resonance Images, Conclusion and Discussion, Case Study: ER/Studio, Erwin data modeler, DbSchema Pro, Archi, SQL Database Modeler, LucidChart, Pgmodeler

#Exemplar/Case Studies	Creating logical data model for l utility company to implement data modeler

*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Chun-houh Chen, Wolfgang Härdle, Antony Unwin, "Handbook of Data Visualization", Springer
2. Ben Fry, "Visualizing Data", O'Reilly Media
3. Clous O.Wilke, "Fundamentals of Data Visualization - A Primer on Making Informative and Compelling Figures", O'Reilly Media, Inc.
4. Kieran Healy, "Data Visualization - A Practical Introduction"
5. McKinney W., "Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython". 2nd edition, O'Reilly Media
6. Gelman, Andrew, and Jennifer Hill, "Data Analysis Using Regression and Multilevel /Hierarchical Models". 1st edition, Cambridge, UK: Cambridge University Press, 2006, ISBN: 9780521867061
7. Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin, "Bayesian Data Analysis", 2nd edition, New York, NY: Chapman & Hall, 2003, ISBN: 9781584883883

Reference Books:
1. Gelman, Andrew, and Jennifer Hill, "Data Analysis Using Regression and Multilevel/Hierarchical Models", 1st edition, Cambridge, UK: Cambridge University Press, 2006, ISBN: 9780521867061
2. David Dietrich, Barry Hiller, "Data Science and Big Data Analytics", EMC education services, Wiley publication, 2012, ISBN: 0-07-120413-X
3. Trent Hauk, "Scikit-learn Cookbook", Packt Publishing, ISBN: 9781787286382
4. Chirag Shah, "A Hands-On Introduction to Data Science", Cambridge University Press, 2020, ISBN: 978-1-108-47244-9
5. S. C. Gupta, V. K. Kapoor, "Fundamentals of Mathematics Statistics (A Modern Approach) "Sultan Chand & Sons Educational Publishers, Tenth revised edition, ISBN: 81-7014-791-3
6. Medhi, "Statistical Methods: An Introductory Text", 2nd Edition, New Age International Ltd., ISBN:8122419577

e-Resources:
1. An Introduction to Statistical Learning by Gareth James
https://www.ime.unicamp.br/~dias/Intoduction%20to%20Statistical%20Learning.pdf
2. Python Data Science Handbook by Jake VanderPlas
https://tanthiamhuat.files.wordpress.com/2018/04/pythondatasciencehandbook.pdf
3. Elements of Statistical Learning: data mining, inference, and prediction, 2nd Edition. (su.domains)

MOOC Courses:
1. https://www.youtube.com/watch?v=WSNqcYqByFk
2. https://www.youtube.com/watch?v=eFByJkA3ti4
3. Computer Science and Engineering - NOC:Data Science for Engineers
4. Computer Science and Engineering - NOC:Python for Data Science
5. Introduction to Data Analytics: https://nptel.ac.in/courses/110106072

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	2	-	-	-	-	-	-	-	1
CO2	3	2	2	2	3	3	-	-	-	-	-	1

CO3	3	3	1	2	2	2	-	-	-	-	-	2
CO4	2	2	2	2	3	2	-	-	-	-	-	2
CO5	1	3	2	3	2	-	-	-	-	-	-	2
CO6	-	2	2	2	3	-	-	-	-	-	-	2

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective III 417523(A): Quantum Artificial Intelligence

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Artificial Intelligence (310253)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To get acquainted with the principles of quantum computing and the usage of Linear algebra in Quantum Computing
- To understand the Architecture of Quantum computing and solve examples of Quantum Fourier Transforms
- To understand the concepts of basic and advanced Quantum Algorithms and apply them to various problems.
- To study quantum machine learning and apply these to develop hybrid solutions
- To study the Quantum Theory with Fault-Tolerant Quantum techniques
- To understand Problem-Solving using various peculiar search strategies for AI

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand quantum requirements and formulate design solutions using quantum circuits.

CO2: Illustrate applicable solutions in one or more application domains using a quantum architecture that integrates ethical, social, and legal concerns

CO3: Apply the Advanced Quantum Algorithms on real time problem

CO4: Analyze the quantum machine learning algorithms and their relevant application

CO5: Analyze quantum information processing & its relevant algorithms

CO6: Evaluate suitable algorithms for AI problems

Course Contents

Unit I	Introduction to Quantum Computation	06 Hours

Overview of Quantum Computation: Single qubit gates, Multiple qubit gates, Measurements in bases Vs computational basis, Quantum circuits, Qubit copying circuit, Example: Bell states & quantum teleportation.

Basics of Linear Algebra: Hilbert Spaces, Products and Tensor Products, Matrices, Graphs, and Sums Over Paths, Example.

#Exemplar/Case Studies	Case study how to create a Quantum Gate from A Unitary Matrix in Qiskit
*Mapping of Course Outcomes for Unit I	CO1, CO2

Unit II	Quantum Architecture	06 Hours

The Framework of Quantum Mechanics: The State of a Quantum System, Time-Evolution of a Closed System, Composite Systems, Mixed States and General Quantum Operations, Universal Sets of Quantum Gates, Quantum measurement and quantum entanglement

The quantum Fourier transform and its Applications- The quantum Fourier transform, Phase estimation, order-finding and factoring, General applications of the quantum Fourier transform- Period-finding, Discrete logarithms, The hidden subgroup problem

#Exemplar/Case Studies	FPGA-based quantum circuit emulation: A case study on Quantum Fourier transform
*Mapping of Course Outcomes for Unit II	CO2

Unit III	**Quantum Algorithms**	**06 Hours**

Probabilistic Versus Quantum Algorithms, Phase Kick-Back, The Deutsch Algorithm, The Deutsch–Jozsa Algorithm, Simon's Algorithm, Shor's Algorithm, Factoring Integers, Grover's Algorithm

#Exemplar/Case Studies	Case study of variational quantum algorithms
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	**Quantum Machine Learning**	**06 Hours**

Quantum Enhanced Machine Learning: Quantum Algorithms for Linear Algebra, Regression, Clustering, Nearest Neighbour Search, Classification. Quantum Boosting, Quantum Support Vector Machines, Quantum Neural Networks, Variational Quantum Algorithms.

#Exemplar/Case Studies	Performance comparison of the classical SVM and the QSVM
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	**Quantum Information Processing**	**06 Hours**

Classical Error Correction: The Error Model Encoding, Error Recovery, The Classical Three-Bit Code, Fault Tolerance.

Quantum Information: Quantum Teleportation, Quantum Dense Coding, Quantum Key Distribution, Noise and error models in quantum systems, Quantum cryptography and secure communication.

#Exemplar/Case Studies	Noisy Intermediate Scale Quantum (NISQ)
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	**Quantum Problem Solving & AI applications**	**06 Hours**

Quantum Problem Solving: Heuristic Search, Quantum Tree Search, Quantum Production System, Tarrataca's Quantum Production System

Quantum AI Application: Introduction to Pennylane: a cross-platform Python library, Quantum Neural Computation, Quantum Walk – Random insect, Walk on graph, Case studies on Quantum-centric supercomputing: The next wave of computing, Quantum computing for data sciences

#Exemplar/Case Studies	The Magic-Square Game
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Nielsen, M. & Chuang I., "Quantum Computation and Quantum Information", 2002
2. Lipton and Reagan, "Quantum Algorithms via Linear Algebra: A Primer"
3. Kaye, LaFlamme and Mosca's, "Introduction to Quantum Computing"
4. Biamonte, J. et al., "Quantum Machine Learning", Nature, 2017
5. Andreas Wichert, "Principles Of Quantum Artificial Intelligence"

Reference Books:
1. Rieffel, E. G. & Polak W. H., "Quantum computing: A gentle introduction", MIT Press, 2011
2. Farhi, E., Goldstone, J. & Gutmann, S., "A quantum approximate optimization algorithm", arXiv preprint arXiv:1411.4028, 2014
3. Kuttler, "Elementary Linear Algebra", 2012
4. Kepner and Gilbert, "Graph Algorithms in the Language of Linear Algebra", 2011
5. Russell, S. & Norvig, P., "Artificial Intelligence: A modern approach", 4th edition, Pearson Education, 2021

e-Resources:
1. http://mmrc.amss.cas.cn/tlb/201702/W020170224608149940643.pdf
2. https://arxiv.org/pdf/1611.09347.pdf
3. http://mmrc.amss.cas.cn/tlb/201702/W020170224608150244118.pdf
4. https://www.researchgate.net/publication/282378154_FPGA-based_quantum_circuit_emulation
5. Microsoft Quantum Development Kit: https://www.microsoft.com/enus/quantum/development-kit Forest
6. Learn quantum programming: https://pennylane.ai/qml/
7. Quantum machine learning: https://qiskit.org/learn/course/machine-learning-course/
8. Center for Excellence in Quantum Technology: https://research.ibm.com/blog/next-wave-quantum-centric-supercomputing

MOOC Courses:
1. https://nptel.ac.in/courses/106106232
2. https://www.coursera.org/learn/introduction-to-quantum-information
3. https://www.udemy.com/topic/quantum-computing/
4. Linear algebra video lectures by Gilbert Strang which are maintained at MITOPENCOURSEWARE: http://ocw.mit.edu/courses/mathematics/18- 06-linear-algebra-spring-2010/video-lectures/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	-	-	-	2	-	1	2
CO2	3	2	3	1	2	1	-	-	-	-	-	1
CO3	3	2	3	2	3	1	-	-	-	-	-	1
CO4	3	3	2	3	2	-	-	-	-	-	2	1
CO5	3	3	2	2	1	2	-	-	-	-	-	1
CO6	3	3	2	2	1	-	1	2	1	-	3	2

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **Elective III 417523(B): Industrial Internet of Things**		
Teaching Scheme: **TH: 03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Internet of Things (217529), Cloud Computing (310254(C)), Cyber Security (317530)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To understand the concepts of Industrial IOT Systems and its relevance in industrial applications
- To discuss and study the implementation system of IIOT
- To identify IIOT components required for IIOT architecture
- To analyze the cloud computing in context of IIOT
- To scrutinize security challenges and solutions in IIOT system
- Use of IIOT in various applications and provide an understanding of use cases of IIOT beneficial for society

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the basic knowledge of Industrial IOT, its challenges, benefits and significance in industrial applications

CO2: Illustrate the use of sensors, actuators and communication protocols used in implementation of IIOT

CO3: Elaborate the IIOT components required for IIOT architecture

CO4: Analyze the role of cloud computing in IIOT including data storage, processing and data analytics and Digital Twin

CO5: Recognize the importance of security in IIOT and solutions to mitigate security risks

CO6: Categorize the various IIOT applications and use cases of IIoT implemented in various industries

Course Contents		
Unit I	**Introduction to Industrial Internet of Things (IIoT)**	**06 Hours**

Introduction to IIOT, History of IIOT, IOT Vs. IIOT, The Various Industrial Revolutions (Brief Conceptual Overview), Role of Industrial Internet of Things (IIoT) in Industry, Role of IIOT in Manufacturing Processes, IIOT Requirements and Design Considerations. Use of IIOT in plant maintenance practices, Key opportunities, Challenges and Benefits in implementing IIOT, Applications of IIOT **[enlist].**

#Exemplar/Case Studies	The Internet of Things (IoT) is penetrating almost all sectors of the global economy, addressing a wide range of opportunities
*Mapping of Course Outcomes for Unit I	CO1

Unit II	**IIoT System Protocols**	**06 Hours**

Sensors and Actuators used for Industrial Processes, Roles of sensors and actuators in IIOT, IIOT Sensor networks, Process automation and Data Acquisitions on IIoT Platform,
Wireless Communication Technologies: ZigBee and ZigBee IP, Z-Wave, Wi-Fi Backscatter, NFC, 6LoWPAN, RPL [**Only characteristic features are expected**].
IIoT Low Power WAN Technologies: SigFox, nWave, Dash7, Low Power Wi-Fi, LTE Category-M, Ingenue RPMA [**Only technical specifications are expected**].

#Exemplar/Case Studies	Building an Industrial IoT Infrastructure with open Source Software for Smart Energy
*Mapping of Course Outcomes for Unit II	CO2

Unit III	IIoT Architecture	06 Hours

Overview of IIOT components including Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN.
Architecture of Industrial IoT: Business Model and Reference Architecture of IIOT, Industrial Internet Architecture Framework (IIAF).
Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking

#Exemplar/Case Studies	Airbus uses Bosch's IIoT platform to build a smart factory
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Cloud and Data Analytics for IIoT	06 Hours

IIoT cloud platforms: Overview of Cloud of Things (COT) cloud platforms, Predix, PTC Thing Worx, Microsoft Azure, cloud services, Business Models: SaaS, PaaS, IaaS.
Data Analytics for IIOT: Role of Data Analytics in IIoT & Data visualization Techniques.
Digital Twin for IIOT: Introduction to Digital Twin, Need for Digital Twin, Elements of Digital Twin, Digital Twin Process Design and Information Requirements.

#Exemplar/Case Studies	Building a Hybrid Edge Cloud IIoT Platform
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	IIoT Security Challenges and Solutions	06 Hours

Introduction- Importance of Security for Industrial IOT, Conventional web technology and relationship with IIoT, Vulnerabilities of IIoT, Privacy, Security requirements.
Components of IIOT Security- Threat analysis, identity establishment, access control, message integrity, non-repudiation and availability. Network security techniques, Management aspects of cyber security.

#Exemplar/Case Studies	An Edge Decentralized Security Architecture for Industrial IoT Applications
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Applications, Use cases and Industry Revolution	06 Hours

Application and Use Cases: - Smart Robotics, Smart Metering, Smart Irrigation, Smart Factory, Healthcare Service Industry, Smart Office, Smart Logistics, Cyber Manufacturing Systems.
Industrial Revolutions: - Industry 4.0-Introduction, Definition, Why Industry 4.0 and Why Now? Characteristics, Design Principles, Advantages and applications of Industry 4.0, **Introduction to Industry 5.0 (Society 5.0).**

#Exemplar/Case Studies	Case Study: Robotics Integrator Discovers Binder Jet 3D Printing for Automotive End-of-Arm Tooling
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2017
2. S. Misra, C. Roy, and A. Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press, 2020
3. Veneri, Giacomo, and Antonio Capasso, "Hands-on Industrial Internet of Things: Create a Powerful Industrial IoT Infrastructure Using Industry 4.0", 1st edition, Packt Publishing Ltd., 2018

Reference Books:
1. Ulrich Sendler München, Germany, "The Internet of Things Ulrich Sendler Editor Industrie 4.0 Unleashed", Springer Viewg
2. R. Anandan, Suseendran Gopalakrishnan, Souvik Pal, Noor Zaman, "Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance", Wiley publication.

e-Resources:
1. How Protocol Conversion Addresses IIoT Challenges: White Paper ByRed Lion
2. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SECA4005.pdf
3. https://www.ge.com/digital/applications/digital-twin
4. https://www2.deloitte.com/us/en/insights/focus/industry-4-0/digital-twin-technology-smart-factory.html

MOOC Courses:
1. Introduction to Industry 4.0 and Industrial Internet of Things: https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2. Developing Industrial Internet of Things Specialization: https://www.coursera.org/specializations/developing-industrial-iot#courses
3. Industrial Internet of Things (IIoT): https://www.coursera.org/learn/industrial-internet-of-things
4. Internet of Things: Sensing and Actuation From Devices: https://www.coursera.org/learn/internet-of-things-sensing-actuation

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	-	-	-	-	-	-	-	-	-	-
CO2	1	2	2	2	-	-	-	-	-	-	-	2
CO3	2	1	2	-	-	-	-	-	-	-	-	2
CO4	2	2	-	-	-	-	-	-	-	-	-	-
CO5	2	2	2	2	-	-	-	-	-	-	-	2
CO6	2	2	2	2	-	-	2	-	-	-	-	2

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective III 417523(C): Enterprise Architecture and Components

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Software Engineering (210253), Database Management System (310241)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To understand the concept of the enterprise information architecture
- To understand different Enterprise architecture frameworks
- To develop skills in designing and implementing enterprise architectures
- To discuss component model and Discuss the operational characteristics of the EIA Reference Architecture
- To describe the strategy for Metadata Management within information-centric use case scenarios
- To Analyze tools of Enterprise Architecture in Modern Organizations

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the fundamental principles and concepts of enterprise architecture

CO2: Describe how the domains can be managed within the enterprise though a coherent Information Governance framework

CO3: Implement EA Process in Enterprise Architecture Design

CO4: Interpret the component and operational model characteristics of the EA Reference Architecture

CO5: Analyze strategy for Metadata Management using use case scenarios

CO6: Choose appropriate tool for Enterprise Architecture in Modern Organization

Course Contents

Unit I	Introduction to Enterprise Architecture	06 Hours

An Introduction to Enterprise Architecture, importance of enterprise architecture, Benefits of enterprise architecture, Challenges for enterprise level designing, Anti Patterns, EA Principles and Methodologies the EA Core Diagram. Lean and Agile EA: Applying Lean and Agile Methods to EA, Lean and Agile Principles: Involve All Stakeholders by Interlocking Architecture Scrums, Practice Iterative Architecture Through EA Kanban

#Exemplar/Case Studies	Enterprise Architecture is Infosys Limited
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Architecture Frameworks	06 Hours

Enterprise architecture frameworks and methodologies, EA Frameworks and Tools; Business Architecture, Application Architecture, Data Architecture, Technology Architecture. Architecture Languages: IDEF, BPMN, Test bed, ARIS, Unified Modeling Language, Architecture Description Languages, Suitability for Enterprise Architecture, Service-Oriented Architecture, Service-Oriented Technologies, Relevance and Benefits for Enterprise Architecture.

#Exemplar/Case Studies	Architecture Frameworks is Tata Consultancy Services (TCS)
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Enterprise Architecture Design and Implementation	06 Hours

Architecture Development Process Overview - plan the EA process, characterize the baseline architecture, Develop the target architecture vision, Architecture design principles, Architecture implementation best practices, Architecture governance

#Exemplar/Case Studies	An enterprise architecture approach to forest management support systems design
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Enterprise Information Architecture: Component and Operational Model	06 Hours

Enterprise information architecture: Overview, The component model, component relationship diagram, component description, component interaction diagrams- a deployment scenario.
Terminology and definitions, Context of operational model design techniques, service qualities, Standards used for operational model relationship diagram framework of operational patterns

#Exemplar/Case Studies	Description of Integrated Components for Validation - A Case Study of Student Internship Programme
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Metadata and Master Data Management	06 Hours

Metadata Management Best Practices - Strategies for effective metadata management,
Master Data Management Implementation- Steps and considerations for implementing a master data management system- Master data integration
Metadata and Master Data Interoperability- Interoperability standards and protocols for metadata and master data exchange- Cross-domain metadata and master data integration- Metadata and master data mapping and transformation techniques qualities.

#Exemplar/Case Studies	Example of Real-World Metadata and Master Data Management Implementation: Company: Acme Manufacturing
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Role of Enterprise Architecture in Modern Organizations	06 Hours

Enterprise architecture and digital transformation, Enterprise architecture and IT strategy, Enterprise Architecture Governance, Enterprise Architecture and Business Process Management, Enterprise Architecture Tools and Technologies, Tools and Resources used for enterprise designing, Enterprise Architecture and Organizational Change

#Exemplar/Case Studies	Procter & Gamble (P&G). P&G is a multinational consumer goods company headquartered in Cincinnati, Ohio, USA
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Marc Lankhorst et. al., "Enterprise Architecture at Work: Modeling, Communication and Analysis"
2. Neal McWhorter , "Enterprise Architecture The Art and Practice of Business"
3. David Marco, "Metadata Management for Information Control and Business Success", Wiley, 2013

Reference Books:
1. Stefan Bente, Uwe Bombosch, Shailendra Langade, "Collaborative Enterprise Architecture"
2. Lankhorst Marc, "Enterprise Architecture at Work"
3. Neal McWhorter, "Enterprise Architecture for Digital Business"
4. Scott A. Bernard, "An Introduction to Enterprise Architecture", 3rd edition

e-Resources:
1. https://www.coursera.org/specializations/ibm-ai-workflow
2. Enterprise Architecture (Coursera)

MOOC Courses:
1. Prof. Jenamani, IIT Kharagpur, E-business, https://nptel.ac.in/courses/110/105/110105083/
2. The Practice of Enterprise Architecture (Part I): https://www.udemy.com/course/the-practice-of-enterprise-architecture-part-i/
3. Enterprise Architecture: https://www.classcentral.com/course/enterprise-architecture-17941

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	-	-	-	-	-	1	-	-	1
CO2	2	2	2	-	1	-	-	-	1	1	-	1
CO3	2	2	2	-	-	-	-	-	1	-	-	1
CO4	2	2	-	-	-	-	-	-	1	-	-	1
CO5	2	2	1	-	-	-	-	-	1	-	-	1
CO6	2	2	1	-	2	-	-	-	1	-	-	1

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **Elective III 417523(D): Bioinformatics**		
Teaching Scheme: **TH: 03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Statistics (217528), Artificial intelligence (310253), Data Science (317529)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To study fundamental concepts of bioinformatics
- To study knowledge from basic to advanced level
- To refer appropriate, suitable datasets
- To study appropriate Bioinformatics tools
- To visualize and analyse recent research

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Become aware of concept of bioinformatics

CO2: Apply Knowledge from basic to advanced level in bioinformatics

CO3: Learn major topics of Bioinformatics

CO4: Demonstrate different biological suitable datasets

CO5: Demonstrate appropriate Bioinformatics tools

CO6: Connect and integrate the knowledge obtained for applications related to Bioinformatics, their tools and database

Course Contents		
Unit I	**Introduction to Bioinformatics and Molecular Biology**	**06 Hours**

Introduction to bioinformatics and its importance. Overview of molecular biology and biotechnology. Understanding biological molecules and cellular processes. DNA, RNA, protein and their functions. Genome wide Association Studies.

#Exemplar/Case Studies	Genomics and Bioconductor
*Mapping of Course Outcomes for Unit I	CO1

Unit II	**Computational Genomics and Transcriptomics**	**06 Hours**

DNA sequence analysis. Intron, Exon, Microarray, RNAseq. Genome annotation and gene prediction. RNA sequencing and analysis. Differential gene expression analysis. NCBI datasets, repositories.

#Exemplar/Case Studies	Genomic Data Visualization
*Mapping of Course Outcomes for Unit II	CO2

Unit III	**Structural Bioinformatics and Drug Discovery**	**06 Hours**

Protein structure prediction. Homology modeling and threading. Protein-ligand interactions and molecular docking. Computer-aided drug design. Data Science for Medical Image analysis.

#Exemplar/Case Studies	Structural Bioinformatics, Cross-cell line Transcriptomic Signature Predictions
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Systems Biology and Network Analysis	06 Hours

Overview of systems biology. Regulatory networks. Metabolic networks. Network analysis and visualization tools.

#Exemplar/Case Studies	AstraZeneca
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Data Mining and Machine Learning in Bioinformatics	06 Hours

Introduction to data mining and machine learning. Clustering and classification. Feature selection and dimensionality reduction. Deep learning in bioinformatics. Machine Learning, Deep Learning, Convolution Neural Network Application for Gene Networks

#Exemplar/Case Studies	DeepChem and Facial Emotion Recognition
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Applications of Bioinformatics	06 Hours

Personalized medicine and pharmacogenomics. Disease diagnosis and treatment. Agricultural and environmental biotechnology. Current research and future directions. Implementation use cases on recent research through Researchgate, GitHub.

#Exemplar/Case Studies	Awesome Bioinformatics
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. S.C. Rastogi & others, "Bioinformatics- Concepts, Skills, and Applications", 2nd edition, CBS Publishing, 2016, ISBN: 9788123914824
2. Cynthia Gibas and Per Jambeck, "Developing Bioinformatics Computer Skills" O'Reilly press, Shorff Publishers and Distributors Pvt. Ltd.,
3. Mario Cannataro, Pietro Hiram Guzzi, et.al., "Artificial Intelligence in Bioinformatics", Elsevier Science
4. Bourne PE, Weissig H., "Structural Bioinformatics" (Methods of Biochemical Analysis, V. 44). Wiley-Liss, 2003

Reference Books:
1. Basant K. Tiwary, "Bioinformatics and Computational Biology : A Primer for Biologists", Springer Nature, 2021
2. Zoe'Lacroix and critchlow, "Bioinformatics: Managing scientific data", Morgan Kaufmann, 2004
3. Campbell AM and Heyer LJm, "Discovering Genomics, Proteomics and Bioinformatics", Pearson Education
4. S.C., Rastogi, Parag, Mendiratta, Namita, "Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery", 5th edition, PHI Learning, 2022

e-Resources:
1. http://www.bioinformatics.org/
2. https://ocw.mit.edu/ans7870/6/6.047/f15/MIT6_047F15_Compiled.pdf

MOOC Courses:
1. https://archive.nptel.ac.in/courses/102/106/102106065/
2. https://www.udemy.com/course/genetics-and-next-generation-sequencing-for-bioinformatics/
3. https://www.coursera.org/specializations/bioinformatics

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	-	-	-	-	-	-	-	-	-
CO2	2	2	1	-	-	-	-	-	-	-	-	-
CO3	2	-	3	-	-	-	-	1	-	-	-	-
CO4	2	-	3	1	-	-	-	1	-	-	-	-
CO5	2	2	-	-	3	-	-	-	-	-	-	-
CO6	3	3	-	2	1	2	1	-	1	-	1	-

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) Elective IV 417524(A): GPU Programming and Architecture		
Teaching Scheme: **TH: 03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Computer Graphics (210244)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To understand Graphics Processing Unit (GPU) architecture
- To understand the basics of CUDA programming
- To write programs for massively parallel processors
- To understand the issues in mapping algorithms for GPUs
- To introduce different GPU programming models
- To optimize and evaluate the performance of modern GPUs

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Describe GPU architecture

CO2: Apply CUDA architecture for parallel programming

CO3: Analyze programming issues in CUDA programming

CO4: Acquire proficiency in programming GPUs using OpenCL

CO5: Identify efficient parallel programming patterns to solve problems

CO6: Apply programming skills that make efficient use of the GPU processing power

Course Contents

Unit I	Introduction to GPU Architecture	06 Hours

Evolution of GPU architectures – Understanding Parallelism with GPU –Typical GPU Architecture – CUDA Hardware Overview – Threads, Blocks, Grids, Warps, Scheduling, **Memory Handling with CUDA:** Shared Memory, Global Memory, Constant Memory and Texture Memory.

#Exemplar/Case Studies	Review of Traditional Computer Architecture
***Mapping of Course Outcomes for Unit I**	CO1

Unit II	CUDA Programming	06 Hours

Benefits of using GPU, CUDA-A General-Purpose Parallel Computing Platform and Programming Model, A scalable Programming Model, Programming Model - Kernels, Thread Hierarchy, Memory Hierarchy, Heterogeneous Programming, Asynchronous SIMT Programming Model, Compute Capability, Using CUDA – Multi CPU – Multi GPU Solutions, **Optimizing CUDA Applications:** Problem Decomposition, Memory Considerations, Transfers, Thread Usage, Resource Contentions

#Exemplar/Case Studies	GPU applications using SYCL and CUDA on NVIDIA
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	CUDA Programming Issues	06 Hours
Common Problems: CUDA Error Handling, Parallel Programming Issues, Synchronization, Algorithmic Issues, Finding and Avoiding Errors. Compilation with NVCC-Compilation Workflow, Binary Compatibility, PTX Compatibility, Application Compatibility, C++Compatibility, 64-bit Compatibility, CUDA Runtime		
#Exemplar/Case Studies	Image feature extraction algorithm based on CUDA architecture	
*Mapping of Course Outcomes for Unit III	CO3	

Unit IV	Introduction to OpenCL Programming	06 Hours
The basic ideas of OpenCL programs, what kind of parallel programming model is OpenCL? Common tasks of OpenCL host programs, alternatives to OpenCL for GPU programming? OpenCL Standard – Kernels – Host Device Interaction – Execution Environment – Memory Model– Basic OpenCL Examples		
#Exemplar/Case Studies	Exploiting Task Parallelism with OpenCL	
*Mapping of Course Outcomes for Unit IV	CO4	

Unit V	Algorithms on GPU	06 Hours
Parallel Patterns: Convolution, Prefix Sum, Sparse Matrix – Matrix Multiplication – Programming Heterogeneous Cluster, Performance- Synchronization, Dynamic-parallelism-enabled Kernel Overhead, Implementation, Restrictions, and Limitations- Runtime-Memory Footprint, Nesting and Synchronization Depth, Pending Kernel Launches, Configuration Options, Memory Allocation and Lifetime.		
#Exemplar/Case Studies	Accelerating genetic algorithms with GPU computing: A selective overview	
*Mapping of Course Outcomes for Unit V	CO5	

Unit VI	OpenCL and Application Design	06 Hours
OpenCL Platform Model, OpenCL Memory Model, Application Specific Processors (ASP), Transport Triggered Architecture (TTA), Practical Issues in compiling OCL Standalone Execution of OpenCL Applications, OpenCL for Heterogeneous Computing, **Application Design**: Efficient Neural Network Training/Inferencing		
#Exemplar/Case Studies	GPU-Accelerated Cone-Beam CT	
*Mapping of Course Outcomes for Unit VI	CO6	

Learning Resources

Text Books:
1. Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs (Applications of GPU Computing)", 1st edition, Morgan Kaufmann, 2012
2. David R. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, "Heterogeneous computing with OpenCL", 3rd edition, Morgan Kauffman, 2015
3. Benedict Gaster, LeeHowes, David R. Kaeli, "Heterogeneous Computing with OpenCL", 2012

Reference Books:
1. Nicholas Wilt, "CUDA Handbook: A Comprehensive Guide to GPU Programming", Addison –Wesley, 2013
2. Jason Sanders, Edward Kandrot, "CUDA by Example: An Introduction to General Purpose GPU Programming", Addison – Wesley, 2010
3. David B. Kirk, Wen-mei W. Hwu, "Programming Massively Parallel Processors, A Hands-on Approach", 3rd edition, Morgan Kaufmann, 2016
4. CUDA C++ Programming Guide
   https://docs.nvidia.com/cuda/cuda-c-programming-guide/index.html#compilation-with-nvcc
5. CUDA Toolkit
   https://developer.nvidia.com/cuda-zone
6. OpenCL http://www.openCL.org

e-Resources:
1. https://edoras.sdsu.edu/~mthomas/docs/cuda/cuda_by_example.book.pdf
2. https://www.cs.utexas.edu/~rossbach/cs380p/papers/cuda-programming.pdf
3. https://www.syncfusion.com/succinctly-free-ebooks/confirmation/cuda
4. https://ptgmedia.pearsoncmg.com/images/9780321749642/samplepages/0321749642.pdf

MOOC Courses:
1. https://onlinecourses.nptel.ac.in/noc20_cs41/preview

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1			-	1	-	-	-	-	-
CO2	1	2	2	2	2	-	-	-	-	-	-	-
CO3	-	2	3	2	2	-	-	-	-	-	-	-
CO4	1	2	2	2	2	-	-	-	1	-	-	1
CO5	1	3	2	2	-	-	-	-	-	-	-	-
CO6	1	2	2	1	2	2	-	-	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective IV 417524(B): Information Retrieval

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Data Structures and Algorithms (210252), Database management systems(310241)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To understand the basics of Information Retrieval
- To understand the concepts of Indexing & Query Processing for Information Retrieval
- To provide comprehensive details about various Evaluation methods
- To understand the different methods of Text Classification and Clustering
- To understand various search engine system operations and web structures
- To understand various applications of Information Retrieval

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the concept of Information Retrieval

CO2: Use an indexing approach for retrieval of documents

CO3: Evaluate and analyze the retrieved information

CO4: Apply appropriate method of Text Classification and Clustering

CO5: Design and implement innovative features in search engines

CO6: Analyze different real-life application of Information Retrieval

Course Contents

Unit I	Introduction	06 Hours

Introduction to information retrieval, Major challenges in IR, Features of an IR system, components of an IR model, IR system block diagram, Boolean retrieval, Information versus Data Retrieval, Text categorization, IR processes and fields, Vector Model, Probabilistic Model and Latent Semantic Indexing Model.

#Exemplar/Case Studies	Visualization and Information Retrieval Techniques for Network Intrusion Detection
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Dictionaries and Query Processing	06 Hours

Components of Index, Index Life Cycle, Static Inverted Index, Dictionaries-Types (Sort Based, Hash Based, Interleaving & Posting Lists), Index Construction (In memory, Sort Based, Merge Based, Disk Based Index Construction), Dynamic Indexing, Query Processing for Ranked Retrieval, Document at a Time Query Processing, Term at a Time Query Processing, Pre-computing Score Contributions, Impact Ordering, Query Optimization.

#Exemplar/Case Studies	Matching of the searched statement with the database which is already stored

*Mapping of Course Outcomes for Unit II	CO2	
Unit III	**Probabilistic Retrieval and Language Modelling related methods**	**06 Hours**

Probabilistic Retrieval: Review of Basic Probability Theory; The Probability Ranking Principle: The 1/0 loss case, the PRP with retrieval costs; The Binary Independence Model; Term Frequency; An appraisal and some extensions: An appraisal of probabilistic models, tree-structured dependencies between terms, Okapi BM25: a non-binary model, Bayesian network approaches to IR, Relevance Feedback, Field Weights:BM25F.

Language models for information retrieval: generating queries from documents; Language models: finite automata and language models; types of language models; multinomial distributions over words; Ranking with Language Models; Divergence from Randomness, Passage Retrieval, and Ranking.

#Exemplar/Case Studies	A Comparative Study of Probabilistic and Language Models for Information Retrieval
*Mapping of Course Outcomes for Unit III	CO3
Unit IV	**Text classification & Text clustering**	**06 Hours**

Text Classification: Introduction to Text Classification, Naiyes Bayes Model, K Nearest neighbor, spam filtering, Support Vector Machine Classifier, Vector Space classification using hyperplanes, kernel function.

Text Clustering: Clustering vs Classification, partitioning methods. Clustering Algorithms: k-means clustering, Agglomerative hierarchical clustering, Expectation Maximization, Mixture of Gaussians Model

#Exemplar/Case Studies	Case Study: Improving Document Organization and Retrieval in a Digital Library
*Mapping of Course Outcomes for Unit IV	CO4
Unit V	**Web Retrieval and Web Crawling**	**06 Hours**

Parallel information retrieval: Parallel query processing, Mapreduce

Web Retrieval: Search Engine Architectures, Cluster based Architecture, Distributed Architectures, Search Engine Ranking. Link based Ranking, Page Ranking Algorithm, Simple Ranking Functions and Evaluations.

Web Crawler: Web Crawler structure, Web crawler libraries, Python Scrapy, Beautiful Soup, Applications

#Exemplar/Case Studies	Study of Google Map/ Geogusser information retrieval
*Mapping of Course Outcomes for Unit V	CO5
Unit VI	**IR applications**	**06 Hours**

Multimedia Information Retrieval: Spoken Language Audio Retrieval, Non-Speech Audio Retrieval, Graph Retrieval, Imagery Retrieval, Video Retrieval

Recommender System: Collaborative Filtering, Content Based Recommendation, Knowledge Based Recommendation Information Extraction and Integration: Extracting Data from Text. Semantic Web, Collecting and Integrating Specialized Information on the web.

#Exemplar/Case Studies	Demonstrate Collaborative filtering using any datasets to recommend items to users

*Mapping of Course Outcomes for Unit VI	CO6

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Learning Resources

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Text Books:
1. C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008, ISBN: 9780521865715
2. S. Buttcher, C. Clarke, and G. Cormack, "Information Retrieval: Implementing and Evaluating Search Engines" MIT Press, 2010, ISBN: 0-408-70929-4
3. Bruce Croft, Donald Metzler and Trevor Strohman, "Search Engines: Information Retrieval in Practice", 1st edition, Addison Wesley, 2009, ISBN: 9780135756324
4. Jannach D., Zanker M. and FelFering A., "Recommender Systems: An Introduction", 1st edition, Cambridge University Press

Reference Books:
1. Manouselis N., Drachsler H., Verbert K., Duval E., "Recommender Systems For Learning", 1st edition, Springer, 2013
2. G. Kowalski, M.T. Maybury, "Information storage and Retrieval System", Springer, 2005
3. W.B. Croft, J. Lafferty, "Language Modeling for Information Retrieval", Springer, 2003

e-Resources:
1. Information Retrieval- http://www.informationretrieval.org

MOOC Courses:
1. https://www.youtube.com/watch?v=fFxpSmyICwI
2. https://www.youtube.com/watch?v=X5GvBh4qY0s

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The CO-PO Mapping Matrix

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CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	–	–	–	–	–	–	–	–	–	–	–
CO2	–	1	2	–	–	–	–	–	–	–	–	–
CO3	1	2	1	1	1	–	–	–	–	–	–	2
CO4	1	–	1	1	–	–	–	–	1	–	–	1
CO5	1	–	–	–	–	–	–	1	1	–	–	1
CO6	–	–	–	–	1	–	–	–	–	–	–	1

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) Elective IV 417524(C): UI/UX Design		
Teaching Scheme: **TH: 03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Design Thinking (

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To learn the factors that determine how people use technology
- To study the usable software-enabled user-interfaces
- To achieve efficient, effective, and safe interaction
- To Explore various models and factors that affect response time
- To explore the challenges associated with information visualization and its societal and individual impacts.
- To learn Usability evaluation methods

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the principles of User Interface

CO2: Describe user experience fundamentals

CO3: Explore strategies for managing design projects

CO4: Recognize the quality of service and data visualization

CO5: Explore the challenges associated with information visualization

CO6: Test the usability of a design through usability evaluations

Course Contents		
Unit I	**Unit Introduction and Overview of UI**	**06 Hours**
The Human –I/P, O/P channels, Human Memory, thinking, emotion, individual difference (diversity), human psychology. **Introduction to User Interface Design (UI)** -The Relationship Between UI and UX , Roles in UI/UX, A Brief historical Overview of Interface Design, Interface Conventions, Approaches to Screen Based UI, Template vs Content, Formal Elements of Interface Design, Active Elements of Interface Design, Composing the Elementsof Interface Design, UI Design Process, Visual Communication design component in Interface Design , Application of UI design **Introduction to Design Technologies and Tools** Sketch ,Wireframe ,Invision, Axure, Figma, Flutter, Mockups		
#Exemplar/Case Studies	Redesigning a Mobile E-commerce App	
***Mapping of Course Outcomes for Unit I**	CO1	
Unit II	**Unit User Experience**	**06 Hours**

UX Basics- Foundation of UX design, Good and poor design, Understanding Your Users, Designing the Experience Elements of user Experience, Visual Design Principles, Functional Layout, Interaction design, Introduction to the Interface, Navigation Design, User Testing, Developing and Releasing Your Design

User experience and user interaction-Usability of interactive systems, goals and measures, Universal Usability, Characteristics of graphical and web user interfaces, guidelines, principles and theories of good design, User Experience- Concept of UX, Trends in UX, 6 Stages used to UX design , Applications of UX design

#Exemplar/Case Studies	Redesigning a Health and Fitness Mobile App
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Unit Design Process	06 Hours

Managing design processes, organizational design to support usability, pillars of design, development methodologies, Human considerations in Design, Usability- principles to support usability, assessment in the design process, Usability problems, practical measures of usability,

objective measures of usability, golden rules of interface design, Evaluating Interface Design – Introduction, Expert reviews, Usability testing, Acceptance tests, Legal issues

#Exemplar/Case Studies	Redesign of a mobile banking application
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Unit Interaction Styles	06 Hours

Direct manipulation and virtual environment, Develop system menus and navigation schemes-Structure of menus, Function of menus, content of menus, phrasing the menu, navigating menus, kinds of graphical menus, form fill-in and dialog boxes, command- organization , functionality, strategies and structure, naming and abbreviations, interaction devices, collaboration and social media participation

#Exemplar/Case Studies	
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Unit Implementation support and Screen Based Controls	06 Hours

Implementation support: Support, training and learning, requirement of user support, element of windowing systems,Individual window design, multiple window design, command organization strategies command menus, natural languages in computer

Screen Based Controls: Selection control-Radio buttons, check boxes, list boxes, Read-only controls- text boxes, Operablecontrols - buttons, slider, tab, scroll bar, clear text and messages, text for web pages, Graphics, icons and images, Presentation controls-Static text fields, Group boxes, column headings, tool tips,progress indicators

#Exemplar/Case Studies	
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Unit Usability Evaluation and Design Issues	06 Hours

Quality of service- Models of response time impacts, user productivity, variability in response time, Balancing function and fashion- Error messages, display design, web page design, window design, color, Information visualization – data type by task taxonomy, challenges for information visualization, societal and individual impact of user interface

Usability Evaluation Methods :
Usability Testing ,Heuristic evaluations , Cognitive walkthrough, Surveys and Questionnaires
Eye Tracking, A/B Testing, Remote Usability Testing, Think-Aloud Protocol, Comparative Usability Evaluation

#Exemplar/Case Studies	
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Creative Tim,"Fundamentals of Creating a Great UI/UX", 1st edition
2. Jon Yablonski, "Laws of UX: Using Psychology to Design Better Products & Services", O'REILLY Publication
3. Jenifer Tidwell, Charles Brewer, Aynne Valencia, "Designing Interfaces: Patterns for Effective Interaction Design", O'REILLY Publication

Reference Books:
1. Shneiderman, Plaisant, Cohen, Jacobs, "Designing the User Interface-Strategies for Effective Human Computer Interaction", 5th edition, PEARSON Publication
2. Wilbert O. Galitz, "The Essential Guide to User Interface Design", 2nd edition, WILEY Publication
3. Alan Dix, Janet Finlay, Gregory D. Abowd, Russell Beale, "Human–Computer Interaction, 3rd edition
4. Alan Coopen, "The essentials of interaction"

e-Resources:
1. "The Guide to Wireframing" by UXPin: https://www.uxpin.com/studio/ebooks/guide-to-wireframing/ - This eBook provides an in-depth guide to wireframing, covering the basics, best practices, and tips for creating effective wireframes.
2. "UX Design for Startups" by Marcin Treder: https://uxpin.com/studio/ebooks/ux-design-for-startups/ - This eBook focuses on UX design principles and strategies specifically tailored for startups, covering topics like user research, prototyping, and user testing.

MOOC Courses:
1. User Interface Design: https://onlinecourses.nptel.ac.in/noc21_ar05/preview

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	1	1	-	-	-	-	-	-	-
CO2	-	2	1	3	1	-	-	-	1	-	-	-
CO3	2	-	2	1	-	1	-	-	-	-	1	-
CO4	1	3	1	2	2	1	-	1	-	-	-	1
CO5	1	1	2	-	3	-	1	1	-	1	-	-
CO6	2	1	-	2	1	1	-	1	-	-	-	-

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective IV 417524(D): Optimization Algorithms

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Discrete Mathematics (210241), Data Structures and Algorithms (210252)

Companion Course: Computer Laboratory II (417526)

Course Objectives:

- To understand the need of optimization Algorithms
- To apply the optimization techniques while solving the problems
- To understand the constraints applied and optimization of the algorithm
- To optimize searching strategies
- To understand and use Self Optimizing algorithms

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Identify Optimization Concepts to incorporate in problem solving in effective way

CO2: To formulate given optimization problem mathematically precisely

CO3: To create model using Optimization Techniques, like linear programming, integer programming and dynamic programming

CO4: To select an optimization strategy to tackle complex optimization problems and evaluate the optimization algorithms

CO5: To distinguish strategies of Optimization Algorithms selected

CO6: To construct an Optimization strategy to solve different problems

Course Contents

Unit I	Introduction	06 Hours

Introduction, Fundamentals of Optimization, general structure of the optimization algorithms, types of optimization problems, examples of optimization, formulation of optimization problem, classification of optimization algorithms, traveling salesman and knapsack problem

#Exemplar/Case Studies	Analyze the traveling salesman problem for optimization
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Classical Optimization	06 Hours

Introduction, Mathematical model of optimization, Optimality conditions, **Solution techniques**-Penalty function, Linear programming (LP)-Formulation of LP Problem Optimality conditions, Integer Linear Programming, LP duality-Farkas Lemma, **Quadratic Programming (QP)**-Convex QP problems, Convex Programming, general constraint optimization problem

#Exemplar/Case Studies	Solve the Multistage Graph Problem with Dynamic Programming
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Constraint Optimization	06 Hours

Introduction **Linear Programming**-Simplex Method, Revised Simplex Method, Karmarkar's Method, Duality Theorem and Transportation Problem, **Non-linear Programming**-Quadratic and Geometric Programming, Karush–Kuhn–Tucker (KKT) conditions test as necessary condition. **Dynamic Programming**- Continuous vs Discrete dynamic programming, multistage graph problem, traveling salesman and knapsack problem

#Exemplar/Case Studies	Solving linear equations with Genetic Algorithms
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Search Optimization	06 Hours

Introduction, **Genetic Algorithms**-Initialize population, Fitness Evaluation, Reproduction, Crossover andMutation, Multimodel test function, Solving linear equations with genetic algorithm, **Simulated Annealing(SA)**-Annealing and Boltzmann Distribution, Parameters, SA Algorithm, Unconstrained Optimization, Basic Convergence Properties, SA Behavior in Practice and Stochastic Tunneling, **Particle Swarm Optimization(PSO)**-Introduction, Swarm Behavior, PSO Algorithm, Variants of PSO Algorithm

#Exemplar/Case Studies	Penalty function implementation in convex computation
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Differential Evolution and Swarm Optimization	06 Hours

Introduction, **Differential Evolution**-Introduction, Differential Evolution, Variants, Choice of Parameters Convergence Analysis and Implementation. **Swarm Optimization**-Swarm Intelligence, PSO Algorithm, Accelerated PSO, Convergence Analysis-PSO, Binary PSO, **Multiobjective Optimization**- Pareto Optimality, Constraint Methods, Weight Methods, Preference Elicitation, Ant colony optimization(ACO)

#Exemplar/Case Studies	Binary PSO implementation
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Self Tuning Algorithms	06 Hours

Introduction, Algorithm Analysis and Parameter Tuning, Framework for Self-Tuning Algorithms, **A Self-Tuning Firefly Algorithm**- Firefly Behavior, Standard Firefly Algorithm, Variations of Light Intensity and Attractiveness, Controlling Randomization Variants of the Firefly Algorithm, Firefly Algorithms in Applications, **Bat Algorithm**- Echolocation of Bats, Bat Algorithms, Binary Bat Algorithms, Convergence Analysis, Applications

#Exemplar/Case Studies	Implementation of Firefly algorithm to understand the self tunning
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Andreas Antoniou, Wu-Sheng Lu, "Practical optimization algorithms and engineering applications", Springer, 2007
2. Vasuki A., "Nature Inspired Optimization Algorithms", CRC Press, 2020
3. Mykel J. Kochenderfer, Tim A. Wheeler, "Algorithms for Optimization", MIT Press, 2019

Reference Books:
1. Rajesh Kumar Arora, "Optimization Algorithms and Applications", Chapman & Hall, CRC, 2015
2. A Schrijver, "Theory of Linear and Integer Programming" (Wiley Series in Discrete Mathematics & Optimization)
3. V. Chvatal, "Linear Programming"

MOOC Courses:
1. https://www.coursera.org/learn/optimization-for-decision-making
2. https://www.coursera.org/learn/solving-algorithms-discrete-optimization

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	2	-	-	-	-	-	-	-	1
CO2	2	2	1	2	-	-	-	-	-	-	-	1
CO3	1	2	2	2	-	-	-	-	-	-	-	1
CO4	-	2	2	2	-	-	-	-	-	-	-	1
CO5	-	2	2	2	-	-	-	-	-	-	-	1
CO6	-	2	2	2	-	-	-	-	-	-	-	1

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417525: Computer Laboratory I

Teaching Scheme: PR: 04 Hours/Week	Credit 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 25 Marks

Prerequisite Courses: Data Science (317529), Artificial Neural Network (317531)

Companion Course: Machine Learning (417521), Data Modeling and Visualization (417522)

Course Objectives:
- Apply regression, classification and clustering algorithms for creation of ML models
- Introduce and integrate models in the form of advanced ensembles
- Conceptualized representation of Data objects
- Create associations between different data objects, and the rules
- Organized data description, data semantics, and consistency constraints of data

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Implement regression, classification and clustering models

CO2: Integrate multiple machine learning algorithms in the form of ensemble learning

CO3: Apply reinforcement learning and its algorithms for real world applications

CO4: Analyze the characteristics, requirements of data and select an appropriate data model

CO5: Apply data analysis and visualization techniques in the field of exploratory data science

CO6: Evaluate time series data

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a reference and hands-on resource. It should include prologue (about University/program/ institute/ department/foreword/ preface), curriculum of the course, conduction and Assessment guidelines, topics under consideration, concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal consists of Certificate, table of contents, and handwritten write-up of each assignment (Title, Date of Completion, Objectives, Problem Statement, Software and Hardware requirements, Assessment grade/marks and assessor's sign, Theory- Concept in brief, algorithm, flowchart, test cases, Test Data Set(if applicable), mathematical model (if applicable), conclusion/analysis). Program codes with sample output of all performed assignments are to be submitted as softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal must be avoided. Use of DVD containing students programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.

Guidelines for Laboratory /Term Work Assessment

Continuous assessment of laboratory work should be based on overall performance of Laboratory assignments by a student. Each Laboratory assignment assessment will assign grade/marks based on parameters, such as timely completion, performance, innovation, efficient codes, and punctuality.

Guidelines for Practical Examination

Problem statements must be decided jointly by the internal examiner and external examiner. During practical assessment, maximum weightage should be given to satisfactory implementation of the problem statement. Relevant questions may be asked at the time of evaluation to test the student's understanding of the fundamentals, effective and efficient implementation. This will encourage, transparent evaluation and

fair approach, and hence will not create any uncertainty or doubt in the minds of the students. So, adhering to these principles will consummate our team efforts to the promising start of student's academics.

Guidelines for Laboratory Conduction

The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy needs to address the average students and inclusive of an element to attract and promote the intelligent students. Use of open source software is encouraged. Based on the concepts learned, Instructors may also set one assignment or mini-project that is suitable to AI & DS branch beyond the scope of the syllabus.

Operating System recommended:- 64-bit Open source Linux or its derivative

Programming tools recommended: - Open Source Python, Programming tool like Jupyter Notebook, Pycharm, Spyder.

PART-1(Machine Learning): 6 Assignments

PART- II(Data Modeling and Visualization): 6 Assignments

PART-III(Mini Project): Mandatory Assignment

Virtual Laboratory

https://cse20-iiith.vlabs.ac.in/

Suggested List of Laboratory Experiments/Assignments

Part I: Machine Learning

1	**Feature Transformation (Any one)** **A.** To use PCA Algorithm for dimensionality reduction. You have a dataset that includes measurements for different variables on wine (alcohol, ash, magnesium, and so on). Apply PCA algorithm & transform this data so that most variations in the measurements of the variables are captured by a small number of principal components so that it is easier to distinguish between red and white wine by inspecting these principal components. Dataset Link: https://media.geeksforgeeks.org/wp-content/uploads/Wine.csv **B.** Apply LDA Algorithm on Iris Dataset and classify which species a given flower belongs to. Dataset Link:https://www.kaggle.com/datasets/uciml/iris

2	**Regression Analysis:(Any one)**
	A. Predict the price of the Uber ride from a given pickup point to the agreed drop-off location. Perform following tasks:
	  1. Pre-process the dataset.
	  2. Identify outliers.
	  3. Check the correlation.
	  4. Implement linear regression and ridge, Lasso regression models.
	  5. Evaluate the models and compare their respective scores like R2, RMSE, etc.
	  Dataset link: https://www.kaggle.com/datasets/yasserh/uber-fares-dataset
	B. Use the diabetes data set from UCI and Pima Indians Diabetes data set for performing the following:
	a. Univariate analysis: Frequency, Mean, Median, Mode, Variance, Standard Deviation, Skewness and Kurtosis
	b. Bivariate analysis: Linear and logistic regression modeling
	c. Multiple Regression analysis
	d. Also compare the results of the above analysis for the two data sets
	
	Dataset link: https://www.kaggle.com/datasets/uciml/pima-indians-diabetes-database

3	**Classification Analysis (Any one)** A. Implementation of Support Vector Machines (SVM) for classifying images of hand-written digits into their respective numerical classes (0 to 9). B. Implement K-Nearest Neighbours' algorithm on Social network ad dataset. Compute confusion matrix, accuracy, error rate, precision and recall on the given dataset. Dataset link:https://www.kaggle.com/datasets/rakeshrau/social-network-ads
4	**Clustering Analysis (Any one)** A. Implement K-Means clustering on Iris.csv dataset. Determine the number of clusters using the elbow method. Dataset Link: https://www.kaggle.com/datasets/uciml/iris B. Implement K-Mediod Algorithm on a credit card dataset. Determine the number of clusters using the Silhouette Method. Dataset link: https://www.kaggle.com/datasets/arjunbhasin2013/ccdata
5	**Ensemble Learning (Any one)** A. Implement Random Forest Classifier model to predict the safety of the car. Dataset link: https://www.kaggle.com/datasets/elikplim/car-evaluation-data-set B. Use different voting mechanism and Apply AdaBoost (Adaptive Boosting), Gradient Tree Boosting (GBM), XGBoost classification on Iris dataset and compare the performance of three models using different evaluation measures. Dataset Link: https://www.kaggle.com/datasets/uciml/iris

6	**Reinforcement Learning (Any one)**
	A. Implement Reinforcement Learning using an example of a maze environment that the agent needs to explore.
	B. Solve the Taxi problem using reinforcement learning where the agent acts as a taxi driver to pick up a passenger at one location and then drop the passenger off at their destination.
	C. Build a Tic-Tac-Toe game using reinforcement learning in Python by using following tasks
	    a. Setting up the environment
	    b. Defining the Tic-Tac-Toe game
	    c. Building the reinforcement learning model
	    d. Training the model
	    e. Testing the model

Part II: Data Modeling and Visualization
7	**Data Loading, Storage and File Formats** **Problem Statement:** Analyzing Sales Data from Multiple File Formats **Dataset:** Sales data in multiple file formats (e.g., CSV, Excel, JSON) **Description:** The goal is to load and analyze sales data from different file formats, including CSV, Excel, and JSON, and perform data cleaning, transformation, and analysis on the dataset. **Tasks to Perform:** Obtain sales data files in various formats, such as CSV, Excel, and JSON. 1. Load the sales data from each file format into the appropriate data structures or dataframes. 2. Explore the structure and content of the loaded data, identifying any inconsistencies, missing values, or data quality issues. 3. Perform data cleaning operations, such as handling missing values, removing duplicates, or correcting inconsistencies. 4. Convert the data into a unified format, such as a common dataframe or data structure, to enable seamless analysis.

	5. Perform data transformation tasks, such as merging multiple datasets, splitting columns, or deriving new variables. 6. Analyze the sales data by performing descriptive statistics, aggregating data by specific variables, or calculating metrics such as total sales, average order value, or product category distribution. 7. Create visualizations, such as bar plots, pie charts, or box plots, to represent the sales data and gain insights into sales trends, customer behavior, or product performance.
8	**Interacting with Web APIs** **Problem Statement:** Analyzing Weather Data from OpenWeatherMap API **Dataset:** Weather data retrieved from OpenWeatherMap API **Description:** The goal is to interact with the OpenWeatherMap API to retrieve weather data for a specific location and perform data modeling and visualization to analyze weather patterns over time. **Tasks to Perform:** 1. Register and obtain API key from OpenWeatherMap. 2. Interact with the OpenWeatherMap API using the API key to retrieve weather data for a specific location. 3. Extract relevant weather attributes such as temperature, humidity, wind speed, and precipitation from the API response. 4. Clean and preprocess the retrieved data, handling missing values or inconsistent formats. 5. Perform data modeling to analyze weather patterns, such as calculating average temperature, maximum/minimum values, or trends over time. 6. Visualize the weather data using appropriate plots, such as line charts, bar plots, or scatter plots, to represent temperature changes, precipitation levels, or wind speed variations. 7. Apply data aggregation techniques to summarize weather statistics by specific time periods (e.g., daily, monthly, seasonal). 8. Incorporate geographical information, if available, to create maps or geospatial visualizations representing weather patterns across different locations. 9. Explore and visualize relationships between weather attributes, such as temperature and humidity, using correlation plots or heatmaps.
9	**Data Cleaning and Preparation** **Problem Statement:** Analyzing Customer Churn in a Telecommunications Company **Dataset:** "Telecom_Customer_Churn.csv" **Description:** The dataset contains information about customers of a telecommunications company and whether they have churned (i.e., discontinued their services). The dataset includes various attributes of the customers, such as their demographics, usage patterns, and account information. The goal is to perform data cleaning and preparation to gain insights into the factors that contribute to customer churn. **Tasks to Perform:** 1. Import the "Telecom_Customer_Churn.csv" dataset. 2. Explore the dataset to understand its structure and content. 3. Handle missing values in the dataset, deciding on an appropriate strategy. 4. Remove any duplicate records from the dataset. 5. Check for inconsistent data, such as inconsistent formatting or spelling variations, and standardize it. 6. Convert columns to the correct data types as needed. 7. Identify and handle outliers in the data. 8. Perform feature engineering, creating new features that may be relevant to predicting customer churn. 9. Normalize or scale the data if necessary.

	10. Split the dataset into training and testing sets for further analysis. 11. Export the cleaned dataset for future analysis or modeling.
10	**Data Wrangling** **Problem Statement:** Data Wrangling on Real Estate Market **Dataset:** "RealEstate_Prices.csv" **Description:** The dataset contains information about housing prices in a specific real estate market. It includes various attributes such as property characteristics, location, sale prices, and other relevant features. The goal is to perform data wrangling to gain insights into the factors influencing housing prices and prepare the dataset for further analysis or modeling. **Tasks to Perform:** 1. Import the "RealEstate_Prices.csv" dataset. Clean column names by removing spaces, special characters, or renaming them for clarity. 2. Handle missing values in the dataset, deciding on an appropriate strategy (e.g., imputation or removal). 3. Perform data merging if additional datasets with relevant information are available (e.g., neighborhood demographics or nearby amenities). 4. Filter and subset the data based on specific criteria, such as a particular time period, property type, or location. 5. Handle categorical variables by encoding them appropriately (e.g., one-hot encoding or label encoding) for further analysis. 6. Aggregate the data to calculate summary statistics or derived metrics such as average sale prices by neighborhood or property type. 7. Identify and handle outliers or extreme values in the data that may affect the analysis or modeling process.
11	**Data Visualization using matplotlib** **Problem Statement:** Analyzing Air Quality Index (AQI) Trends in a City **Dataset**: "City_Air_Quality.csv" **Description:** The dataset contains information about air quality measurements in a specific city over a period of time. It includes attributes such as date, time, pollutant levels (e.g., PM2.5, PM10, CO), and the Air Quality Index (AQI) values. The goal is to use the matplotlib library to create visualizations that effectively represent the AQI trends and patterns for different pollutants in the city. **Tasks to Perform:** 1. Import the "City_Air_Quality.csv" dataset. 2. Explore the dataset to understand its structure and content. 3. Identify the relevant variables for visualizing AQI trends, such as date, pollutant levels, and AQI values. 4. Create line plots or time series plots to visualize the overall AQI trend over time. 5. Plot individual pollutant levels (e.g., PM2.5, PM10, CO) on separate line plots to visualize their trends over time. 6. Use bar plots or stacked bar plots to compare the AQI values across different dates or time periods. 7. Create box plots or violin plots to analyze the distribution of AQI values for different pollutant categories. 8. Use scatter plots or bubble charts to explore the relationship between AQI values and pollutant levels. 9. Customize the visualizations by adding labels, titles, legends, and appropriate color schemes.

12	**Data Aggregation** **Problem Statement:** Analyzing Sales Performance by Region in a Retail Company **Dataset:** "Retail_Sales_Data.csv" **Description:** The dataset contains information about sales transactions in a retail company. It includes attributes such as transaction date, product category, quantity sold, and sales amount. The goal is to perform data aggregation to analyze the sales performance by region and identify the top-performing regions. **Tasks to Perform:** 1. Import the "Retail_Sales_Data.csv" dataset. 2. Explore the dataset to understand its structure and content. 3. Identify the relevant variables for aggregating sales data, such as region, sales amount, and product category. 4. Group the sales data by region and calculate the total sales amount for each region. 5. Create bar plots or pie charts to visualize the sales distribution by region. 6. Identify the top-performing regions based on the highest sales amount. 7. Group the sales data by region and product category to calculate the total sales amount for each combination. 8. Create stacked bar plots or grouped bar plots to compare the sales amounts across different regions and product categories.
13	**Time Series Data Analysis** **Problem statement: Analysis and Visualization of Stock Market Data** **Dataset:** "Stock_Prices.csv" **Description:** The dataset contains historical stock price data for a particular company over a period of time. It includes attributes such as date, closing price, volume, and other relevant features. The goal is to perform time series data analysis on the stock price data to identify trends, patterns, and potential predictors, as well as build models to forecast future stock prices. **Tasks to Perform:** 1. Import the "Stock_Prices.csv" dataset. 2. Explore the dataset to understand its structure and content. 3. Ensure that the date column is in the appropriate format (e.g., datetime) for time series analysis. 4. Plot line charts or time series plots to visualize the historical stock price trends over time. 5. Calculate and plot moving averages or rolling averages to identify the underlying trends and smooth out noise. 6. Perform seasonality analysis to identify periodic patterns in the stock prices, such as weekly, monthly, or yearly fluctuations. 7. Analyze and plot the correlation between the stock prices and other variables, such as trading volume or market indices. 8. Use autoregressive integrated moving average (ARIMA) models or exponential smoothing models to forecast future stock prices.

Learning Resources

Text Books:
1. Ethem Alpaydin, "Introduction to Machine Learning", 2nd edition, PHI, 2013
2. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, 2012
3. Chun-houh Chen, Wolfgang Härdle, Antony Unwin, "Handbook of Data Visualization", Springer
4. Ben Fry Beijing, "Visualizing Data", O'Reilly Media

5. McKinney W., "Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython", 2nd edition, O'Reilly Media, 2017
6. O'Neil, C., & Schutt, R., "Doing Data Science: Straight Talk from the Frontline", O'Reilly Media, 2013

Reference Books:
1. Ian H Witten, Eibe Frank, Mark A Hall, "Data Mining, Practical Machine Learning Tools and Techniques", 3rd edition, Elsevier
2. Jiawei Han, Micheline Kamber, and Jian Pie, "Data Mining: Concepts and Techniques", 3rd edition Elsevier Publishers, ISBN: 9780123814791, 9780123814807
3. Gelman, Andrew, and Jennifer Hill, "Data Analysis Using Regression and Multilevel/ Hierarchical Models", 1st edition, Cambridge, UK: Cambridge University Press, 2006, ISBN: 9780521867061
4. Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin, "Bayesian Data Analysis", 2nd edition, New York, NY: Chapman & Hall, 2003, ISBN: 9781584883883
5. Gelman, Andrew, and Jennifer Hill, "Data Analysis Using Regression and Multilevel /Hierarchical Models", 1st edition, Cambridge, UK: Cambridge University Press, 2006, ISBN: 9780521867061

e-Resources:
1. Reinforcement Learning
   https://www.cs.toronto.edu/~urtasun/courses/CSC411_Fall16/19_rl.pdf
2. An Introduction to Statistical Learning by Gareth James
   https://www.ime.unicamp.br/~dias/Intoduction%20to%20Statistical%20Learning.pdf

e-Books:
1. A brief introduction to machine learning for Engineers: https://arxiv.org/pdf/1709.02840.pdf
2. Introductory Machine Learning Nodes : http://lcsl.mit.edu/courses/ml/1718/MLNotes.pd
3. Python Data Science Handbook by Jake VanderPlas
   https://tanthiamhuat.files.wordpress.com/2018/04/pythondatasciencehandbook.pdf
4. Elements of Statistical Learning: data mining, inference, and prediction.
   https://hastie.su.domains/ElemStatLearn/index.html

MOOC Courses:
1. Introduction to Machine Learning(IIT kharagpur) : https://nptel.ac.in/courses/106105152
2. Introduction to Machine Learning (IIT Madras):
   https://onlinecourses.nptel.ac.in/noc22_cs29/prevew
3. Machine Learning A-Z™: AI, Python & R + ChatGPT Bonus [2023]
   https://www.udemy.com/course/machinelearning/
4. Machine Learning and Deep Learning A-Z: Hands-On Python
   https://www.udemy.com/course/machine-learning-and-deep-learning-a-z-hands-on-pyt
5. Introduction to Data Analytics
   https://nptel.ac.in/courses/110106072

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	-	-	-	2	2	1	1
CO2	3	3	3	2	3	-	-	-	2	2	1	1
CO3	3	3	3	2	3	-	-	-	2	2	1	1
CO4	3	2	2	3	3	-	-	-	2	1	1	1
CO5	3	2	2	3	3	-	-	-	2	1	1	1
CO6	3	2	2	3	3	-	-	-	2	2	1	1

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417526: Computer Laboratory II: Quantum AI		
Teaching Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme and Marks** **Term Work (TW): 50 Marks** **Practical (PR): 25 Marks**

Prerequisites Courses: Software Laboratory I (317523)

Companion Course: Elective III: Quantum AI (417523(A))

Course Objectives:
- To develop real-world problem-solving ability
- To enable the student to apply AI techniques in applications that involve perception, reasoning, and planning
- To work in a team to build industry-compliant Quantum AI applications

Course Outcomes:
On completion of the course, learner will be able to–
CO1: Evaluate and apply core knowledge of Quantum AI to various real-world problems.
CO2: Illustrate and demonstrate Quantum AI tools for different dynamic applications.

Guidelines for Instructor's Manual

Lab Assignments: Following is a list of suggested laboratory assignments for reference. Laboratory Instructors may design a suitable set of assignments for their respective courses at their level. Beyond curriculum assignments, the mini-project is also included as a part of laboratory work. The Inclusion of a few optional assignments that are intricate and/or beyond the scope of the curriculum will surely be a valuable addition for the students and it will satisfy the intellectuals within the group of learners and will add to the perspective of the learners. For each laboratory assignment, it is essential for students to draw/write/generate flowcharts, algorithms, test cases, mathematical models, Test data sets, and comparative/complexity analysis (as applicable).

Guidelines for Student's Laboratory Journal

Program codes with sample output of all performed assignments are to be submitted as a softcopy. The use of DVDs or similar media containing student programs maintained by the Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journals may be avoided. Submission of journal/ term work in the form of softcopy is desirable and appreciated.

Guidelines for Laboratory/Term Work Assessment

Term work is a continuous assessment that evaluates a student's progress throughout the semester. Term work assessment criteria specify the standards that must be met and the evidence that will be gathered to demonstrate the achievement of course outcomes. Categorical assessment criteria for the term work should establish unambiguous standards of achievement for each course outcome. They should describe what the learner is expected to perform in the laboratories or on the fields to show that the course outcomes have been achieved. It is recommended to conduct an internal monthly practical examination as part of continuous assessment.

Guidelines for Practical Examination

Problem statements must be decided jointly by the internal examiner and external examiner for Elective III and Elective IV courses. **Student has to perform only one practical assignment during external evaluation either for Elective III and Elective IV courses.** During practical assessment, maximum weightage should be given to satisfactory implementation of the problem statement. Relevant questions may be asked at the time of evaluation to test the student's understanding of the fundamentals, effective and efficient implementation. Adhere to these principles will consummate our team efforts to the promising start of student's academics.

Guidelines for Laboratory Conduction

Following is a list of suggested laboratory assignments for reference. Laboratory Instructors may design a suitable set of assignments for respective courses at their level. Beyond curriculum assignments and mini-project may be included as a part of laboratory work. The instructor may set multiple sets of assignments and distribute them among batches of students. It is appreciated if the assignments are based on real-world problems/applications. The Inclusion of a few optional assignments that are intricate and/or beyond the scope of the curriculum will surely be a value addition for the students and it will satisfy the intellectuals within the group of learners and will add to the perspective of the learners. For each laboratory assignment, it is essential for students to draw/write/generate flowcharts, algorithms, test cases, mathematical models, Test data sets, and comparative/complexity analysis (as applicable). Batch size for practical and tutorials may be as per guidelines of authority.

Instructions:
1. Practical can be performed on suitable development platform.
2. Perform any 5 experiments.

Virtual Laboratory

1. https://learn.qiskit.org/course/quantum-hardware/introduction-to-quantum-error-correction-via-the-repetition-code
2. https://quantumcomputinguk.org/tutorials/16-qubit-random-number-generator
3. https://quantumcomputinguk.org/tutorials/quantum-fourier-transform-in-qiskit
4. https://www.sciencedaily.com/releases/2021/02/210212094105.htm
5. https://www.medrxiv.org/content/10.1101/2020.11.07.20227306v1.full

List of Assignments

1. Implementations of 16 Qubit Random Number Generator
2. Tackle Noise with Error Correction
3. Implement Tarrataca's quantum production system with the 3-puzzle problem
4. Implement Quantum Teleportation algorithm in Python
5. The Randomized Benchmarking Protocol
6. Implementing a 5 qubit Quantum Fourier Transform

Learning Resources

Reference Books:

1. Nielsen, M. & Chuang I. "Quantum Computation and Quantum Information", 2002
2. Biamonte, J. et al., "Quantum Machine Learning", Nature, 2017
3. Rieffel, E. G., & Polak, W. H., "Quantum computing: A gentle introduction", MIT Press, 2011
4. Kaye, P., Laflamme, R., & Mosca, M., "An introduction to quantum computing", Rinton Press, 2007
5. Farhi, E., Goldstone, J., & Gutmann, S., "A quantum approximate optimization algorithm", arXiv preprint arXiv:1411.4028, 2014

MOOC Courses:
- https://nptel.ac.in/courses/106106232
- https://www.coursera.org/learn/introduction-to-quantum-information
- https://www.udemy.com/topic/quantum-computing/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	1	-	1	1	1	-	3
CO2	2	2	1	-	3	2	1	1	3	1	2	3

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417526: Computer Laboratory II: Industrial Internet of Things		
Teaching Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme and Marks** **Term Work (TW): 50 Marks** **Practical (PR): 25 Marks**

Prerequisites Courses: Internet of Things Laboratory (217531)

Companion Course: Elective III: Industrial Internet of Things (417523(B))

Course Objectives:
- To explore the needs and fundamental concepts of IIoT
- To elucidate the roles of sensors and protocols in IIoT
- To design and assemble IIOT system for various applications

Course Outcomes:
On completion of the course, learners will be able to–
    CO1: Understand IIoT technologies, architectures, standards, and regulation
    CO2: Build IIOT systems that include hardware and software and be exposed to modern and exciting hardware prototyping platforms
    CO3: Develop real applications and improve them through smart technologies

Instructions:
1. Practical work can be performed on a suitable development platform (Arduino/ Raspberry pi)
2. Perform total 5 experiments.

Virtual Laboratory

1. https://nielit.gov.in/node/12096
2. https://www.fp-lims.com/en/industrial-internet-of-things-iiot-lims/

List of Assignments

1. Write a program for building a small-scale IIoT network using wireless communication protocols

2. Write a program for sending alert messages to the user for controlling and interacting with your environment.

3. Write an Arduino/ Raspberry pi program for interfacing with PIR sensor Experiment

4. Write a Program to design and develop a user interface for monitoring and controlling CPS system

5. Write a program for sending sensor data to the cloud and storing it in a database

6. Write a program for developing an IIoT application for energy monitoring and optimization

7. Write a program for implementing IIoT-enabled robotics and automation solutions

8. Write a program for implementing security measures in an IIoT system

9. Write a program for performing industrial data analysis using relevant tools and techniques

Learning Resources

Text Books:
1. Mahmood, Zaigham, "The Internet of Things in the Industrial Sector", Springer Publication
2. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat, "Industrial Internet of Things: Cyber manufacturing System", Springer Publication
3. Ismail Butun, "Industrial IoT Challenges, Design Principles, Applications, and Security"

Reference Books:
1. R. Anandan, Suseendran Gopalakrishnan, Souvik Pal, Noor Zaman, "Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance", Wiley publication
2. S. Misra, C. Roy, and A. Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press, 2020

e-Books:
1. How Protocol Conversion Addresses IIoT Challenges: White Paper ByRed Lion.
2. https://www.ibm.com/topics/industry-4-0
3. https://www.wevolver.com/article/the-engineer-s-guide-to-industrial-iot-and-industry-4-0

MOOC Courses:
1. https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2. https://www.coursera.org/specializations/developing-industrial-iot#courses
3. https://www.coursera.org/learn/industrial-internet-of-things
4. https://www.coursera.org/learn/internet-of-things-sensing-actuation

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	-	-	-	-	-	-	-	-	2
CO2	2	2	1	2	2	2	-	-	-	-	-	2
CO3	2	2	2	2	-	-	2	-	2	2	-	2

<table>
<tr><td colspan="4">

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417526: Computer Laboratory II: Enterprise Architecture and Components

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</table>

Teaching Scheme: PR: 04 Hours/Week	Credit 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 25 Marks

Companion Course: Elective III: Enterprise Architecture and Components (417523(C))

Course Objectives:
- Describe structure, components, and design of an organizations in EA related to Business and IT
- Select different tools for Enterprise Architecture Framework

Course Outcomes:
On completion of the course, learners will be able to–
  CO1: Design Enterprise Architecture framework using tools
  CO2: Build various reports based on Enterprise Architecture

Instructions:
1. Perform any 5 experiments.

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List of Assignments

</div>

1. Write a short report on planning, securing, and governing the enterprise architecture.

2. Sketch enterprise architecture with emerging technologies such as cloud / IoT / AI / Blockchain.

3. Design and Implement enterprise architecture using TOGAF for banking/healthcare domain.

4. Develop an enterprise architecture using - IDEF, ARIS using Architecture Description Languages like SysML/piADL

5. Design enterprise security architecture using SABSA for Finance / Defense/Agriculture domain.

6. Design and implement an enterprise architecture framework for a hypothetical organization, considering the key components such as business architecture and technology architecture.

7. Design an enterprise information architecture that includes a detailed component model and operational model.

8. Generate a comprehensive report on open source Enterprise Architecture Tools - LeanIX Enterprise Architecture Management, ADOIT EA Suite, UPMX, Avolution ABACUS

<div align="center">

Learning Resources

</div>

Text Books:
1. Philippe Desfray , Gilbert Raymond, Morgan Kaufmann, "Modeling Enterprise Architecture with TOGAF: A Practical Guide Using UML and BPMN", 1st edition, 2014
2. Neal McWhorter, William Ulrich, "Business Architecture: The Art and Practice of Business Transformation", Meghan-Kiffer Press

Reference Books:
1. Daniel Minoli, "Enterprise Architecture A to Z", Auerbach Publications, ISBN: 9781420013702
2. David Marco, Metadata Management for Information Control and Business Success", Wiley, 2013
3. Marc Lankhorst, "Enterprise Architecture at Work Modelling, Communication and Analysis", ISBN: 978-3-662-53933-0

e-Resources:
1. TOGAF: https://www.opengroup.org/architecture/togaf8/downloads.htm
2. SABSA: https://sabsa.org/sabsa-matrices-2018-download-request/
3. https://www.dragon1.com/tutorials/how-to-create-an-enterprise-architecture-framework-diagram
4. https://sparxsystems.com/downloads/whitepapers/enterprise_architecture_framework_design.pdf
5. https://www.udemy.com/course/enterprise-architecture-how-to-design-models-diagrams/
6. https://www.g2.com/categories/enterprise-architecture-tools/free
7. https://edisciplinas.usp.br/pluginfile.php/977101/course/section/268855/Seminar2_ADLs%20and%20Tools.pdf
8. https://www.kau.edu.sa/GetFile.aspx?id=191995&fn=CPIS352_Lect_05w05.pdf
9. https://cs.emis.de/LNI/Proceedings/Proceedings160/309.pdf

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	3	1	-	-	1	1	-	3
CO2	2	2	2	-	1	-	-	-	-	-	-	2

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417526: Computer Laboratory II: Bioinformatics		
Teaching Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme and Marks** **Term Work (TW): 50 Marks** **Practical (PR): 25 Marks**

Prerequisites Courses: Statistics (217528), Artificial Intelligence (310253), Data Science (317529)

Companion Course: Elective III: Bioinformatics (417523(D))

Course Objectives:
- To refer appropriate, suitable datasets
- To study appropriate Bioinformatics tools

Course Outcomes:
On completion of the course, learners will be able to
CO1: Use suitable datasets for various problems
CO2: Demonstrate and apply appropriate Bioinformatics tools

Instructions:
1. Practical can be performed on suitable development platform.
2. Perform total 4 experiments (Group A) and one mini-project (Group B)

List of Assignments

1. Assignment: DNA Sequence Analysis. Task: Analyze a given DNA sequence and perform basic sequence manipulation, including finding motifs, calculating GC content, and identifying coding regions. Deliverable: A report summarizing the analysis results and any insights gained from the sequence.

2. Assignment: RNA-Seq Data Analysis. Task: Analyze a provided RNA-Seq dataset and perform differential gene expression analysis. Deliverable: A detailed report presenting the differentially expressed genes, their functional annotations, and any potential biological interpretations

3. Assignment: Protein Structure Prediction. Task: Predict the 3D structure of a given protein sequence using homology modeling or threading techniques. Deliverable: A report presenting the predicted protein structure, along with an analysis of its potential functions and interactions.

4. Assignment: Molecular Docking and Virtual Screening. Task: Perform molecular docking simulations to predict the binding affinity between a protein target and a small molecule ligand. Additionally, conduct virtual screening to identify potential drug candidates. Deliverable: A report summarizing the docking results, including the binding poses and potential lead compounds.

5. Assignment: Machine Learning for Genomic Data. Task: Apply machine learning algorithms, such as random forests or support vector machines, to classify genomic data based on specific features or markers. Deliverable: A comprehensive analysis report presenting the classification results, model performance evaluation, and insights into the predictive features.

6. Assignment: Agricultural Genomics and Crop Improvement. Task: Analyze genomic data from crops to identify genetic markers associated with desirable traits, such as disease resistance or yield. Deliverable: A research poster summarizing the analysis methodology, key findings, and potential applications in crop improvement.

Learning Resources

Text Books:
1. S.C. Rastogi et. al., "Bioinformatics- Concepts, Skills, and Applications", 2nd edition, CBS Publishing, 2016, ISBN: 9788123914824
2. Cynthia Gibas and Per Jambeck, "Developing Bioinformatics Computer Skills", O'Reilly press, Shorff Publishers and Distributors Pvt. Ltd., 2001

Reference Books:
1. Jean-Michel Claverie and Cedric Notredame, "Bioinformatics – A Beginners Guide" , Wiley – Dreamtech India Pvt. Ltd., 2003
2. Zoe'Lacroix and critchlow, "Bioinformatics: Managing scientific data", Morgan Kaufmann Publishers, 2004
3. Campbell AM and Heyer LJ, "Discovering Genomics, Proteomics and Bioinformatics", Pearson Education, 2003

e-Books:
1. http://www.bioinformatics.org/
2. http://www.bioinfo.mbb.yale.edu/mbb452a/intro/

MOOC Courses:
1. https://archive.nptel.ac.in/courses/102/106/102106065/
2. https://www.udemy.com/course/genetics-and-next-generation-sequencing-forbioinformatics/

<table>
<tr><th colspan="13">The CO-PO Mapping Matrix</th></tr>
<tr><th>CO/ PO</th><th>PO1</th><th>PO2</th><th>PO3</th><th>PO4</th><th>PO5</th><th>PO6</th><th>PO7</th><th>PO8</th><th>PO9</th><th>PO10</th><th>PO11</th><th>PO12</th></tr>
<tr><td>CO1</td><td>3</td><td>2</td><td>1</td><td>3</td><td>3</td><td>2</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>-</td></tr>
<tr><td>CO2</td><td>3</td><td>2</td><td>1</td><td>3</td><td>3</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>1</td><td>-</td></tr>
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Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417526: Computer Laboratory II: GPU Programming and Architecture		
Teaching Scheme: PR: 04 Hours/Week	Credit 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 25 Marks

Prerequisites Courses: OOP and Computer Graphics Lab. (217523)

Companion Course: Elective IV: GPU Programming and Architecture (417524(A))

Course Objectives:
- To learn the fundamentals of GPU Computing in the CUDA environment.
- To understand and implement parallel searching algorithms.
- To understand and implement parallel sorting algorithms

Course Outcomes:
After completion of the course, learners will be able to-
  CO1: Analyze and measure performance of sequential and parallel algorithms.
  CO2: Design and Implement solutions for multicore/parallel environment.
  CO3: Identify and apply the suitable algorithms to solve real life problems

Instructions:
1. Practical can be performed on suitable development platform.
2. Perform any 5 experiments.

List of Assignments

1. Write a CUDA program for dot product and calculation of pi using integration method

2. Write a CUDA program for Addition of two large vectors

3. Write a CUDA program for matrix transpose and matrix multiplication

4. Write a program using OpenCL to display "Hello World"

5. Write a program using OpenCL for Heterogeneous computing

6. Develop a program using combining abilities of OpenGL and CUDA to accelerate the performance of simple graphics.

Learning Resources

Text Books:
1. Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, "Introduction toParallel Computing", 2nd edition, Addison-Wesley, 2003, ISBN: 0-201-64865-2
2. Aaftab Munshi, Benedict R. Gaster, Timothy G. Mattson, James Fung, Dan Ginsburg "OpenCL Programming Guide", Addison-Wesley, 2011, ISBN: 9780132488006
3. John Cheng, Max Grossman, and Ty McKercher, "Professional CUDA C Programming", John Wiley & Sons, Inc., ISBN: 978-1-118-73932-7

Reference Books:
1. Seyed H. Roosta, "Parallel Processing and Parallel Algorithms Theory and Computation", Springer-Verlag 2000, ISBN 978-1-4612-7048-5
2. Jason Sanders, Edward Kandrot, "CUDA by Example: An Introduction to General Purpose GPU Programming", Addison – Wesley, 2010
3. David R. Kaeli, Perhaad Mistry, Dana Schaa, Dong Ping Zhang, "Heterogeneous computing with OpenCL", 3rd edition, Morgan Kauffman, 2015

e-Books:
1. https://edoras.sdsu.edu/~mthomas/docs/cuda/cuda_by_example.book.pdf
2. https://www.cs.utexas.edu/~rossbach/cs380p/papers/cuda-programming.pdf
3. https://www.syncfusion.com/succinctly-free-ebooks/confirmation/cuda
4. https://ptgmedia.pearsoncmg.com/images/9780321749642/samplepages/0321749642.pdf

MOOC Courses:
1. https://onlinecourses.nptel.ac.in/noc20_cs41/preview
2. https://www.coursera.org/specializations/gpu-programming
3. https://www.udemy.com/course/cuda-gpu-programming-beginner-to-advanced/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	1	-	2	1	-	-	-	-	-
CO2	1	2	1	-	-	1	-	-	-	-	-	1
CO3	-	1	3	3	2	2	-	-	-	-	-	1

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **417526: Computer Laboratory II: Information Retrieval**		
Teaching Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme and Marks** **Term Work (TW): 50 Marks** **Practical (PR): 25 Marks**

Companion Course: Elective IV: Information Retrieval (417524(B))

Course Objectives:
- Understand the concepts of information retrieval and web mining
- Understand information retrieval process using standards available tools

Course Outcomes:
    CO1: Apply various tools and techniques for information retrieval and web mining
    CO2: Evaluate and analyze retrieved information

Instructions:
Perform any 5 assignments.

List of Assignments

1. Write a program for pre-processing of a text document such as stop word removal, stemming.

2. Implement a program for retrieval of documents using inverted files.

3. Write a program to construct a Bayesian network considering medical data. Use this model to demonstrate the diagnosis of heart patients using the standard Heart Disease Data Set (You can use Java/Python ML library classes/API.

4. Implement e-mail spam filtering using text classification algorithm with appropriate dataset.

5. Implement Agglomerative hierarchical clustering algorithm using appropriate dataset.

6. Implement Page Rank Algorithm. (Use python or beautiful soup for implementation).

7. Build the web crawler to pull product information and links from an e-commerce website.

Learning Resources

Text Books:
1. C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval", Cambridge University Press, 2008
2. Ricardo Baeza-Yates, Berthier Riberio–Neto, "Modern Information Retrieval", Pearson Education, ISBN: 81-297-0274-6
3. C.J. Rijsbergen, "Information Retrieval", 2nd edition, ISBN: 978-408709293
4. Ryan Mitchell, "Web Scraping with Python", O'reilly

Reference Books:
1. S. Buttcher, C. Clarke and G. Cormack, "Information Retrieval: Implementing and Evaluating Search Engines" MIT Press, 2010, ISBN: 0-408-70929-4
2. Amy N. Langville and Carl D. Meyer, "Google's PageRank and Beyond: The Science of Search Engine Rankings", Princeton University Press, ISBN: 9781400830329

e-Books:
1. http://nlp-iiith.vlabs.ac.in/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	3	2	-	-	-	-	-	-	1
CO2	1	1	2	3	2	-	-	-	-	-	-	1

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417526: Computer Laboratory II: UI /UX Design		
Teaching Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme and Marks** **Term Work (TW): 50 Marks** **Practical (PR): 25 Marks**

Prerequisites Courses: Human Computer Interface (310245(B))

Companion Course: Elective IV: User Experience Design (417524(C))

Course Objectives:
- To study various tools of UI/UX Design
- To develop skills in creating visually appealing and cohesive user interfaces.
- To learn to conduct usability testing and evaluation
- To understand the role of prototyping in the design process
- To study collaborative features of UI/ UX Tool
- To gain awareness of ethical considerations in UI/UX design

Course Outcomes:

On completion of the course, learners will be able to–
   CO1: Apply user-centered design methodologies
   CO2: Create effective user interfaces / user experiences
   CO3: Develop proficiency in design tools
   CO4: Design for multiple platforms and devices
   CO5: Conduct usability testing and analysis
   CO6: Develop a portfolio of UI/UX design projects

Instructions:
1. Practical can be performed on suitable development platform.
2. Perform any 5 experiments.

List of Assignments

Group A

1. Design user persona for the users of selected product / system.
    II.   How To Create A User Persona (Video Guide) - YouTube
    III. How to Create A User Persona in 2022 [FULL GUIDE] - YouTube

2. Online Learning Platform: Design a wireframe for an online learning platform that includes course listings, video lectures, quizzes, and progress tracking.
    I.   E-learning Website Design in Figma - YouTube

3. Designing a Social Fitness App: Create wireframes and a prototype for a social fitness app that allows users to track workouts, connect with friends, and share progress.
Design the user interface for logging exercises, setting goals, and incorporating social features.
    I.   Fitness App Design In Figma || Figma Tutorial || Design & Prototyping - YouTube

4. Product Packaging Mockup: Choose a product and create a mockup of its packaging design. Use a mockup tool that specializes in packaging design or graphic design. Design the product packaging, including the layout, colors, logos, and product visuals.Showcase the packaging design from different angles and perspectives.

    I.   Poster or Flyer Mockup: Select a specific event, campaign, or promotional material. Design a poster or flyer using a graphic design tool with mockup capabilities. Create a visually appealing mockup of the poster or flyer in different sizes and formats. Showcase the design within a realistic environment or context, such as a wall or display.

5. Use Figma tool to Design a user interface for a recipe finder application, allowing users to search for recipes based on ingredients, categories, and dietary restrictions. Include features like recipe details, cooking instructions, and saving favorites.

    I.   Create a Food & Drink Recipe app with reviews from Figma no code - YouTube

6. Use Figma tool for Improving the User Interface of a Fitness Tracking App: Improve the user interface of an existing fitness tracking app by focusing on simplicity, clarity, and motivational elements. Enhance features like tracking workouts, setting goals, and visualizing progress to create a more engaging and intuitive experience.

    I.   Figma Fitness mobile app Design | design a Fitness app in Figma | UIUX Design 2021 | Techno-fine - YouTube

7. Collaborative Design Exercise:
Form a design team and work on a collaborative design project using Figma. Assign different design tasks to team members, such as wireframing, visual design, or prototyping.Utilize Figma's collaboration features to work together in real-time.Coordinate and provide feedback to each other to refine and improve the design.
Create Teams in Figma & Real-Time Collaboration in Figma for Designers - YouTube

8. Usability Testing Simulation: Develop a high-fidelity interactive prototype using any UI/UX tool. Prepare a usability testing plan, recruit participants, and simulate usability testing sessions. Analyze the feedback and iterate on the design based on the insights gathered during the testing.
Usability Testing in UX Design Thinking Process - YouTube

Learning Resources

Text Books:
1. Creative Tim,"Fundamentals of Creating a Great UI/UX", 1st Edition
2. Jon Yablonski, "Laws of UX: Using Psychology to Design Better Products & Services" , O'REILLY Publication
3. Jenifer Tidwell, Charles Brewer, Aynne Valencia "Designing Interfaces: Patterns for
4. Effective Interaction Design", O'REILLY Publication

Reference Books:
1. Shneiderman, Plaisant, Cohen, Jacobs, "Designing the User Interface-Strategies for Effective Human Computer Interaction", 5th edition, PEARSON Publication
2. Wilbert O. Galitz "The Essential Guide to User Interface Design", 2nd Edition, WILEY Publication
3. Alan Dix, Janet Finlay, Gregory D. Abowd, Russell Beale, "Human–Computer Interaction, 3rdEdition,
4. Alan Coopen, "The essentials of interaction"

MOOC Courses:
1. Uset Interface Design: https://onlinecourses.nptel.ac.in/noc21_ar05/preview

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417526: Computer Laboratory II: Optimization Algorithms

Teaching Scheme: PR: 04 Hours/Week	Credit 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 25 Marks

Companion Course: Elective IV: Optimization Algorithms (417524(D))

Course Objectives:
- Understand different optimization techniques
- To make an effective use of optimization techniques in real time problem solving
- Analyze the performance of the algorithm

Course Outcomes:
On completion of the course, learners will be able to–
CO1: Model different optimization techniques and analyze the performances of an algorithm developed/used
CO2: Improving the efficiency of an algorithm through feature selection
CO3: Tuning the parameters of an algorithm for better throughput

Instructions:
1. Practical can be performed on suitable development platform.
2. Perform any 9 assignments (from 1 to 11: 8th and 9th is compulsory) and one mini project

Virtual Laboratory

1. https://nielit.gov.in/node/12096

List of Assignments

Group A

1. A mechanical industry has three warehouses in the Solapur area and needs to deliver camshafts to its three shops in and around for tomorrow. The three shops demand 10, 20, and 40 units respectively. The current stock level of shafts in the three warehouses are 80, 62, and 32 respectively. Delivery costs from each warehouse to each store are different due to different distances. Find the least expensive way to deliver the chairs to the stores. The delivery cost matrix is represented below. Use Linear Programming to write a program in python.

	Shop 1	Shop 2	Shop 3
Warehouse 1	3000/-	2000/-	5000/-
Warehouse 2	2000/-	7000/-	3000/-
Warehouse 3	2200/-	2400/-	1000/-

2. Write a python program to maximize the function $f(x) = 2x_1 + 3x_2 - x^2_1\blacksquare + x_2{}^2$ with constraints $x_1 + x_2 <= 3$ and $2x_1 + 3x_2 <= 4$ find out the values of x_1 and x_2 such a that it maximizes the given objective function $f(x)$ using Quadratic Programming

3. A linear equation of the form $aX_1 + bX_2 + cX_3 + dX_4 = T$ is to be solved with the help of Genetic Algorithms applying Initialize population, Fitness Evaluation, Reproduction, Crossover and Mutation. Find out the approximate values of the coefficients a, b, c and d with python programming

4. There is a dataset **D** over R^{mXn} , supplied to the machine learning algorithm for classification purposes. We are cautious about the selection of the attributes for training and testing the model. Use Particle Swarm Optimization for feature section and show that the performance of a classification algorithm is improved over the use of PSO.

5. A Binary Particle Swarm Optimization algorithm to be applied on a dataset **D** for selection of the features to be used for training a binary class classifier. Mine the performance of the classifier when Binary PSO is applied.

6. Mini Project: Design and develop a mini project for classification of images into different categories using CNN along with Particle Swarm Optimization/Firefly/Binary PSO. The group of students developing this application need to use different datasets. Priority must be given for self-data creation, publishing and using it in this project.

Learning Resources

Text Books:
1. Andreas Antoniou and Wu-Sheng Lu, "Practical optimization Algorithms and Engineering Applications", Springer
2. Xin-She Yang, "Nature-Inspired Optimization Algorithms", Elsevier Publication
3. Rajesh Kumar Arora, "Optimization Algorithms and Applications" CRC Press Taylor & Francis Group
4. Nature-Inspired Optimization Algorithms- A Vasuki by CRC Press

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	2	2	1	-	-	-	-	-	-	1
CO2	1	2	2	2	2	-	-	-	-	-	-	1
CO3	1	2	2	1	1	-	-	-	-	-	-	1

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417527: Project Stage I		
Teaching Scheme: **PR: 04 Hours/Week**	**Credit** **02**	**Examination Scheme:** **Term Work: 50 Marks** **Presentation: 50Marks**

Course Objectives:
- To Apply the knowledge for solving realistic problem
- To develop problem solving ability
- To Organize, sustain and report on a substantial piece of team work over a period of several months
- To Evaluate alternative approaches, and justify the use of selected tools and methods
- To Reflect upon the experience gained and lessons learned
- To Consider relevant social, ethical and legal issues
- To find information for yourself from appropriate sources such as manuals, books, research journalsand from other sources, and in turn increase analytical skills
- To Work in team and learn professionalism

Course Outcomes:
On completion of the course, student will be able to–
    CO1: Solve real life problems by applying knowledge
    CO2: Analyze alternative approaches, apply and use most appropriate one for feasible solution
    CO3: Write precise reports and technical documents in a nutshell
    CO4: Participate effectively in multi-disciplinary and heterogeneous teams exhibiting team work
    CO5: Inter-personal relationships, conflict management and leadership quality

Guidelines

Project work Stage – I is an integral part of the Project work. In this, the student shall complete the partial work of the Project which will consist of problem statement, literature review, SRS, Model and Design. The student is expected to complete the project at least up to the design phase. As a part of the progress report of project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertainingto the selected project topic. The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute. The examinee will be assessed by a panel of examiners of which one is necessarily an external examiner. The assessment will be broadly based on work undergone, content delivery, presentation skills, documentation, question-answers and report.

Follow guidelines and formats as mentioned in Project Workbook recommended by Board of Studies

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **417528: MOOC**		
Teaching Scheme: **TUT: 02 Hours/Week**	**Credit** **02**	**Examination Scheme:** **Term Work: 50 Marks**

Course Objectives:
- To promote interactive user forums to support community interactions among students, professors, and experts
- To promote learn additional skills anytime and anywhere
- To enhance teaching and learning on campus and online

Course Outcomes:

After completion of the course, learners should be able to-

    CO1: To acquire additional knowledge and skill

    CO2: Explore new areas of interest in a relevant field

Course Contents

MOOCs (Massive Open Online Courses) provide affordable and flexible ways to learn new skills, pursue lifelong interests and deliver quality educational experiences at scale. Whether you're interested in learning for yourself, advancing your career or leveraging online courses to educate your workforce, SWAYAM, NPTEL, edx or similar ones can help. World's largest SWAYAM MOOCs, a new paradigm of education for anyone, anywhere, anytime, as per your convenience, aimed to provide digital education free of cost and to facilitate hosting of all the interactive courses prepared by the best more than 1000 specially chosen faculty and teachers in the country. SWAYAM MOOCs enhance active learning for improving lifelong learning skills by providing easy access to global resources. SWAYAM is a programme initiated by the Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. This is done through an indigenous developed IT platform that facilitates hosting of all the courses, taught in classrooms from 9th class till post-graduation to be accessed by anyone, anywhere at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to the residents in India. More than 1,000 specially chosen faculty and teachers from across the Country have participated in preparing these courses. The courses hosted on SWAYAM are generally in 4 quadrants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multimedia and state of the art pedagogy / technology. In order to ensure best quality content is produced and delivered, seven National Coordinators have been appointed: They are NPTEL for engineering and UGC for post-graduation education. Guidelines: Instructors are requested to promote students to opt for courses (not opted earlier) with proper mentoring. The departments will take care of providing necessary infrastructural and facilities for the learners. Learning can also be more interesting by knowledge sharing through different blogs, learning communities and social media platforms.

References:
1. https://swayam.gov.in/
2. https://onlinecourses.nptel.ac.in/
3. https://www.edx.org
4. https://www.mygreatlearning.com/academy
5. https://www.simplilearn.com

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417529: Audit Course 7

In addition to credits, it is recommended that there should be audit course, in preferably in each semester starting from second year in order to supplement students' knowledge and skills. Studentwill be awarded the bachelor's degree if he/she earns specified total credit and clears all the audit courses specified in the curriculum. The student will be awarded grade as AP on successful completion of audit course. The student may opt for one of the audit courses per semester, starting in second year first semester. Though not mandatory, such a selection of the audit courses helps the learner to explore the subject of interest in greater detail resulting in achieving the very objective of audit course's inclusion. List of options offered is provided. Each student has to choose one audit
course from the list per semester. Evaluation of audit course will be done at Institute level itself. Method of conduction and method of assessment for audit courses are suggested.

Criteria
The student registered for audit course shall be awarded the grade AP (Audit Course Pass) and shall be included such AP grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory performance and secured a passing grade in that audit course. No grade points are associated with this _AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at Institute level itself.

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations or presentations
- Surveys
- Mini-Project
- Hands on experience on focused topic

Course Guidelines for Assessment (Any one or more of following but not limited to):
- Written Test
- Demonstrations/ Practical Test
- Presentation or Report

Audit Course 7 Options

Audit CourseCode	Audit Course Title
AC7-I	Block Chain
AC7-II	Entrepreneurship Development
AC7-III	Botnet of Things
AC7-IV	Foreign Language
AC7-V	MOOC-Learn New Skills

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417529: Audit Course 7
AC7-I: Block Chain

Course Objectives:

- Imparting knowledge of block chain methods and being able to deliver the topics in a systematic and straightforward manner
- To get knowledgeable about emerging currencies and to develop one's own crypto token or NFTGram

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Able to know how to use current currencies in the market
CO2: Analyze the applications for block chains in a structured way
CO3: Comprehensively elucidate contemporary block chain technology principles

Course Contents

1. **Introduction to Block chain:** Distributed DBMS – Limitations of Distributed DBMS, Introduction to Block chain – History, Definition, Distributed Ledger, Blockchain Categories – Public, Private, Consortium, Blockchain Network and Nodes, Peer-to-Peer Network, Mining Mechanism, Generic elements of Blockchain, Features of Blockchain, and Types of Blockchain.
2. **Block Chain Architecture:** Operation of Bitcoin Blockchain, Blockchain Architecture – Block, Hash, Distributer P2P, Structure of Blockchain- Consensus mechanism: Proof of Work (PoW), Proof of Stake (PoS).
3. **Cryptography Algorithms:** Introduction to cryptography-Encryption and Decryption-Ciphers-Cryptography using arithmetic modulo primes-hashing algorithms-SHA-256 algorithm-Application of SHA algorithm.
4. **Cryptocurrency and Etherium:** Building Your Own Cryptocurrency- Compiling Bitcoin from source- New cryptocurrency – Readercoin: Cloning Bitcoin, Readercoin rebranding-Peer-to-Peer Auctions in Ethereum: Introduction to Ethereum.

Case Study
Blockchain in Supply Chain
Blockchain in Manufacturing
Blockchain in Automobiles
Blockchain in Healthcare
Blockchain in Cyber security
Blockchain in Financial Industry

Blockchain with IOT: Create two Ether accounts and perform transactions using Metamask Wallet and analyze the gas consumption.

Blockchain with AI: Deployment of Cryptocurrencies & Predictions using AI

Text Books:
1. Narayanan, Bonneau, Felten, Miller and Goldfeder, "Bitcoin and Cryptocurrency Technologies – A Comprehensive Introduction", Princeton University Press
2. Josh Thompson, "Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming", Create Space Independent Publishing Platform, 2017
3. Imran Bashir, "Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained", Packt Publishing

References:
1. Merunas Grincalaitis, "Mastering Ethereum: Implement Advanced Blockchain Applications Using Ethereum-supported Tools, Services, and Protocols", Packt Publishing

MOOC Courses:
1. Prof. Sandip Chakraborty, Dr. Praveen Jayachandran, "Blockchain Architecture Design and Use Cases" [MOOC], NPTEL: https://nptel.ac.in/courses/106/105/106105184/
2. Udemy course: Blockchain - Complete Blockchain Course for Beginners

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417529: Audit Course 7
AC7-II: Entrepreneurship Development

Course Objectives:

- Develop Entrepreneurial Thinking: Foster an entrepreneurial mindset among students, enabling them to think creatively, identify opportunities, and embrace calculated risk-taking
- Understand Business Planning: Equip students with the knowledge and skills to develop comprehensive business plans and create value propositions
- Foster Innovation and Product Development: Cultivate students' ability to apply innovation principles, navigate the product development lifecycle, and continuously improve their products or services
- Develop Leadership and Management Skills: Enhance students' leadership capabilities by focusing on effective communication, team building, decision-making, and problem-solving skills necessary for leading and managing a startup

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Develop an understanding of startup eco system and entrepreneurial mindset and its significance in the economy

CO2: Create a comprehensive business plan by conducting market research, defining target markets, and designing a value proposition

CO3: Evaluate different funding sources and develop financial management skills necessary for startup success

CO4: Formulate effective marketing strategies and sales techniques to target specific customer segments

CO5: Develop leadership and management skills necessary for leading teams and making informed decisions

CO6: Apply innovation and product development concepts to create and refine products or services

Course Contents

1. Introduction to Entrepreneurship:

Understanding the entrepreneurial mindset, Importance of entrepreneurship in the economy, identifying opportunities and generating ideas, Exploring different types of entrepreneurship (social, tech, etc.)

Case study: *Expert session from Industry, academia and integrate college incubation center activities in collaboration with SPPU incubation center*

2. Introduction to Entrepreneurship:

Understanding the entrepreneurial mindset, Importance of entrepreneurship in the economy, identifying opportunities and generating ideas, Exploring different types of entrepreneurship (social, tech, etc.)

Case study: *Expert session from Industry, academia and integrate college incubation center activities in collaboration with SPPU incubation center*

3. Introduction to Entrepreneurship:

Understanding the entrepreneurial mindset, Importance of entrepreneurship in the economy, identifying opportunities and generating ideas, Exploring different types of entrepreneurship (social, tech, etc.)

Case study: *Expert session from Industry, academia and integrate college incubation center activities in collaboration with SPPU incubation center*

4. **Business Planning:**

Developing a business plan, conducting market research and analysis, defining target market and positioning, understanding competitive landscape, Creating a value proposition and revenue model. **Case study:** Expert session from Alumni and incubator

5. **Funding and Finance:**

Identifying different funding sources (bootstrapping, angel investors, venture capital, crowdfunding), Financial management and budgeting, Valuation and equity distribution, Managing cash flow and financial projections

link : https://msme.gov.in/incubation

6. **Marketing and Sales:**

Developing a marketing strategy, Branding and positioning, Market segmentation and targeting, Digital marketing and social media strategies, Sales techniques and customer acquisition

7. **Innovation and Product Development:**

Design thinking and idea generation, Product development lifecycle, Minimum Viable Product (MVP) concept, User experience and usability testing, Iterative development and continuous improvement. **Case study** *of AI Chatbot application.*

8. **Leadership and Management:**

Leadership styles and traits, Effective communication and negotiation, Team building and motivation, Decision-making and problem-solving, managing conflicts and embracing diversity

link: https://www.startupindia.gov.in/content/sih/en/ams-application/incubator-program.html?applicationId=5f06b1dde4b0f2b258378ee9

References:

1. Eric Ries, "The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses"
2. Alexander Osterwalder and Yves Pigneur, "Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers"
3. by Steve Blank and Bob Dorf, "The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company"

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **417529: Audit Course 7** **AC7-III: Botnet of Things**

Course Objectives:

- To Understand the various IoT Protocols
- To Understand the IoT Reference Architecture and Real-World Design Constraints
- To learn the concept of Botnet

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Implement security as a culture and show mistakes that make applications vulnerable to attacks

CO2: Understand various attacks like DoS, buffer overflow, web specific, database specific, web - spoofing attacks

CO3: Demonstrate skills needed to deal with common programming errors that lead to most security problems and to learn how to develop secure applications

<div align="center">

Course Contents
</div>

1. **Introduction:** Internet Relay Chat (IRC),DorkBot,RageBot, Phorpiex, and IRCBot.HI.
2. **IRC-Based Bot Networks:** Anatomy of a Botnet, Packet sniffer, Keylogger, Polymorphic code, Rootkit installer, Information harvest, SMTP Client Spam, HTTP client Click Fraud, Remote Buffer Overflow.
3. Anatomy of a Botnet: The Gaobot Worm
4. **IoT Sensors and Security:** Sensors and actuators in IoT, Communication and networking in IoT, Real-time data collection in IoT, Data analytics in IoT , IoT applications and requirements, Security threats and techniques in IoT, Data trustworthiness and privacy in IoT, Balancing utility and other design goals in IoT , Future of Botnets in the Internet of Things, Thingbots, Elements of Typical IRC Bot Attack , Malicious use of Bots and Botnet
5. **Service Layer Protocols and Security:** Security: PHP Exploits, Cross-Site Scripting and Other Browser-Side Exploits, Bots and Botnets, Service Layer -oneM2M, ETSI M2M, OMA, BBF –Security in IoT Protocols –MAC 802.15.4 , 6LoWPAN, RPL, Application Layer Transport and Session layer protocols- transport Layer (TCP, MPTCP, UDP, DCCP, SCTP) - (TLS, DTLS) – Session Layer - HTTP, CoAP, XMPP, AMQP, MQTT

Text Books:

1. Bernd Scholz - Reiter, Florian Michahelles, "Architecting the Internet of Things", Springer ISBN 978 – 3 – 642 – 19156 - 5 e - ISBN 978-3-642-19157-2
2. Frank Swiderski and Window Snyder, "Threat Modeling", Microsoft Professional, 1st edition, 2004

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures • Visits (Social/Field) and reports • Demonstrations	• Surveys • Mini-Project • Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **417529: Audit Course 7** **AC7-IV: Foreign Language**

Course Objectives:

- Get introduced to the Culture, Routine of the Foreign Society through language
- Meet the needs of ever growing foreign industry with respect to language support

Course Outcomes:

After completion of the course, learners-

CO1: Will have the ability of basic communication
CO2: Will have the knowledge of Language script
CO3: Will get introduced to reading, writing and listening skills
CO4: Will develop interest to pursue profession in Foreign Industry

Course Contents

Instructions:

All course contents should be completed in only one language (German, French, Japanese and any other suitable foreign language)

1. **Introduction to the Foreign Language:** Introduction of Alphabets, Spell the names, Addresses, Numbers, Telephone numbers, OrdinalNumbers, Pin code Numbers, Dates, Birthdates, Age, days of the week, Months.
2. **Communication Part 1:** Basic Greetings, Personal Pronouns, Possessive Pronouns.
3. **Communication Part 2:** Self-Introduction, Introducing other people, about family, friends, course mates, seasons, and seasons in Other countries and in neighboring countries.

Text Books:

1. The Everything Learning German Book: Speak, write, and understand basic German in no time (Everything®) Kindle Edition with Audio/Video by Edward Swick (Author)
2. NETZWERK Deutsch als Fremdsprache A1(Goyal, New Delhi, 2015)
3. Japanese from Zero!, Book 1 by George Trombley, Yukari Takenaka

References:

1. Best Books for Learning French By David Issokson
2. Easy Spanish Step-By-Step By Barbara Bregstain

MOOC Courses:

1. https://onlinecourses.nptel.ac.in/noc21_hs30/preview
2. https://nptel.ac.in/courses/109106166
3. https://nptel.ac.in/courses/109106085

e-Resources:

1. https://www.coursera.org/browse/language-learning
2. https://alison.com/?utm_source=google&utm_medium=cpc&utm_campaign=PPC_Tier-4_First-Click_Courses-_Broad_&utm_adgroup=Product_Courses&gclid=CjwKCAjwhdWkBhBZEiwA1ibLmIZPl30Tg6Zd7UDPSU2vcB2J1doDOAi9SnBCElqJWK2_Hhdfo2iCSRoCGwkQAvD_BwE
3. FACTS ABOUT GERMANY   https://www.tatsachen-ueber-deutschland.de/en
4. ONLINE GERMAN-ENGLISH DICTIONARY www.leo.org
5. PRACTICE MATERIAL https://www.goethe.de/en/spr/kup/prf/prf/sd1/ueb.html

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **417529: Audit Course 7** **AC7-V: MOOC-Learn New Skills**

Course Objectives:

- To promote interactive user forums to support community interactions among students, professors, and experts
- To promote learn additional skills anytime and anywhere
- To enhance teaching and learning on campus and online

Course Outcomes:

After completion of the course, learners should be able to-
   CO1: To acquire additional knowledge and skill
   CO2: Explore new areas of interest in a relevant field

<div align="center">

Course Contents

</div>

MOOCs (Massive Open Online Courses) provide affordable and flexible ways to learn new skills, pursue lifelong interests and deliver quality educational experiences at scale. Whether you're interested in learning for yourself, advancing your career or leveraging online courses to educate your workforce, SWAYAM, NPTEL, edx or similar ones can help. World's largest SWAYAM MOOCs, a new paradigm of education for anyone, anywhere, anytime, as per your convenience, aimed to provide digital education free of cost and to facilitate hosting of all the interactive courses prepared by the best more than 1000 specially chosen faculty and teachers in the country. SWAYAM MOOCs enhance active learning for improving lifelong learning skills by providing easy access to global resources. SWAYAM is a programme initiated by the Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. This is done through an indigenous developed IT platform that facilitates hosting of all the courses, taught in classrooms from 9th class till post-graduation to be accessed by anyone, anywhere at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to the residents in India. More than 1,000 specially chosen faculty and teachers from across the Country have participated in preparing these courses. The courses hosted on SWAYAM are generally in 4 quadrants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multimedia and state of the art pedagogy / technology. In order to ensure best quality content is produced and delivered, seven National Coordinators have been appointed: They are NPTEL for engineering and UGC for post-graduation education. Guidelines: Instructors are requested to promote students to opt for courses (not opted earlier) with proper mentoring. The departments will take care of providing necessary infrastructural and facilities for the learners. Learning can also be more interesting by knowledge sharing through different blogs, learning communities and social media platforms.

References:

1. https://swayam.gov.in/
2. https://onlinecourses.nptel.ac.in/
3. https://www.edx.org
4. https://www.mygreatlearning.com/academy
5. https://www.simplilearn.com

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Semester VIII

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417530: Computational Intelligence

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Artificial Neural Network (317531), Artificial Intelligence (310253)

Companion Course: Computer Laboratory III (417533)

Course Objectives:

- To provide students with a comprehensive understanding of the fundamental concepts, theories, and techniques in the field of computational intelligence
- To understand, explain, and apply the fuzzy set and fuzzy logic in real life applications
- To familiarize with various evolutionary algorithms and optimization techniques inspired by natural evolution processes
- To understand the principles, techniques, and applications of genetic algorithms
- To apply computational intelligence techniques to solve complex NLP problems
- To introduce the concepts inspired by the human immune system and their application in problem-solving and optimization

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand Computational Intelligence techniques to solve real-life problems

CO2: Apply fuzzy logic techniques to solve real life problems

CO3: Design and implement evolutionary algorithms to solve optimization problem

CO4: Analyze and evaluate the performance of genetic algorithms in terms of convergence and computational efficiency

CO5: Interpret and analyze the results obtained from computational intelligence models in NLP, providing meaningful insights and recommendations

CO6: Design and Develop Artificial Immune System to solve complex problems

Course Contents

Unit I	Introduction To Computational Intelligence	06 Hours

Introduction to Computational Intelligence, Paradigms of Computational Intelligence, Difference between Artificial Intelligence and Computational Intelligence, Approaches to Computational Intelligence, Synergies of Computational Intelligence Techniques, Applications of Computational Intelligence, Grand Challenges of Computational Intelligence

#Exemplar/Case Studies	Study of Intelligent Waste Classification System using Computational Intelligence
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Fuzzy Logic	06 Hours

Introduction to Fuzzy Set- Introduction, definition, membership Function, Fuzzy operator, Fuzzy Set Characteristics, Fuzziness and Probability.
Fuzzy Logic and Reasoning–Fuzzy Logic: Linguistics Variables and Hedges, Fuzzy Rules.
 Fuzzy Inferencing: neuro inferencing Fuzzification, Defuzzification
Fuzzy logic Controllers: Fuzzy logic Controllers, Fuzzy logic Controller Types

#Exemplar/Case Studies	Study of Object Detection Robot Using Fuzzy Logic Controller
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Evolutionary Computing	06 Hours

Introduction, Evolutionary Computing, Terminologies of Evolutionary Computing, Genetic Operators, Evolutionary Algorithms: - Genetic Algorithm, Evolution Strategies, Evolutionary Programming, Genetic Programming, Performance Measures of EA, Evolutionary Computation versus Classical Optimization.
Advanced Topics: Constraint Handling, Multi-objective Optimization, Dynamic Environments
Swarm Intelligence: Ant Colony Optimization

#Exemplar/Case Studies	Study of Engineering application of Artificial humming bird algorithm
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Genetic Algorithm	06 Hours

Introduction to Basic Terminologies in Genetic Algorithm: Individuals, Population, Search space, Genes, Fitness function, Chromosome, Trait, Allele, Genotype and Phenotype.
GA Requirements and representation- Binary Representations, Floating-Point Representations
Operators in Genetic Algorithm: Initialization, Selection, Crossover (Recombination), Mutation; fitness score, Stopping Condition, reproduction for GA Flow, Constraints in Genetic Algorithms.
Genetic Algorithm Variants: Canonical Genetic Algorithm (Holland Classifier System), Messy Genetic Algorithms, Applications, and benefits of Genetic Algorithms**.**

#Exemplar/Case Studies	Use Genetic Algorithm to design a solution to the Traveling Salesman Problem. **Solution**:1. Use Permutation Encoding 2. DefineObjective Function. 3. Apply Selection Method 4. Crossover 5. Mutation 6. Repeat Until stopping criteria is met. 7.Stop
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Computational Intelligence and NLP	06 Hours

Introduction, Word embedding Techniques-Bag of Words, TF-IDF,Word2Vec, Glove, Neural word embedding, Neural Machine Translation, Seq2Seq and Neural Machine Translation, translation Metrics (BLEU Score & BERT Score) , Traditional Versus Neural Metrics for Machine Translation Evaluation, Neural Style Transfer, Pertained NLP BERT Model and its application

#Exemplar/Case Studies	1) Study of Patient Triage using ChatGPT which can be utilized by physicians for expedited diagnoses. 2) Study of Question Answering System with BERT
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Artificial Immune Systems	06 Hours

Natural Immune System, Artificial Immune Models, Artificial Immune System Algorithm, Classical View Models, Clonal Selection Theory Model, Network Theory Model, Danger Theory Model, Dendritic cell Model, Applications of AIS models

#Exemplar/Case Studies	Study of an artificial immune system with bootstrap sampling for the diagnosis of recurrent endometrial cancers

*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Andreis P. Engelbrecht, "Computational Intelligence an introduction", 2nd edition, Wiley publication
2. Nazmul Siddique, Hojjat Adeli, "Computational Intelligence, Synergies of Fuzzy logic, Neural Networks and Evolutionary computing", Wiley publication
3. S. Rajasekaran, G. A. Vijayalakshami, "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications", PHI, 2007

Reference Books:
1. Seyedali Mirjalili, "Evolutionary Algorithms and Neural Networks Theory and Applications, Studies in Computational Intelligence", Vol 780, Springer, 2019,
2. Sitendra Tamrakar, Shruti Bhargava Choubey, Abhishek Choubey, "Computational Intelligence in Medical Decision Making and Diagnosis Techniques and Applications", CRC Press, 2023
3. Melanie Mitchell, "An Introduction to Genetic Algorithms," MIT Press, 2000
4. James M. Keller, Derong Liu, David B. Fogel, "Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation", John Wiley & Sons, 2016
5. Sudharsan Ravichandiran, "Getting Started with Google BERT, Build and train state-of-the-art natural language processing models using BERT", Packt Publishing, 2021, ISBN 9781838826239
6. Mitchell Melanie, "An Introduction to Genetic Algorithms", The MIT Press Cambridge, Massachusetts, MIT Press paperback edition, 1998
7. Xin-She Yang, "Nature-Inspired Metaheuristic Algorithms", 2nd edition, University of Cambridge, United KingdomLuniver Press

MOOC Courses:
1. Fuzzy Sets, Logic and Systems & Applications, IIT Kanpur: https://nptel.ac.in/courses/108104157
2. Fuzzy Logic and Neural Networks: https://youtu.be/xwUKQcT1bKc
3. Evolutionary Computation for Single and Multi-Objective Optimization: https://onlinecourses.nptel.ac.in/noc21_me43/preview
4. Traditional and Non-Traditional Optimization Tools, IIT Kharagpur: https://nptel.ac.in/courses/112105235
5. Introduction to Soft Computing, IIT Kharagpur: https://nptel.ac.in/courses/106105173
6. Applied Natural Language Processing, Chennai Mathematical Institute: https://nptel.ac.in/courses/106106211

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	-	-	-	-	-	-	-	-
CO2	3	2	2	2	1	-	-	-	-	-	-	-
CO3	2	2	3	2	-	-	-	-	-	-	-	-
CO4	2	3	3	2	-	-	-	-	-	-	-	-
CO5	2	2	2	2	1	1	-	-	-	1	-	1
CO6	2	2	3	2	1	1	-	-	-	-	-	1

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417531: Distributed Computing

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Computer Network (317521), Data Science (317529)

Companion Course: Computer Laboratory III (417533)

Course Objectives:

- To understand the fundamentals and knowledge of the architectures of distributed systems
- To gain knowledge of working components and fault tolerance of distributed systems
- To make students aware about security issues and protection mechanisms for distributed environments

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the features and properties of Distributed computing system with integration of AI

CO2: Analyze the Concept of data management and storage in distributed computing

CO3: Understand the algorithm used in distributed computing by applying artificial intelligence

CO4: Understand the integration of machine learning algorithm and advanced tools used in distributed computing

CO5: Analyze how big data is processed in distributed computing

CO6: Identify Security and privacy issues of distributed computing and apply on specific application

Course Contents

Unit I	Introduction to Distributed Computing	06 Hours

Fundamentals of distributed computing: Characteristics of Distributed Systems: Issues, Goals, and Types of distributed systems, Distributed System Models

Introduction to Artificial Intelligence and Data Science in distributed computing:
Distributing computational tasks, handling large volumes of data, and leveraging parallel processing capabilities, issues related to data storage and retrieval, data consistency, communication overhead, synchronization, and fault tolerance.

Use cases and applications of integrating AI and data science in distributed systems:
Predictive Maintenance, Fraud Detection, Intelligent Transportation Systems, Supply Chain Optimization, Energy Management, Healthcare and Medical Diagnostics, Customer Behavior Analysis and Natural Language Processing (NLP)

#Exemplar/Case Studies	Introduction to Distributed Computing in E-commerce
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Distributed Data Management and Storage	06 Hours

Overview of Distributed Computing Frameworks and Technologies
Parallel Computing, Distributed Computing Models, Message Passing, Distributed File Systems: Hadoop Distributed File System (HDFS) and Google File System (GFS), Cluster Computing: (AWS), Microsoft Azure, and Google Cloud Platform (GCP), Message Brokers and Stream Processing, Edge Computing

Data Replication and Consistency Model: Eager Replication, Lazy Replication, Quorum-Based Replication, Consensus-Based Replication, Selective Replication, Strong Consistency, Eventual Consistency, Read-your-writes Consistency, Consistent Prefix Consistency, Causal Consistency

Distributed data indexing and retrieval techniques: Distributed Hash Tables (DHTs), Distributed Inverted Indexing, Range-based Partitioning, Content-based Indexing, Peer-to-Peer (P2P) Indexing, Hybrid Approaches

#Exemplar/Case Studies	Distributed Data Management and Storage in Healthcare
*Mapping of Course Outcomes for Unit II	CO2

Unit III	**Distributed Computing Algorithms**	**06 Hours**

Distributed Computing Algorithms: Communication and coordination in distributed systems
Distributed consensus algorithms (Other consensus algorithms ● Viewstamped Replication ● RAFT ● ZAB ● Mencius ● Many variants of Paxos (Fast Paxos, Egalitarian Paxos etc)
Fault tolerance and recovery in distributed systems,

Load balancing and resource allocation strategies: Weighted Round Robin, Least Connection, Randomized Load Balancing, Dynamic Load Balancing, Centralized Load Balancing, Distributed Load Balancing, Predictive Load Balancing

Applying AI techniques to optimize distributed computing algorithms: Machine Learning for Resource Allocation, Reinforcement Learning for Dynamic Load Balancing, Genetic Algorithms for Task Scheduling, Swarm Intelligence for Distributed Optimization

#Exemplar/Case Studies	Distributed Computing Algorithms in Weather Prediction
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	**Distributed Machine Learning and AI**	**06 Hours**

Introduction to distributed machine learning algorithms: Types of Distributed Machine Learning: Data Parallelism and Model Parallelism, Distributed Gradient Descent, Federated Learning, All-Reduce, Hogwild, Elastic Averaging SGD

Software to implement Distributed ML: Spark, GraphLab, Google TensorFlow, Parallel ML System (Formerly Petuum), Systems and Architectures for Distributed Machine Learning

Integration of AI algorithms in distributed systems: Intelligent Resource Management, Anomaly Detection and Fault Tolerance, Predictive Analytics, Intelligent Task Offloading

#Exemplar/Case Studies	Distributed Machine Learning and AI in Fraud Detection
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	**Big Data Processing in Distributed Systems**	**06 Hours**

Big data processing frameworks in distributed computing: Hadoop, Apache Spark, Apache Storm, Samza, Flink

Parallel and distributed data processing techniques: Single Instruction Single Data (SISD), Multiple Instruction Single Data (MISD), Single Instruction Multiple Data (SIMD), Multiple Instruction Multiple Data (MIMD), Single program multiple data (SPMD), Massively parallel processing (MPP)

Scalable data ingestion: types of data ingestion, Benefits, challenges, tools, transformation in distributed systems

Real-time analytics and Streaming analytics: types of real time analytics, types of streaming analytics, Comparison of real time analytics and streaming analytics, Applying AI and data science for large-scale data processing and analytics.

#Exemplar/Case Studies	Big Data Processing in Distributed Systems for Social Media Analytics
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Distributed Systems Security and Privacy	06 Hours

Security Challenges in Distributed Systems, Insider Threats, Encryption and Secure Communication: TLS/SSL, PKI, VPN, AMQP, Privacy Preservation Techniques: Differential Privacy, Homomorphic Encryption, Secure Multi-Party Computation (SMPC), Federated Learning, Anonymization and Pseudonymization, Access Control and Data Minimization, AI-based Intrusion Detection and Threat Mitigation Techniques: Anomaly Detection, Behavior-based Detection, Threat Intelligence and Analysis, Real-time Response and Mitigation, Adaptive Security, User and Entity Behavior Analytics (UEBA), Threat Hunting and Visualization.

#Exemplar/Case Studies	Distributed Systems Security and Privacy in Healthcare
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Sigeru Omatu, Qutaibah M. Malluhi, Sara Rodríguez Gonzalez, Grzegorz Bocewicz, Edgardo Bucciarelli, Gianfranco Giulioni, Farkhund Iqba, "Distributed Computing and Artificial Intelligence", 12th International Conference: 373 (Advances in Intelligent Systems and Computing) Paperback
2. George Coulouris, J Dollimore and Tim Kindberg, "Distributed Systems, Concepts and Design", Pearson Education, 5th edition
3. Andrew S.Tanenbaum, Maarten Van Steen, "Distributed Systems, Principles and paradigms", 2nd edition, PHI
4. Michael Huhns, "Distributed Artificial Intelligence" Volume I 1st edition, 1987

Reference Books:

1. Pradeep K. Sinha, "Distributed Operating System", PHI
2. Tanenbaum S., "Distributed Operating Systems", Pearson Education
3. Sikumar Ghosh, "Distributed Systems, An Algorithm Approach", Chapman & Hall/CRC, Taylor & Francis Group, 2007.
4. Ajay D. Kshemkalyani, Mukesh Singhal, "Distributed Computing: Principles, Algorithms, and Systems"

MOOC Courses:
1. NPTEL: https://archive.nptel.ac.in/courses/106/106/106106168/
2. Distributed Computing with Spark SQL | Coursera
3. Distributed Systems for Practitioners | Educative

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	1	-	-	-	-	-	-	1	-
CO2	1	-	1	2	-	-	-	-	-	-	-	-
CO3	-	-	1	1	-	-	-	-	-	-	1	-
CO4	2	-	2	1	1	-	-	-	-	-	1	-
CO5	1	-	1	2	2	-	-	-	-	-	-	-
CO6	1	-	2	2	3	-	-	-	-	-	1	-

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<table>
<tr><td colspan="3" align="center">Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective V 417532(A): Virtual Reality and Game Development</td></tr>
<tr><td>Teaching Scheme:
TH: 03 Hours/Week</td><td align="center">Credit
03</td><td>Examination Scheme:
In-Sem (Paper): 30 Marks
End-Sem (Paper): 70 Marks</td></tr>
</table>

Prerequisites Courses: Data Science (317529), Artificial Neural Network (317531)

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

- To introduce the fundamentals of Virtual Reality
- To understand VR systems and development tools
- To acquaint with the tools like blender, unreal which are required to develop virtual reality concept
- To understand the game development process with content creation strategies and production techniques
- To enable students to continue their studies in the areas of virtual reality, gaming and artificial intelligence

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Review the basics of virtual reality and its applications

CO2: Explore the many levels at which the user interacts with a virtual world using the medium of virtual reality

CO3: Recognize the human aspects in Virtual Reality & it's tools

CO4: Design a game prototype

CO5: Utilize Blender's modeling tools to create and manipulate the objects

CO6: Describe about the methods used in VR and AI game development

Course Contents

Unit I	Introduction	06 Hours

Introduction to virtual reality- Definition of VR, modern experiences, historical perspective
Human psychology and Perception. How virtual reality really works
Geometry of virtual worlds: -Geometric modeling, transforming rigid bodies, yaw, pitch, roll, axis-angle representation, quaternions
Virtual Reality: -Applications, Limitations, Challenges

#Exemplar/Case Studies	Osso VR: surgical training & assessment platform
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Virtual reality system	06 Hours

Input Devices: - Trackers, Navigation, and gesture interface,
Output Devices: -Graphics, three - dimensional sound and haptic display, CAVE and HMD VR systems **Rendering the Virtual World** - Rendering systems - Interaction, Graphical rendering, ray tracing, shading
Motion in Real and Virtual Worlds: -Velocities, acceleration, vestibular system, virtual world physics, collision detection, avatar motion

#Exemplar/Case Studies	Oculus Quest - All in one device
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Human Factors in VR & Tools	06 Hours

Human factors: Introduction, the eye, the ear, the somatic senses, human Vision, **Methodology and Terminology:** Data Collection and Analysis, Usability Engineering Methodology.
Human Factors in VR Evaluations: Testbed Evaluation of Universal VR Tasks, Influence of System Responsiveness on User Performance, Influence of Feedback Multimodality,
VR Health, and Safety Issues, Direct Effects of VR Simulations on User, VR in social aspects
VR Tools: Introduction to Unity, Blender, MAYA, Amazon Sumerian, Google VR, 3ds Max, Unreal

#Exemplar/Case Studies	Study of Unity tools
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Game Design & Prototyping	08 Hours

Introduction to gaming: History of Video games, Gaming Platforms and Player Modes, Ludology, Common Frameworks for Ludology – MDA; Formal, Dramatic, and Dynamic Elements; Elemental Tetrad, Designer centric & Player centric design goals, Game Genres, Player motivations
Story & Character development, Guiding the Player, Creating gaming experience Level Design: Structure, Time, Space **Game Testing**: Why Playtest? Circles of Play testers, Methods of Playtesting

#Exemplar/Case Studies	Study of Puzzle Design and Puzzle Examples in Action Games
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Gaming VR with Blender	08 Hours

Introduction to Blender's interface and Modelling: Selecting, transforming, and adjusting the objects in 2D, Texturing and Shading 2D images in Blender, performing object modifiers, Working with blend files
Performing 3D Animation on blender: - Introduction to 3D modelling basics, 3d View in Blender, The Concept of Timeline and Keyframes

#Exemplar/Case Studies	Prepare a case study on how VR is helping to solve the challenges in construction site. Write a case study on how to understand the working of computer using VR.
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	VR & AI in Gaming	06 Hours

VR in game: -Features of VR game, Problems with VR game, Impact of artificial intelligence on VR game,
Introduction to AI in Game: - Game AI Model, Solving problems by searching algorithms heuristic & non heuristic methods, optimal path finding using AI

#Exemplar/Case Studies	Navigation Mesh & Path finding game

*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Burdea, G. C., P. Coffet., "Virtual Reality Technology", 2nd edition, Wiley-IEEE Press, 2006
2. Jeannie Novak, "Game Development Essentials", 3rd edition, Cengage Learning
3. James Chronister, "Blender Basics Classroom Tutorial Book", 5th edition

Reference Books:
1. Jeremy Gibson Bond, "Introduction to Game Design, Prototyping, and Development - From Concept to Playable Game with Unity and C#", 2nd edition, Pearson Publication
2. Jesse Schell, "The Art of Game Designing - A Book of Lenses", Morgan Kaufmann Publishers
3. Lance Flavell, "Beginning Blender: Open Source 3D Modeling, Animation, and Game Design"
4. Steven M. LaValle, "Virtual Reality", Cambridge University Press, 2016
5. Millington, Ian, "Artificial Intelligence for Games", 3rd edition, CRC Press, 2019
6. Stuart J. Russell, Peter Norvig, "Artificial Intelligence A Modern Approach", Pearson, Education, 2003

e-Resources:
1. https://nptel.ac.in/courses/106/106/106106138/
2. https://www.coursera.org/learn/introduction-virtual-reality
3. https://www.udemy.com/course/virtual-reality-game-development/
4. https://docs.idew.org/video-game/
5. https://gamecodeschool.com/essentials-tutorials/
6. https://github.com/Kavex/GameDev-Resources
7. https://www.blender.org/support/tutorials/

MOOC Courses:
1. Introduction to Game Development: https://www.codecademy.com/learn/introduction-to-game-development
2. Introduction to Game Design: https://www.coursera.org/learn/game-design
3. Certificate Course in Augmented & Virtual Reality: https://futureskillsprime.in/course/certificate-course-in-augmented-%26-virtual-reality

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	-	1	-	-	-	-	-	2
CO2	3	1	-	-	1	-	-	-	-	-	-	2
CO3	3	3	3	2	3	3	-	2	-	-	-	2
CO4	3	3	3	2	-	-	-	-	-	-	-	2
CO5	3	2	3	1	3	-	-	-	-	-	-	3
CO6	3	2	3	2	-	-	-	-	-	-	-	2

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective V 417532(B): Big Data Analytics

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Artificial Intelligence (310253), Data Science (317529)

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

- To introduce students to basic concepts, terms, applications of big data
- To apprehend Advanced Analytical Methods in Data Science
- To acquaint with the tools like Hadoop, NoSQL, MapReduce which are required to manage and analyze big data
- To program various issues related to Industry standards using Big Data Analytics
- To visualize Big Data using different tools

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Apply the techniques to handle missing data for real world applications.

CO2: Exemplify Analytical Methods like Clustering and Association Rule for Big Data Analytics

CO3: Use the novel architectures and platforms introduced for Big data, in particular Hadoop and Map Reduce

CO4: Differentiate the advanced predictive analytics algorithms in various applications like Retail, Finance, Healthcare

CO5: Evaluate needs, challenges, and techniques for big data visualization

CO6: Design various applications and simulate the analytics tools

Course Contents		
Unit I	**Unit Introduction to Big Data and Analytics**	**06 Hours**

Introduction to Big Data: Characteristics – Evolution – Definition - Challenges with Big Data, Traditional Business Intelligence versus Big Data. State of Practice in Analytics, Key roles for New Big Data Ecosystems.

Big Data Analytics: Introduction & importance of Analytics, Classification of Analytics – Challenges - Big Data Analytics, Big Data Technologies (Apache Hadoop, Rapid miner, Looker), Soft state eventual consistency.

#Exemplar/Case Studies	Study on big data business models like Walmart, Netflix, Uber
*Mapping of Course Outcomes for Unit I	CO1, CO3

Unit II	**Basic Data Analytic Methods**	**06 Hours**

Need of Big Data Analytics

Advanced Analytical Theory and Methods:

Clustering- Overview, K means- Use cases, Overview of methods, determining number of clusters, diagnostics, reasons to choose and cautions.

Association Rules- Overview, a-priori algorithm, evaluation of candidate rules, case study- transactions in grocery store, validation and testing, diagnostics.

Regression- linear, logistics, reasons to choose and cautions, additional regression models.

#Exemplar/Case Studies	K means clustering- Food Delivery Case Study/Customer Data Segmentation Association Rule - Super Market Analysis
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Predictive Analysis Process and R	06 Hours

Introduction to R: R graphical User Interfaces, Data import and Export, Dirty Data, Data Analysis, Linear regression with R, clustering with R hypothesis testing, Data cleaning and validation tools: MapReduce

Data Analytics Lifecycle: Discovery, Data Preparation, Model Planning, Model Building, communicate results, Operationalize, Building a Predictive model.

#Exemplar/Case Studies	Case study on how data analytics stacks work and the factors influencing their performance
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Advanced Predictive Analytics Algorithms and Python	06 Hours

Introduction of Exploratory Data Analytics (EDA) -Definition, Motivation, Steps in data exploration, data types.

Techniques to Improve Classification Accuracy: Introducing Ensemble Methods, Bagging, Boosting and AdaBoost, Random Forest.

Model Evaluation and Selection - Confusion Matrix, Dataset Partitioning Methods-Holdout Method and Random Subsampling, Cross Validation.

#Exemplar/Case Studies	Case Study on Big Data Analytics in Healthcare Domain - How Big Data is transforming the healthcare industry?
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Big Data Visualization	06 Hours

Introduction to Data Visualization: Objective and challenges to Big data visualization, Conventional data visualization tools, techniques for visual data representation, types of data visualization, Tools used in data visualization, Open – source data visualization tools, Analytical techniques used in Big data visualization, Data Visualization using Tableau

Introduction to: Candela, D3.js, Google Chart API

#Exemplar/Case Studies	Analysis of a business problem of online delivery system using visualization
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Big Data Analytics Applications and Tools	06 Hours

Big Data Analytics Applications: Retail Analytics, Financial Data Analytics, Healthcare Analytics, Supply chain management

Types of Big Data Analytics tools: Data Collection Tools-Semantria tool, AS Sentiment Analysis tool, Data Storage tools and frameworks: Apache HBase, CouchDB, Data filtering and extraction tool: Scraper, Mozenda,

Comparison of Various Tools

#Exemplar/Case Studies	Customer Case Study using Big Data Analytics Tool

*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Wiley CIO, Michael Minelli, Michele Chambers, Ambiga Dhiraj, John Wiley & Sons, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", 2012
2. EMC Education Services, "Data Science and Big Data Analytics-Discovering, analyzing Visualizing and Presenting Data", 1st edition
3. Han, Jiawei Kamber, Micheline Pei and Jian, "Data Mining: Concepts and Techniques", Elsevier Publishers, ISBN:9780123814791, 9780123814807

Reference Books:

1. Manovich, Lev., "Trending: The Promises and the Challenges of Big Social Data. Debates in the Digital Humanities", The University of Minnesota Press, 2012
2. Raj, Pethuru, "Handbook of Research on Cloud Infrastructures for Big Data Analytics", IGI Global, 2014
3. Wajid Khattak, Paul Buhler, Thomas Erl, "Big Data Fundamentals: Concepts, Drivers & Techniques", John Wiley & Sons, ISBN: 13: 9780134291079

e-Resources:

1. https://files.eric.ed.gov/fulltext/ED536788.pdf
2. https://www.iare.ac.in/sites/default/files/NEW%20LECHURE%20NOTES.pdf
3. https://mrcet.com/downloads/digital_notes/CSE/IV%20Year/(R17A0528%20)%20Big%20Data%20Analytics%20Digital%20notes.pdf
4. https://content.e-bookshelf.de/media/reading/L-11307411-11b3dd5f67.pdf

MOOC Courses:

1. Big Data Computing: https://onlinecourses.nptel.ac.in/noc20_cs92/preview
2. Applied Optimization For Wireless, Machine Learning, Big Data: https://onlinecourses.nptel.ac.in/noc23_ee99/preview
3. Big Data Computing by NPTEL: https://www.shiksha.com/online-courses/big-data-computing-by-nptel-course-nptel33

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	-	-	-	-	-	-	1
CO2	2	2	1	2	1	-	-	1	-	-	1	1
CO3	3	2	1	1	-	-	1	1	1	-	-	-
CO4	1	1	2	2	-	-	-	-	-	1	-	1
CO5	1	3	2	-	2	1	-	-	-	1	1	-
CO6	1	2	3	-	2	1	1	-	1	-	1	1

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective V 417532(C): Software Development for Portable Devices

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Object Oriented Programming, Computer Network

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

- To introduce the fundamentals of software development for portable devices
- To understand android application architecture, its components, device discovery and communication in portable devices
- To acquaint with the use of various hardware sensors (location etc.) and software services (e.g., notifications) on android devices
- To understand the GoogleFit platform for portable devices
- To enable students to continue their studies in the real-world application and future use of portable devices

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Differentiate types of portable devices and sensor fundamentals

CO2: Design and develop a software application for device discovery and communication in portable devices

CO3: Design and develop application using different sensors and services on portable devices

CO4: Design applications in Android wear OS

CO5: Utilize application development GoogleFit platform for portable devices and Database

CO6: Identify the role of portable devices in real world application

Course Contents

Unit I	Introduction	06 Hours

Introduction: Introduction to software development for portable devices, types of Portable Devices, hardware & software for Portable Devices, Applications of Portable Devices, Sensor Fundamentals: Types of sensors (Motion, Position, Environmental), Components of the sensor framework, applications of sensors, Features of Portable Devices, Mobile App development Challenges, Android tooling support

#Exemplar/Case Studies	Study of different sensors with their applications
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Android Device Discovery and Communication	06 Hours

Android: An Open Platform for Mobile Development, Android SDK Features, Android Software Stack, Android Application Architecture, Types of Android Applications, Android development tools.

Creating Applications and Activities: Manifest Editor, Android Application Lifecycle, Android Creating Activities, Activity Lifecycle, Android Activity Classes, Introducing Fragment, Introducing Intents.

Android Interconnectivity: Advertisement and Discovery, Bluetooth: Remote Device Discovery, Bluetooth Communications, Wi-Fi: Monitoring Wi-Fi Connectivity, Active Wi-Fi Connection, Transferring Data Using Wi-Fi, Transferring Data Between Peers. Near Field Communication: NFC Tags, Android Beam.

#Exemplar/Case Studies	https://developer.android.com/training/cars , https://developer.android.com/training/tv/start Example: Smartphone Bluetooth App to Control LED Lights
*Mapping of Course Outcomes for Unit II	CO2

Unit III	MAPS Location based Services, Audio, Video and Camera	06 Hours

Using Location-Based Services: - Using Location-Based Services, Using the Emulator with Location-Based Services, Selecting a Location Provide, Using Proximity Alert ,Using the Geocoder , Example: Map-based activity

Hardware Support and Devices (AUDIO, VIDEO, AND USING THE CAMERA): -Using Sensors and the Sensor Manager, Monitoring a Device's Movement and Orientation, Introducing the Environmental Sensors, Playing Audio and Video, Using Audio Effects, Using the Camera, Recording Video

#Exemplar/Case Studies	Example: Map-based activity
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Android Wear OS	06 Hours

Android Wear platform: Android Wear OS, Wear Devices and wear API, Android notifications and android wear, (Android 5.0 Lollipop notification), Google now and Android wear.

Android Wear Devices: Android SDK Wear Platform updates, Procuring an Android Wear device, Using Android Emulator with Wear AVD, Pairing and Enabling Developer Mode, Unboxing your Wear device, Pairing your Handheld device with your Wear device

Wear Debugging and Android SDK: Wear Debugging and Android SDK via Bluetooth and USB.

Android wear API: Google Services and Google play services, Android Wear Network, Android Wear API (Node Interface, DataEvent, MessagEvent)

#Exemplar/Case Studies	https://wearos.google.com, https://developer.android.com/training/wearables
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Google Fit Platform and API, Databases and Content Providers	06 Hours

Google Fit Platform Overview; Google Fit Core Concepts: Fit Data Types, Fit Data Store (Storage), Sensors; Permissions, User Consent: Permission Groups, Fitness Scopes; Google Fit: Developer Responsibilities: Developer Terms and Conditions, Developer Branding Guidelines; Procuring Sensor Peripherals; Hello Fit: hands-on example

Google Fit API: Google fit main package, Fitness class, FitnessActivities class, FitnessStatusCodes class, BleApi interface, SensorsApi, RecordingApi, SessionsApi, HistoryApi, ConfigApi

Databases and Content Providers: Introducing Android Databases, Introducing SQLite, Content Values and Cursors, Working with SQLite Databases, Creating Content Providers, Using Content Providers

#Exemplar/Case Studies	1. The Fitness Tracker App using Google Fit API. 2. Adding Search to Your Application 3. Native Android Content Providers
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	**Real World Application and Future of Portable Devices**	**06 Hours**

Wearable Technology: Wearable Computer, Smartphone and Variety of wearable devices

Real world Application of Portable Devices: Handheld Application, Home Automation, Home Entertainment, Gaming, Wearable at workplace

Fitness, Health and Medical: Predictive and Proactive Consumer Health, Wearable for Medical Professional, Wearable and remote medical diagnostics

Industrial Manufacturing and Safety, Civic, Governance and Democracy

#Exemplar/Case Studies	Portable Devices: Market Estimates and Forecasts, Android Things
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:
1. Varun Nagpal, "Android Sensor Programming By Example", Packt Publishing, 2016, ISBN: 978-1-78528-550-9
2. Reto Meier, "Professional Android 4 Application Development", WROX Press, Wiley Publishing, 2012, ISBN: 978-1-118-10227-5
3. Sanjay M. Mishra, "Wearable Android: Android Wear and Google FIT App Development", John Wiley & Sons, 2015, ISBN: 9781119050865

Reference Books:
1. Rick Rogers, John Lombardo, Zigurd Mednieks, Blake Meike, SPD, "Android Application Development, Programming with the Google SDK", Oreilly, ISBN: 13:978-81-8404-733-2
2. Ed Burnette, "Hello Android, Introducing Google's Mobile Development Platform", 3rd edition, Pragmatic Programmers, LLC, ISBN-10: 1-934356-56-5

MOOC Courses:
1. https://www.youtube.com/watch?v=-foyVzTOf8o&list=PLJ5C_6qdAvBEJ6TBzKoa1Ov21lwDzJfM
2. https://archive.nptel.ac.in/courses/106/106/106106156/#

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	2	2	2	1	2	-	-	-	-	-	-	-
CO2	2	2	3	1	2	-	-	-	-	-	2	1
CO3	2	2	2	1	2	-	-	-	-	1	2	1
CO4	2	2	2	1	3	-	-	-	-	1	2	1
CO5	2	2	2	1	3	-	-	-	-	1	2	1
CO6	2	2	2	1	1	-	-	-	-	-	-	3

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective V 417532(D): Deep Learning

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Machine Learning (417521)

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

- To understand the basics of neural networks
- Comparing different deep learning models
- To understand the Recurrent and Recursive nets in Deep Learning
- To understand the basics of deep reinforcement learning models
- To analyze Types of Networks
- To Describe Reinforcement Learning

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the basics of Deep Learning and apply the tools to implement deep learning applications

CO2: Evaluate the performance of deep learning models

CO3: Implement the technique of Convolution neural network (CNN)

CO4: Solve the language translation problem by Recurrent neural network (RNN)

CO5: Construct new data by deep generative models

CO6: Apply on-policy reinforcement learning algorithms

Course Contents

Unit I	Foundations of Deep learning	06 Hours

What is machine learning and deep learning? History of deep learning, Advantage and challenges of deep learning. Learning representations from data , Understanding how deep learning works in three figures(input, hidden layer, output), Common Architectural Principles of Deep Network, Architecture Design, Applications of Deep learning, Hyperparameters : Learning Rate, Regularization, Momentum, Sparsity, Hidden Units, cost functions, error back propagation, Gradient-Based Learning, Implementing Gradient Descent, vanishing and Exploding gradient descent, Optimization algorithm(SGD, AdaGrad, RMSProp, adam).

#Exemplar/Case Studies	Deep Mind, AlphaGo, Boston Dynamics, Amazon go store
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Deep Neural Networks (DNNs)	06 Hours

Introduction to Neural Networks :The Biological Neuron, The Perceptron(AND,OR,NOT,XOR), Deep forward network, Multilayer Feed-Forward Networks , **Training Neural Networks** :Backpropagation and Forward propagation **Activation Functions** :Linear ,Sigmoid, Tannh, Hard Tanh, Softmax, Rectified Linear, **Loss Functions** :Loss Function Notation , Loss Functions for Regression , Loss Functions for Classification, Loss Functions for Reconstruction.

#Exemplar/Case Studies	A Case Study for Music Genre Classification

*Mapping of Course Outcomes for Unit II	CO2

Unit III	**Convolution Neural Network (CNN)**	**06 Hours**

Introduction, CNN architecture overview, The Basic Structure of a Convolutional Network- Padding, Strides, Typical Settings, the ReLU layer, Pooling, Fully Connected Layers, The Interleaving between Layers, Local Response Normalization, Training a Convolutional Network

#Exemplar/Case Studies	AlexNet, VGG
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	**Recurrent Neural Network (RNN)**	**06 Hours**

Recurrent and Recursive Nets: Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory.
Practical Methodology: Performance Metrics, Default Baseline Models, Determining Whether to Gather More Data, Selecting Hyper parameters.

#Exemplar/Case Studies	Multi-Digit Number Recognition, Google, bing, DuckDuckGo
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	**Deep Generative Models**	**08 Hours**

Introduction to deep generative model, Boltzmann Machine, Deep Belief Networks, Generative adversarial network (GAN), discriminator network, generator network, types of GAN, Applications of GAN networks

#Exemplar/Case Studies	GAN for detection of real or fake images, chatGPT
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	**Reinforcement Learning**	**06 Hours**

Introduction of deep reinforcement learning, Markov Decision Process, basic framework of reinforcement learning, challenges of reinforcement learning, Dynamic programming algorithms for reinforcement learning, Q Learning and Deep Q-Networks, Deep Q recurrent networks, Simple reinforcement learning for Tic-Tac-Toe.

#Exemplar/Case Studies	Self driving cars, Deep learning for chatbots
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Goodfellow, I., Bengio, Y., Courville, A, "Deep Learning", MIT Press, 2016
2. Josh Patterson & Adam Gibson, "Deep Learning"
3. Charu Agarwal, "Neural Networks and deep learning"
4. Nikhil Buduma, "Fundamentals of Deep Learning", SPD
5. Francois chollet, "Deep Learning with Python"

Reference Books:
1. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction"
2. SethWeidman, "Deep Learning from Scratch: Building with Python from First Principles" O'Reily
3. Francois Duval, "Deep Learning for Beginners, Practical Guide with Python and Tensorflow"

e-Resources:
1. http://csis.pace.edu/ctappert/cs855-18fall/DeepLearningPractitionersApproach.pdf
2. https://www.dkriesel.com/_media/science/neuronalenetze-en-zeta2-1col-dkrieselcom.pdf

MOOC Courses:
1. Deep Learning- Part 1, IIT Madras: https://nptel.ac.in/courses/106106184
2. Deep Learning Specialization: https://www.coursera.org/specializations/deep-learning

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	-	-	-	-	2
CO2	3	2	2	2	2	-	-	-	-	-	-	1
CO3	3	2	2	2	2	-	-	-	-	-	-	1
CO4	2	2	2	2	2	-	-	-	-	-	-	1
CO5	2	2	3	2	2	-	-	-	-	-	-	1
CO6	2	2	2	2	2	-	-	-	-	-	-	1

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective VI 417533(A): Augmented Reality

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Programming and Problem-Solving, Artificial Intelligence &Machine Learning

Companion Course: Computer Laboratory IV (417534)

Course Objectives:
- To introduce the importance of augmented reality and its need
- To create awareness of augmented reality and its application for society
- Visual Perception is used to develop the future of Business and Industry

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the working of AR systems and list the applications of AR

CO2: Understand and analyze the hardware requirement of AR

CO3: Use computer vision concepts for AR and describe AR techniques

CO4: Analyze and understand the working of various state-of-the-art AR devices

CO5: Identify the working of various AR components and AR devices

CO6: Prediction of AR business applications

Course Contents

Unit I	Introduction to Augmented Reality	06 Hours

Introduction to Augmented Reality: Defining augmented reality, history of augmented reality, Augmented reality as an emerging technology, The Relationship between Augmented Reality and Other Technologies-Media, Technologies, Comparative study of AR, VR, and Mixed Reality, Other Ideas Related to the Spectrum between Real and Virtual Worlds, applications of Augmented reality, **Augmented Reality Concepts-** Working of Augmented Reality? Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

#Exemplar/Case Studies	Augmented Reality simulation system application in a Healthcare
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Component & Hardware Device in Augmented Reality	06 Hours

Augmented Reality Hardware – Displays – Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model.
Processors – Role of Processors, Processor System Architecture, Processor Specifications.
Tracking &Sensors - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, and Sensor Fusion. Types of AR devices.

#Exemplar/Case Studies	Study the design of an AR application with C# and Unity
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Computer Vision and Augmented Reality	06 Hours

Computer Vision for Augmented Reality -Computer Vision for Augmented Reality - Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, and Outdoor Tracking.

Augmented Reality Software - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application.

#Exemplar/Case Studies	Study all the available AR toolkits.
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Augmented Reality Techniques	06 Hours

Augmented Reality Techniques- Marker-based, Marker-less, Location-based, types of markers, marker camera pose, and identification, visual tracking, mathematical representation of matrix multiplication

Marker-Based AR Example, Marker types- Template markers, 2D barcode markers, imperceptible markers

Marker-less approach- Localization-based augmentation, real-world examples

Tracking methods- Visual tracking, feature-based tracking, hybrid tracking, initialization and recovery, Augmented Reality System, Threats of Augmented Reality

#Exemplar/Case Studies	Study on enhancement and improving markers with Vuforia engine
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Augmented Reality Components and Devices	06 Hours

Augmented Reality Components – Scene Generator, Tracking system, monitoring system, display, and Game scene

AR Devices – Optical See-Through HMD, Virtual retinal systems, monitor bases systems, Projection displays, Video see-through systems

#Exemplar/Case Studies	Case study on generating a scene using AR components
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Unit Augmented Reality Tools and its Applications	06 Hours

Tools available for Augmented Reality and Recognition, Software Tools, Google Poly, Unity, software approaches, recognition types, and native software solutions

ARKit, ARCore – software development kit - Cloud services

AR business applications – weather prediction, market prediction, smart cities

AR application for the healthcare sector, Education, Agriculture, Civil Engineering, Architecture, Archaeology, Crime and Security, Games, and IoT

#Exemplar/Case Studies	Case study on generating a scene using AR components
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Allan Fowler, "AR Game Development", 1st edition, A press Publications, 2018, ISBN: 978-1484236178
2. Schmalstieg / Hollerer, "Augmented Reality: Principles & Practice", 1st edition, Pearson Education India, 2016, ISBN: 10: 9332578494

Reference Books:
1. Kharis O'Connell, "Designing for Mixed Reality', O'Reilly Media, Inc., 2016, ISBN: 9781491962381
2. Sanni Siltanen, "Theory and applications of marker-based augmented reality" Julkaisija – Utgivare Publisher, 2012, ISBN: 978-951-38-7449-0

e-Resources:
1. https://www.vttresearch.com/sites/default/files/pdf/science/2012/S3.pdf
2. https://docs.microsoft.com/en-us/windows/mixed-reality/
3. https://docs.microsoft.com/en-us/archive/msdn-magazine/2016/november/hololens-introduction-to-the-hololens

MOOC Courses:
1. Introduction to Augmented Reality and ARCore: https://www.coursera.org/learn/ar
2. Master Computer Vision™ OpenCV4 in Python with Deep Learning: https://www.udemy.com/share/101XPi/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	2	-	-	-	-	-	1
CO2	3	2	1	-	-	1	-	-	-	-	1	1
CO3	3	2	2	-	1	2	-	-	-	-	1	1
CO4	3	2	2	-	2	-	-	-	-	-	-	3
CO5	3	3	2	1	2	-	-	-	-	-	1	1
CO6	3	-	2	-	2	1	-	-	-	-	-	3

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective VI 417533(B): Business Intelligence

Teaching Scheme: TH: 03 Hours/Week	Credit 03	Examination Scheme: In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

Prerequisites Courses: Database Management System (310241), Data Science (317529), Machine Learning (417521)

Companion Course: Computer Laboratory IV (417534)

Course Objectives:
- To Gain knowledge of the basic concepts of BI, principles, and components of BI, including data warehousing, data mining, analytics, and reporting
- To learn techniques for data visualization and reporting to facilitate effective decision-making
- To explain different data pre-processing techniques
- To Explore emerging trends and machine learning models in Business Intelligence
- To understand the BI Applications in various industries

Course Outcomes:
After completion of the course, learners should be able to-
CO1: Apply conceptual knowledge on how BI is used in decision support systems
CO2: Use Modelling Concepts in Business Intelligence
CO3: Understand and apply the concept of data provisioning and data Visualization
CO4: Apply different data pre-processing techniques on data set
CO5: Implement machine learning algorithms as per business needs
CO6: Identify role of BI in Management, Inventory, Production, Logistics and Management

Course Contents

Unit I	Introduction to BI and Decision Support system	06 Hours

Business Intelligence: Definition of Business Intelligence, Brief History of Business Intelligence, Architecture & Components of Business Intelligence, Business Intelligence Scenarios, Future & Goals of Business Intelligence, Data Information & Knowledge, Business Intelligence Tasks & Analysis Formats

Decision Support System: Definition of Decision Support System. Information Systems Support for Decision Making, Simon's Decision Making Process, The Decision Support System-Business Intelligence Connection

#Exemplar/Case Studies	Case study of how American Nationwide Insurance Company Used Bl to Enhance Customer Service.https://www.chegg.com/homework-help/questions-and-answers/case-study-3-end-chapter-1-nationwide-insurance-used-bl-enhance-customer-service-nationwid-q86305996
*Mapping of Course Outcomes for Unit I	CO1

Unit II	Modelling in Business Intelligence	06 Hours

Models and modelling in BI, Model Presentation, Model Building, Model Assessment and Quality of Models, Modelling using Logical Structures: ontology & Frame, Modelling using graph structure: Business process model and notation (BPMN), Modelling using probabilistic structures, Modelling using analytical structure. Model and Data: data Generation, The Role of time, Data Quality.

#Exemplar/Case Studies	Case Study : https://link.springer.com/chapter/10.1007/978-3-642-31095-9_33

*Mapping of Course Outcomes for Unit II	CO2

Unit III	**Data Provisioning and Data Visualization**	**06 Hours**

Data Provisioning: Data warehouse, schemas, Data Quality, Data profiling, Data enrichment, data duplication, ETL Architecture and what is ETL, Extraction concept and Change data capture, Transformation concept, lookups, time lag, formats, consistency, Loading concept, Initial and Incremental loading, late arriving facts, What is Staging, Data marts, Cubes.

Data Visualization: What Is a Business Report, Components of Business Reporting Systems, Data and Information Visualization, Types of Charts and Graphs, Visual Analytics, Performance Dashboards, Business Performance Management?

BI Tools: Tableau, power BI, Dundas BI, Oracle BI,bMs excel

#Exemplar/Case Studies	Data Visualization Case Study: https://mschermann.github.io/data_viz_reader/case-studies.html#uber-crafting-data-driven-maps
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	**Data Pre-processing Techniques**	**06 Hours**

Data validation: Incomplete data, Data affected by noise, **Data transformation:** Standardization, Feature extraction, **Data reduction:** Sampling, Feature selection, Principal component analysis, Data discretization, **Data exploration: 1. Univariate analysis:** Graphical analysis of categorical attributes, Graphical analysis of numerical attributes, Measures of central tendency for numerical attributes, Measures of dispersion for numerical attributes, Identification of outliers for numerical attributes. **2. Bivariate analysis**: Graphical analysis, Measures of correlation for numerical attributes, Contingency tables for categorical attributes, **3. Multivariate analysis:** Graphical analysis, Measures of correlation for numerical attributes

#Exemplar/Case Studies	Case study on Data preparation phase of BI system https://blog.panoply.io/load-and-transform-how-to-prepare-your-data-forbusiness-intelligence
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	**Impact of Machine Learning in BI**	**06 Hours**

Regression: Regression problems, Evaluation of regression models, Linear regression.

Classification: Classification problems, Evaluation of classification models, Bayesian methods, Logistic regression. **Clustering**: Clustering methods, Partition methods, Hierarchical methods, Evaluation of clustering models. Association Rule: Structure of Association Rule, Apriori Algorithm

#Exemplar/Case Studies	Business applications for comparing the performance of a stock over a period of time https://cleartax.in/s/stock-market-analysis
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	**BI Applications, Emerging Trends and Future Impacts**	**06 Hours**

BI Applications: Applications of Business Intelligence in Higher Education, Healthcare Monitoring, Logistics and Supply Chain Management, Customer Relationship Management, Banking Industry, Telecommunication Industry, Manufacturing Industry.

Emerging Trends and Future Impacts: Location based analytics for organisations, Mobile BI, Web 2.0 and Online Social Networking, Cloud Computing and BI. Issues related to analytics.

#Exemplar/Case Studies	Case Study : https://www.researchgate.net/publication/346664060_Emerging_trends_and_impact_of_business_intelligence_analytics_in_organizations_Case_studies_from_India
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:
1. Grossmann W, Rinderle-Ma, "Fundamental of Business Intelligence", Springer, ISBN: 978-662-46531-8
2. R. Sharda, D. Delen & E. Turban, "Business Intelligence and Analytics, system for Decision support", 10th edition. Pearson/Prentice Hall, 2015
3. Jiawei Han, Micheline Kamber and Jian Pei, "Data Mining Concepts and Techniques", 3rd edition", Elsevier publishers, ISBN: 9780123814791

Reference Books:
1. Paulraj Ponnian, "Data Warehousing Fundamentals", John Willey
2. "Introduction to business Intelligence and data warehousing", IBM, PHI
3. Carlo Vercellis, "Business Intelligence: Data Mining and Optimization for Decision Making", Wiley, 2019
4. "Data Mining for Business Intelligence", Wiley
5. "EMC Educational Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley, ISBN:13 978 1118876138
6. Ken W. Collier, "Agile Analytics: A value driven Approach to Business Intelligence and Data"
7. "Warehousing", Pearson Education, 2012, ISBN: 13 978 8131786826

e-Resources:
1. https://www.knime.com/sites/default/files/inline-images/KNIME_quickstart.pdf
2. www.cs.ccsu.edu/~markov/weka-tutorial.pdf
3. http://www.biomedicahelp.altervista.org/Magistrale/Clinics/BIC_PrimoAnno/IdentificazioneModelliDataMining/Business%20Intelligence%20-%20Carlo%20Vercellis.pdf
4. https://download.e-bookshelf.de/download/0000/5791/06/L-G-0000579106-0002359656.pdf

MOOC Courses:
1. Business Analytics for management decision: https://nptel.ac.in/courses/110105089
2. Business analytics and data mining modelling using R: https://nptel.ac.in/courses/110107092
3. Business Analysis for Engineers: https://nptel.ac.in/courses/110106050

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	2	-	-	-	-	-	-	-	-	-
CO2	-	-	2	-	3	-	-	-	-	-	-	-
CO3	-	2	2	2	3	-	-	-	-	-	-	-
CO4	-	3	-	-	3	-	-	-	-	-	-	-
CO5	-	3	3	2	3	-	-	-	-	-	-	-
CO6	-	-	-	-	-	2	-	2	-	-	2	-

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) Elective VI 417533(C): Information Systems Management		
Teaching Scheme: TH: **03 Hours/Week**	**Cre** **dit0** **3**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Operating Systems (217521), Management Information System (217530), Database Management System (310241)

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

- Information Management Systems enables new approaches to improve efficiency and efficacy of business models
- To understand the role, advantages and components of an Information System
- To integrate their learning from functional areas, decision making process in an organization and role of Information Systems to have a vintage point in this competitive world

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand the concepts of Information systems and design the strategies

CO2: Illustrate the need of Ethical and Social Issues to Information Systems

CO3: Identify and evaluate the knowledge for Decision-Making Process

CO4: Analysis and Design of system development in project management

CO5: Apply the concept of Enterprise System Management and its Applications

CO6: Analysis how E-Commerce Business Models used in global marketplace

Course Contents		
Unit I	**Organizations and Information Systems**	**06 Hours**

What Is an organization? Features of Organizations, How Information Systems Impact Organizations and Business Firms, The Fundamental Roles of IS in Business, Trends in Information Systems, Types of Information Systems, Managerial Challenges of Information Technology, The Internet and Organizations, Implications for the Design and Understanding of Information Systems, Using Information Systems to Achieve Competitive Advantage, Porter 's Competitive Forces Model, Information System Strategies for Dealing with Competitive Forces, The Internet 's Impact on Competitive Advantage.

#Exemplar/Case Studies	eCourier, ERP
***Mapping of Course Outcomes for Unit I**	CO1

Unit II	**Ethical and Social Issues in Information Systems**	**06 Hours**

Understanding Ethical and Social Issues Related to Systems, A Model for Thinking About Ethical, Social, and Political Issues, Five Moral Dimensions of the Information Age, Key Technology Trends That Raise Ethical Issues, Ethics in an Information Society, Basic Concepts: Responsibility, Accountability, and Liability, Ethical Analysis, Candidate Ethical Principles, Professional Codes of Conduct, Some Real-World Ethical Dilemmas, The Moral Dimensions of Information Systems, Information Rights, Privacy and Freedom in the Internet Age, Property Rights: Intellectual Property

#Exemplar/Case Studies	Kiuwan Code Security (SAST), Nmap, Netsparker

*Mapping of Course Outcomes for Unit II	CO2	
Unit III	**Managing Knowledge and Enhancing Decision Making**	**06 Hours**

The Knowledge Management Landscape, Important Dimensions of Knowledge, The Knowledge Management Value Chain, Types of Knowledge Management Systems, Enterprise-Wide Knowledge Management Systems, Enterprise Content Management Systems, Knowledge Network Systems, Collaboration And Social Tools and Learning Management Systems, Knowledge Work Systems, Knowledge Workers and Knowledge Work, Requirements of Knowledge Work Systems, Examples of Knowledge Work Systems, Decision Making and Information Systems, Business Value of Improved Decision Making, Types of Decisions, The Decision-Making Process, Managers and Decision Making in the Real World, High-Velocity Automated Decision Making, Business Intelligence in the Enterprise, What Is Business Intelligence?, The Business Intelligence Environment

#Exemplar/Case Studies	Moneyball: Data-Driven Baseball
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	**Systems Development and Organizational Change Business Process Redesign**	**06 Hours**

Overview of systems development: Systems Analysis, Systems Design, Completing the Systems Development Process, Modeling and Designing Systems: Structured and Object-Oriented Methodologies. Alternative systems-building approaches: Traditional Systems Life Cycle, Prototyping, End-User Development, Application Software Packages and Outsourcing
Project management: Objectives, Management Structure for Information Systems Projects, Linking Systems Projects to the Business Plan, Information Requirements and Key Performance Indicators, Portfolio Analysis, Scoring Models, Information System Costs and Benefits, Dimensions of Project Risk. project management software tools like JIRA etc.

#Exemplar/Case Studies	JIRA, SCRUM
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	**Achieving Operational Excellence and Customer Intimacy: Enterprise Applications**	**06 Hours**

Enterprise Systems, What Are Enterprise Systems? Enterprise Software, Business Value of Enterprise Systems, Supply Chain Management Systems, The Supply Chain Information Systems and Supply Chain

Management, Supply Chain Management Software, Global Supply Chains and the Internet, Business Value of Supply Chain Management Systems, Customer Relationship Management Systems, What Is Customer Relationship Management? Customer Relationship Management Software, Operational and Analytical CRM, Business Value of Customer Relationship Management Systems

#Exemplar/Case Studies	Summit Electric Lights Up with a New ERP System
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	**E-commerce: Digital Markets, Digital Goods**	**06 Hours**

E-commerce and the Internet , E-Commerce Today, Why E-commerce Is Different, Key Concepts in E-commerce: Digital Markets and Digital Goods in a Global Marketplace E-commerce: Business and Technology, Types of E-Commerce , E-Commerce Business Models , E-Commerce Revenue Models, Social Networking and The Wisdom of Crowds, E-Commerce Marketing, B2B E-commerce: New Efficiencies and Relationships The Mobile Digital Platform and Mobile E-commerce, Location-based Services and Applications , Other Mobile Commerce Services

#Exemplar/Case Studies	To Pay or Not to Pay: Zagat's Dilemma, BHIM UPI
*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Kenneth C. Laudon, Jane P. Laudon "Management Information Systems: Managing the Digital Firm", 13th edition, 2014, Pearson
2. James A O'Brien, George M Marakas and Ramesh Behl, "Management Information Systems", 9th edition, Tata McGraw Hill Education, New Delhi, 2009
3. James A O'Brien, George M Marakas Introduction to Information Systems, 15th edition, Tata McGraw Hill Education, New Delhi
4. Michael Hammer and James Champy, "Reengineering the Corporation: A Manifesto for Business Revolution", 1st edition, HarperCollins, 2003

Reference Books:

1. Turban, E., McLean, E. and Wetherbe, J., "Information Technology for Management: Making Connections for Strategic Advantage", 2nd edition, John Wiley and Sons, 2000
2. D.P.Goyal, "Management Information Systems-Managerial Perspectives", 2nd edition, Macmillan, New Delhi, 2006
3. S. A. Kelkar, "Management Information Systems-A concise Study", 2nd edition, Prentice Hall of India, 2009
4. Nirmalya Bagchi, "Management Information Systems", 1st edition, Vikas Publishing House, New Delhi, 2010

e-Resources:

1. David T. Bourgeois, James L. Smith Shouhong Wang, Joseph Mortati, "Information Systems for Business and Beyond"

MOOC Courses:

1. Prof. Kunal Ghosh, Prof. Surojit Mookherjee, Prof. Saini Das, IIT Kharagpur, Management Information System https://nptel.ac.in/courses/110/105/110105148/
2. Dr. Abhilasha Ambatipudi, Savitribai Phule Pune University, Management Information System https://onlinecourses.swayam2.ac.in/cec21_ge05/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	2	2
CO2	3	-	-	-	-	2	-	3	-	-	-	2
CO3	3	-	2	-	-	-	-	-	-	-	-	2
CO4	3	-	2	-	3	-	-	-	2	-	2	2
CO5	3	-	-	-	-	-	-	-	-	2	1	2
CO6	3	-	-	-	-	-	1	-	-	-	2	2

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) Elective VI 417533(D): Reinforcement Learning		
Teaching Scheme: **TH: 03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Machine learning (417521)

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

- To provide students with a basic understanding of RL and its connection with other related field.
- Familiarize with five main components of reinforcement learning.
- To make optimal decisions for dynamic systems using Markov decision process
- To solve real world problems using the concept of Reinforcement Learning.

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Understand RL tasks and the core principals of RL

CO2: Summarize Markov Decision Process

CO3: Model a control task in the framework of MDP

CO4: Correlate Monte Carlo Methods

CO5: Apply deep Q-network based algorithms

CO6: Solve classical control problems with tabular methods

Course Contents		
Unit I	**Introduction**	**06 Hours**
Introduction and Basics of RL, Origin and history of Reinforcement Learning research. Its connections with other related fields and with different branches of machine learning, Limitations and scope of RL		
#Exemplar/Case Studies	Horizon: Facebook's Open Source Applied Reinforcement Learning Platform	
*Mapping of Course Outcomes for Unit I	CO1	
Unit II	**Markov Decision Process**	**06 Hours**
Markov decision processes: The Markov property, The S state set, Actions, Transition model, Rewards and Policy, **The sequence of rewards assumptions** : The infinite horizons, Utility of sequences, The Bellman equations, Policy iteration, **Partially observable Markov decision processes**: State estimation, Value iteration in POMDPs		
#Exemplar/Case Studies	Use of Markov decision process in inventory management	
*Mapping of Course Outcomes for Unit II	CO2	
Unit III	**Prediction and Control by Dynamic Programing**	**06 Hours**

Overview of dynamic programing for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration, Banach fixed point theorem, proof of contraction mapping property of Bellman expectation and optimality operators, proof of convergence of policy evaluation and value iteration algorithms.

#Exemplar/Case Studies	Reinforcement Learning in Autonomic Computing: A Manifesto and Case Studies
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	Monte Carlo Methods for Model Free Prediction and Control	06 Hours

Overview of Monte Carlo methods for model free RL, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Monte Carlo tree search, Importance sampling: Discounting-aware Importance Sampling, Per-decision Importance Sampling.

#Exemplar/Case Studies	Monte Carlo for the mountain car problem in OpenAI gym
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	Q-Learning and Deep Q-Networks	06 Hours

Model based learning and model free learning, **Temporal difference learning:** On-policy and off-policy learning, Q-learning, **Deep Q-networks** using a convolution neural network instead of a single layer neural network, Separate target network to compute the target Q-values, **Advancements in deep Q-networks and beyond**: Double DQN, Dueling DQN, Q-Learning and their variants.

#Exemplar/Case Studies	Deep Q-network for Cartpole problem in OpenAI gym
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	Planning and Learning with Tabular Methods	06 Hours

Models and Planning, Dyna: Integrated Planning, Acting, and Learning, When the Model Is Wrong, Prioritized Sweeping, Expected vs. Sample Updates, Trajectory Sampling, Real-time Dynamic Programming, Planning at Decision Time, Heuristic Search, Rollout Algorithms

#Exemplar/Case Studies	Multiagent Reinforcement Learning: Rollout and Policy Iteration, IEEE/CAA Journal of Automatica Sinica (Volume: 8, Issue: 2, February 2021)
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:
1. Reinforcement Learning with TensorFlow: A beginner's guide to designing self-learning systems with TensorFlow and OpenAI Gym, Sayon Dutta, Packt Publishing (24 April 2018)
2. Reinforcement Learning: An Introduction, second edition Richard S. Sutton and Andrew G. Barto, The MIT Press Cambridge, Massachusetts

Reference Books:
1. Sudharsan Ravichandiran, "Hands-On Reinforcement Learning with Python: Master Reinforcement and Deep Reinforcement Learning Using OpenAI Gym and TensorFlow"
2. Maxim Lapan, "Deep Reinforcement Learning Hands-On: Apply Modern RL Methods, with Deep Q-networks, Value Iteration, Policy Gradients, TRPO, AlphaGo Zero and More"

e-Resources:
1. Jason Gauci, "Horizon: Facebook's Open Source Applied Reinforcement Learning Platform", https://doi.org/10.48550/arXiv.1811.00260
2. G. Tesauro, "Reinforcement Learning in Autonomic Computing: A Manifesto and Case Studies," in IEEE Internet Computing, vol. 11, no. 1, pp. 22-30, Jan.-Feb. 2007, doi: 10.1109/MIC.2007.21
3. D. Bertsekas, "Multiagent Reinforcement Learning: Rollout and Policy Iteration," in IEEE/CAA Journal of Automatica Sinica, vol. 8, no. 2, pp. 249-272, February 2021, doi: 10.1109/JAS.2021.1003814

MOOC Courses:
1. Reinforcement Learning Specialization: https://www.coursera.org/specializations/reinforcement-learning
2. Reinforcement Learning Lecture Series 2021: https://www.deepmind.com/learning-resources/reinforcement-learning-lecture-series-2021
3. Introduction to Reinforcement Learning with David Silver: https://www.deepmind.com/learning-resources/introduction-to-reinforcement-learning-with-david-silver
4. Deep RL Bootcamp: https://sites.google.com/view/deep-rl-bootcamp/lectures

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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CO2	3	2	3	-	3	-	-	-	-	-	-	-
CO3	3	3	3	-	3	-	-	-	-	-	-	-
CO4	3	3	3	3	3	-	-	-	2	-	-	-
CO5	3	3	3	3	3	-	-	-	-	-	-	-
CO6	3	-	-	3	-	-	-	-	-	-	-	2

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417534: Computer Laboratory III		
Teaching Scheme: **PR: 02 Hours/Week**	**Credit** **01**	**Examination Scheme and Marks** **Term Work (TW): 50 Marks** **Practical (PR): 25 Marks**

Prerequisites Courses: Computer Network Laboratory (317527), Software Laboratory-III (317536)

Companion Course: Computational Intelligence (417529), Distributed Computing (417530)

Course Objectives:
- To understand the fundamentals of a distributed environment in complex application
- To introduce the concepts inspired by the human immune system and their application in problem-solving and optimization
- To make students aware about security issues and protection mechanisms for distributed environments
- To familiarize with various evolutionary algorithms and optimization techniques inspired by natural evolution processes

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Apply the principles on which the internet and other distributed systems are based

CO2: Understand and apply the basic theoretical concepts and algorithms of distributed systems in problem solving

CO3: Apply fuzzy logic techniques to model and solve problems

CO4: Design and implement evolutionary algorithms to solve optimization and search problems in diverse domains

CO5: Design and implement artificial immune system algorithms to solve complex problems in different domains

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a reference and hands-on resource. It should include prologue (about University/program/ institute/ department/foreword/ preface), curriculum of the course, conduction and Assessment guidelines, topics under consideration, concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by students in the form of Journal. Journal consists of Certificate, table of contents, and handwritten write-up of each assignment (Title, Date of Completion, Objectives, Problem Statement, Software and Hardware requirements, Assessment grade/marks and assessor's sign, Theory- Concept in brief, algorithm, flowchart, test cases, Test Data Set(if applicable), mathematical model (if applicable), conclusion/analysis. Program codes with sample output of all performed assignments are to be submitted as softcopy. As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to Journal must be avoided. Use of DVD/Softcopy containing student programs maintained by Laboratory In-charge is highly encouraged. For reference one or two journals may be maintained with program prints in the Laboratory.

Guidelines for Laboratory /Term Work Assessment

Continuous assessment of laboratory work should be based on overall performance of Laboratory assignments by a student. Each Laboratory assignment assessment will assign grade/marks based on parameters, such as timely completion, performance, innovation, efficient codes, and punctuality.

Guidelines for Practical Examination

Problem statements must be decided jointly by the internal examiner and external examiner. During practical assessment, maximum weightage should be given to satisfactory implementation of the problem statement. Relevant questions may be asked at the time of evaluation to test the student's understanding of the fundamentals, effective and efficient implementation. This will encourage, transparent evaluation and fair approach, and hence will not create any uncertainty or doubt in the minds of the students. So, adhering to these principles will consummate our team efforts to the promising start of student's academics.

Guidelines for Laboratory Conduction

The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic. The assignment framing policy needs to address the average students and inclusive of an element to attract and promote the intelligent students. Use of open source software is encouraged. Based on the concepts learned. Instructors may also set one assignment or mini-project that is suitable to the AI & DS branch beyond the scope of the syllabus.
Recommended Programming Languages: Python or Java

Suggested List of Laboratory Experiments/Assignments

Part I: Perform Any 6 assignments

1	Design a distributed application using RPC for remote computation where client submits an integer value to the server and server calculates factorial and returns the result to the client program.
2	Design a distributed application using RMI for remote computation where client submits two strings to the server and server returns the concatenation of the given strings.
3	Design a distributed application using MapReduce under Hadoop for: a) Character counting in a given text file. b) Counting no. of occurrences of every word in a given text file.
4	Implement Union, Intersection, Complement and Difference operations on fuzzy sets. Also create fuzzy relations by Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.
5	Write code to simulate requests coming from clients and distribute them among the servers using the load balancing algorithms.
6	Optimization of genetic algorithm parameter in hybrid genetic algorithm-neural network modelling: Application to spray drying of coconut milk.
7	Implementation of Clonal selection algorithm using Python.
8	Create and Art with Neural style transfer on given image using deep learning.

Part II: (Perform Any 4 Assignments)

1	To apply the artificial immune pattern recognition to perform a task of structure damage Classification.
2	Implement DEAP (Distributed Evolutionary Algorithms) using Python.
3	Design and develop a distributed Hotel booking application using Java RMI. A distributed hotel booking system consists of the hotel server and the client machines. The server manages hotel rooms booking information. A customer can invoke the following operations at his machine i) Book the room for the specific guest ii) Cancel the booking of a guest.
4	Design and develop a distributed application to find the coolest/hottest year from the available weather data. Use weather data from the Internet and process it using MapReduce.
5	Implement Ant colony optimization by solving the Traveling salesman problem using python Problem statement- A salesman needs to visit a set of cities exactly once and return to the original city. The task is to find the shortest possible route that the salesman can take to visit all the cities and return to the starting city.
6	Create and Art with Neural style transfer on given image using deep learning.

Learning Resources

Text Books:
1. Nazmul Siddique, HojjatAdeli, "Computational Intelligence, Synergies of Fuzzy logic, Neural Networks and Evolutionary computing", Wiley publication
2. Andreis P. Engelbrecht, "Computational Intelligence an introduction", 2nd edition, Wiley publication

Reference Books:
1. George Coulouris, Jean Dollimore, Tim Kindberg, & Gordon Blair, "Distributed Systems – Concept and Design", 5th edition, Pearson, ISBN: 978-13-214301-1
2. Randay Chow, Theodore Johnson, "Distributed Operating System and Algorithm Analysis", Pearson (LPE), ISBN: 978-81-317-2859-8.
3. Seyedali Mirjalili, "Evolutionary Algorithms and Neural Networks Theory and Applications, Studies in Computational Intelligence", Vol. 780, Springer, 2019, ISBN: 978-3-319-93024-4 Press, 1998
4. Sitendra Tamrakar, Shruti Bhargava Choubey, Abhishek Choubey, "Computational Intelligence in Medical Decision Making and Diagnosis Techniques and Applications", CRC Press, 2023

e-Resources:
1. https://induraj2020.medium.com/implementation-of-ant-colony-optimization-using-python-solve-traveling-salesman-problem-9c14d3114475
2. https://blog.tensorflow.org/2018/08/neural-style-transfer-creating-art-with-deep-learning.html
3. https://www.professionalcipher.com/2018/04/design-and-develop-distributed-hotel-booking-application-using-java-rmi.html

MOOC Courses:
1. Advanced Distributed systems: https://onlinecourses.nptel.ac.in/noc22_cs80/preview
2. Computational Intelligence Laboratory: https://www.iit.demokritos.gr/labs/cil/

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	2	-	-	-	-	-	1	-
CO2	2	1	1	2	2	-	-	-	-	-	-	-
CO3	1	2	-	1	2	-	-	-	-	-	1	-
CO4	1		1	2	1	-	-	-	-	-	-	-
CO5	1	2	1	1	2	-	-	-	-	-	1	-

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417535: Computer Laboratory IV

Teaching Scheme: PR: 02 Hours/Week	Credit 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR) : 25 Marks

Companion Course: Elective V (417531), Elective VI (417532)

Course Objectives:
- To understand the fundamental concepts and techniques of Virtual reality
- To understand Big Data Analytics Concepts
- To learn the fundamentals of software development for portable devices
- To understand fundamental concepts of Deep Learning
- To be familiar with the various application areas of augmented realities
- To introduce the concepts and components of Business Intelligence (BI)
- To understand the concepts of Information Systems

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Apply basic principles of elective subjects to problem solving and modeling

CO2: Use tools and techniques in area of software development to build mini projects

CO3: Design and develop applications on subjects of their choice

CO4: Implement and manage deployment, administration & security

Guidelines for Instructor's Manual

The faculty member should prepare the laboratory manual for all the experiments and it should be made available to students and laboratory instructor/Assistant.

The instructor's manual is to be developed as a hands-on resource and reference. The instructor's manual needs to include a prologue (about the University/program/ institute/ department/foreword/ preface etc.), University syllabus, conduction & Assessment guidelines, topics under consideration-concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by students in the form of a journal. Journal consists of prologue, Certificate, table of contents, and handwritten write-up of each assignment (Title, Objectives, Problem Statement, Outcomes, software & Hardware requirements, Date of Completion, Assessment grade/marks, and assessor's sign, Theory- Concept in brief, Database design, test cases, conclusion/analysis.

1. Students should submit term work in the form of the journal with write-ups based on a specified list of assignments.
2. Practical /Oral Examinations will be based on all the assignments in the lab manual.
3. Candidate is expected to know the theory involved in the experiment.
4. The practical/Oral examination should be conducted only if the journal of the candidate is complete in all respects.

Guidelines for Laboratory /Term Work Assessment

Continuous assessment of laboratory work is done based on the overall performance and lab assignments performance of students. Each lab assignment assessment will assign grade/marks based on parameters (Attendance, conduction & viva). Suggested parameters for the overall evaluation as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality, and neatness.

1. Examiners will assess the student based on the performance of students considering the parameters such as timely conduction of practical assignment, the methodology adopted for the implementation of practical assignment, timely submission of assignment in the form of handwritten write-up along with results of the implemented assignment, attendance, etc.

2. Examiners will judge the understanding of the practices performed in the examination by asking some questions related to theory & implementation of experiments he/she has carried out.

3. The concerned faculty member should check appropriate knowledge of the usage of software and hardware related to the respective laboratory.

Guidelines for Oral/ Practical Examination

Both internal and external examiners should jointly set problem statements. During the practical assessment, the expert evaluator should give the maximum weightage to the satisfactory implementation of the problem statement. The supplementary and relevant questions may be asked at the time of evaluation to test the students for advanced learning, understanding of the fundamentals, and effective and efficient implementation. So, encouraging efforts, transparent evaluation, and a fair approach of the evaluator will not create any uncertainty or doubt in the minds of the students. So, adhering to these principles will consummate our team efforts to the promising start of the student's academics.

Guidelines for Laboratory Conduction

Set of Suggested assignment lists are provided in Groups – A and B. Each Student must perform at least 10 assignments (8 from Group A, 2 from Group B i.e. 1 Mini Project from each elective).
Operating System Recommended: - 64-bit Open-source Linux or its derivative
Programming tools recommended: SQL, PL/SQL, Front End: Java/Perl/PHP/Python/Ruby/.net,
Backend: Monod/MYSQL/Oracle, Database Connectivity: ODBC/JDBC.

PART I (417531): ELECTIVE V

417531(A): Virtual Reality & Game Development

Perform any 5 Assignments.

1. Installation of Blender, setting up Blender for VR development, understanding documentation of the same.

2. Create a VR gallery space with a blender tool.

3. Create a 2D cube and apply pivot points snapping and proportional editing functions in blender.

4. Design a 3D cube shape in a blender, apply textures and shades in the object.

5. Create any shape and perform the effects using The Extrude, Inset, and Knife Tools using blender.

6. Create a simple Tic Tac Toe game using HTML5 and JavaScript and CSS.

7. Create a Dodge the Creeps 2D / 3D game using Godot Gaming Engine.

417531(B): Big Data Analytics

Perform any 5 Assignments.

1. Set up and Configuration Hadoop Using CloudEra/ Google Cloud BigQuery. Databricks Lakehouse Platform. Snowflake. Amazon Redshift.

2. Develop a MapReduce program to calculate the frequency of a given word in a given file.

3. Implement Matrix Multiplication using Map-Reduce

4.	Develop a MapReduce program to find the grades of students.
5.	Develop a MapReduce program to analyze Titanic ship data and to find the average age of the people (only male) who died in the tragedy. How many persons are dead in each class (only female).
6.	Mongo DB: Installation and Creation of database and Collection CRUD Document: Insert, Query, Update and Delete Document.
7.	Hive: Introduction Creation of Database and Table, Hive Partition, Hive Built in Function and Operators, Hive View and Index.
8.	Visualization: Connect to data, Build Charts and Analyze Data, Create Dashboard, Create Stories using Tableau/PowerBI.

417531(C): Software Development for portable devices

Perform any 5 Assignments.

1.	Create a simple Android application using native Android Views and layouts
2.	Develop an app for motion detection.
3.	Develop an app to enable and disable Wi-Fi in Android.
4.	Develop an app to enable and disable Bluetooth in Android.
5.	App to demo SQLite - Insert, Update, Delete operation. App to demo to extract World Population information from the database.
6.	Develop Hello wear world by using android studio.
7.	Develop an app to get users current location.

417531(D): Deep Learning

Perform any 5 Assignments.

1. Problem Statement – Real estate agents want help to predict the house price for regions in the USA. He gave you the dataset to work on and you decided to use the Linear Regression Model. Create a model that will help him to estimate what the house would sell for.
URL for a dataset:
https://github.com/huzaifsayed/Linear-Regression-Model-for-House-Price-Prediction/blob/master/USA_Housing.csv

2. Build a Multiclass classifier using the CNN model. Use MNIST or any other suitable dataset. a. Perform Data Pre-processing b. Define Model and perform training c. Evaluate Results using confusion matrix.

3. Design RNN or its variant including LSTM or GRU a) Select a suitable time series dataset. Example – predict sentiments based on product reviews b) Apply for prediction

4. Design and implement a CNN for Image Classification a) Select a suitable image classification dataset (medical imaging, agricultural, etc.). b) Optimized with different hyper-parameters including learning rate, filter size, no. of layers, optimizers, dropouts, etc.

5. Design and implement Deep Convolutional GAN to generate images of faces/digits from a set of given images.

6. Perform Sentiment Analysis in the network graph using RNN.

417531(E): Open Elective

Suitable set of Programming assignments for Open elective opted.

PART II (417532): ELECTIVE VI

417532(A): Augmented Reality

Perform any 5 Assignments.

1. Study of various AR VR Development tools.

2. Case study of any single application using both VR and AR technologies.
3. Installation and understanding of UNITY 3D IDE.
4. Create a C# script that plays a video when an image is scanned using AR App (ARCore& Unity).
5. Develop & Deploy a simple marker-based AR app in which you have to write a C# program to play video on tracking a particular marker.
6. Develop and deploy an AR app, implement the following using Vuforia Engine developer portal: i) Plane detection ii) Marker based Tracking (Create database of objects to be tracked in Vuforia) iii) Object Tracking

417532(B): Business Intelligence

Perform any 5 Assignments.

1. Import Data from different Sources such as (Excel, Sql Server, Oracle etc.) and load in targeted system.
2. Data Visualization from Extraction Transformation and Loading (ETL) Process
3. Perform the Extraction Transformation and Loading (ETL) process to construct the database in the Sql server / Power BI.
4. Data Analysis and Visualization using Advanced Excel.
5. Perform the data classification algorithm using any Classification algorithm
6. Perform the data clustering algorithm using any Clustering algorithm

417532(C): Information Systems Management

Perform any 5 Assignments.

1. Study Google Cloud Dataflow fully managed data processing service tool which is built to optimize computing power and automate resource management.
2. Study of different ETL Tools used in Enterprise used for Information System Management (Data Integration, Data Visualization, Reducing the cost of Project etc.
3. Study Blue Ocean strategy. Prepare case study on any of the company (Example: NetFlix / Apple / Uber/ Airbnb/Starbuck)
4. Implement In-house or cloud-based ERP application system for small Enterprise with consideration of accurate information on a variety of organizational assets: Purchase like, Inventory
5. Use any data set in Google excel sheet, import to Google data studio an open-source tool for Extraction Transformation and Loading of information and visualize desired output. (sorting / data cleaning / filtering)
6. Think of a decision that you make in your daily life and build your own DSS using a spreadsheet that would help you make that decision.
7. To secure the information do research on the intellectual property portion of the End User License Agreement (EULA) on your project. Explain what the EULA is saying about protection of work

417532(D): Reinforcement Learning

Perform any 5 Assignments.

1. Study of the TensorFlow and OpenAI Gym Library
2. Develop a model-based RL algorithm, such as Monte Carlo Tree Search (MCTS), to solve a complex environment like Atari games.
3. Implement a Deep Q-Network (DQN) using a deep neural network library (e.g., TensorFlow or PyTorch) and train it on a simple environment like CartPole or Mountain Car.
4. Implement a policy gradient algorithms like REINFORCE or Proximal Policy Optimization (PPO) to solve a continuous control task.

5. Build a multi-agent environment, such as a cooperative or competitive game, and implement algorithms like Independent Q-Learning or Multi-Agent Deep Deterministic Policy Gradients (MADDPG).
6. Develop an actor-critic model using neural networks and train it on a classic RL benchmark, such as the Acrobot or Inverted Pendulum.

417532(E): Open Elective

Suitable set of Programming assignments for Open elective opted.

Learning Resources

Text Books:

Software Development for Portable Devices
1. Varun Nagpal, "Android Sensor Programming By Example", Packt Publishing, 2016, ISBN: 978-1-78528-550-9
2. Professional Android 4 Application Development, by Reto Meier, WROX Press, Wiley Publishing, 2012, ISBN: 978-1-118-10227-5
3. Sanjay M. Mishra, Wearable Android: Android Wear and Google FIT App Development, John Wiley & Sons, 2015, ISBN: 9781119050865

Virtual & Augmented Reality
1. Steve Aukstakalnism, "Practical Augmented Reality: A Guide to the Technologies, Applications and Human Factors for AR and VR", Addison-Wesley Professional, 2016, ISBN: 9780134094328
2. Allan Fowler, "Beginning iOS AR Game Development Developing Augmented Reality Apps with Unity and C#", 1st edition, Apress Publications, 2018, ISBN: 978-1484236178

Reinforcement Learning
1. Csaba Szepesvari, "Algorithms for Reinforcement Learning", Morgan and Claypool Publishers
2. Taweh Beysolow, "Applied Reinforcement Learning with Python", APRESS publications

Reference Books:

Virtual & Augmented Reality
1. Terry Norton, "Learning C# by Developing Games with Unity 3D Beginner's Guide", Packt publishing, 2017, ISBN-13: 978-1787286436
2. Jonathan Linowes, Krystian Babilinski, "Augmented Reality for Developers: Build practical augmented reality applications with Unity", ARCore, ARKit, and Vuforia

Information Systems Management
1. Grant Kemp Gerry White, "Google Data Studio for Beginner, Start Making Your Data Actionable", A press Media LLC, ISBN: 13 (electronic): 978-1-4842-5156-0
2. Adrian Payne, "Handbook of CRM: Achieving Excellence in Customer Management", Elsevier Ltd., ISBN-13: 978-07506-6437-0
3. Francis Buttle, "Customer Relationship Management Concepts and Technologies", Elsevier Ltd., ISBN: 978-1-85617-522-7
4. http://www.faadooengineers.com/threads/17441-Enterprise-resource-planning-ebook-free-download-pdf
5. https://www.academia.edu/6262473/Customer_Relationship_Management_Second_Edition

Reinforcement Learning
1. Phil Winder, "Reinforcement Learning: Industrial Applications of Intelligent Agents", O'Reilly Publications
2. Maxim Lapan, "Deep Reinforcement Learning Hands-On: Apply Modern RL Methods, with Deep Q-networks, Value Iteration, Policy Gradients, TRPO, AlphaGo Zero and More"

e-Books/web sources:
1. http://nlp-iiith.vlabs.ac.in/
2. Online links
   Manual:https://docs.unity3d.com/Packages/com.unity.xr.arfoundation@4.1/manual/index.html
3. https://rl-lab.com/
4. https://ai.vub.ac.be/reinforcement-learning/?utm_source=www.google.com&utm_medium=organic&utm_campaign=Google&referrer-analytics=1
5. https://mll.iiit.ac.in/projects/

The CO-PO Mapping Matrix											
CO/ PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	-	-	-	2	-	-	-	-	-	-	1
CO2	-	2	-	-	-	-	-	-	-	-	-	1
CO3	-	-	-	2	-	-	-	-	2	-	-	1
CO4	3	2	2	2	-	-	-	-	-	-	-	1

Savitribai Phule Pune University **Fourth Year of Artificial Intelligence and Data Science (2020 Course)** **417536: Project Stage II**		
Teaching Scheme: **PR: 12 Hours/Week**	**Credit** **06**	**Examination Scheme:** **Term Work: 100 Marks** **Oral: 50 Marks**

Prerequisites Courses: Project Stage I (417527)

Course Objectives:

- To follow SDLC meticulously and meet the objectives of proposed work
- To test rigorously before deployment of system
- To validate the work undertaken
- To consolidate the work as furnished report

Course Outcomes:

After completion of the course, learners should be able to-

   CO1: Show evidence of independent investigation

   CO2: Critically analyze the results and their interpretation

   CO3: Report and present the original results in an orderly way and placing the openquestions in the right perspective

   CO4: Link techniques and results from literature as well as actual research and futureresearch lines with the research

   CO5: Appreciate practical implications and constraints of the specialist subject

Guidelines

In Project Work Stage–II, the student shall complete the remaining project work which consists of Selection of Technology and Tools, Installations, UML implementations, testing, Results, performance discussions using data tables per parameter considered for the improvement with existing/known algorithms/systems and comparative analysis and validation of results and conclusions. The student shall prepare and submit the report of Project work in standard format for satisfactory completion of the work that is the duly certified by the concerned guide and head of the Department/Institute.

Follow guidelines and formats as mentioned in Project Workbook recommended by Board of Studies.

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417537: Audit Course 8

In addition to credits, it is recommended that there should be audit course, in preferably in each semester starting from second year in order to supplement students' knowledge and skills. Studentwill be awarded the bachelor's degree if he/she earns specified total credit and clears all the audit courses specified in the curriculum. The student will be awarded grade as AP on successful completion of audit course. The student may opt for one of the audit courses per semester, starting in second year first semester. Though not mandatory, such a selection of the audit courses helps the learner to explore the subject of interest in greater detail resulting in achieving the very objective of audit course's inclusion. List of options offered is provided. Each student has to choose one audit
course from the list per semester. Evaluation of audit course will be done at Institute level itself. Method of conduction and method of assessment for audit courses are suggested.

Criteria

The student registered for audit course shall be awarded the grade AP (Audit Course Pass) and shall be included such AP grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory performance and secured a passing grade in that audit course. No grade points are associated with this _AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at Institute level itself.

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations or presentations
- Surveys
- Mini-Project
- Hands on experience on focused topic

Course Guidelines for Assessment (Any one or more of following but not limited to):

- Written Test
- Demonstrations/ Practical Test
- Presentation or Report

Audit Course 8 Options

Audit Course Code	Audit Course Title
AC8-I	Usability Engineering
AC8-II	Conversational Interfaces
AC8-III	Social Media and Analytics
AC8-IV	Foreign Language
AC8-V	MOOC-Learn New Skills

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417537: Audit Course 8
AC8-I: Usability Engineering

In this course you will have a hands-on experience with usability evaluation and user-centered design. This course will not help to learn how to implement user interfaces, but rather how to design based on the needs of users, which you will determine, and learn how to evaluate your designs rigorously. This help in knowing more about the usability; human computer interaction, the psychological aspects of computing, evaluation.

Course Objectives:

- To understand the human centered design process and usability engineering process and their roles in system design and development
- To know usability design guidelines, their foundations, assumptions, advantages, and weaknesses
- Understand the user interface based on analysis of human needs and prepare a prototype system

Course Outcomes:

After completion of the course, learners should be able to-

CO1: Describe the human centered design process and usability engineering process and their roles in system design and development

CO2: Discuss usability design guidelines, their foundations, assumptions, advantages, and weaknesses

CO3: Design a user interface based on analysis of human needs and prepare a prototype system

CO4: Assess user interfaces using different usability engineering techniques

CO5: Present the design decisions

Course Contents

1. What Is Usability?: Usability and Other Considerations, Definition of Usability,Example: Measuring the Usability of Icons, Usability Trade-Offs, Categories of Users and Individual User Differences
2. Usability in Software Development: The Emergence of Usability, Human Computer Interaction,Usability Engineering
3. The usability Engineering Lifecycle: Requirement Analysis, Design, Testing, Development
4. Usability Assessment Methods beyond Testing
5. International User Interfaces

References:

1. Mary Beth Rosson, John Millar Carroll, "Usability Engineering: Scenario-based Development of Human-Computer Interaction"
2. Jakob Nielsen, "Usability Engineering"
3. Deborah J. Mayhew, "The usability engineering lifecycle"

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417537: Audit Course 8 AC8-II: Conversational Interfaces

Effective information security at the enterprise level requires participation, planning, and practice. It is an ongoing effort that requires management and staff to work together from the same script. Fortunately, the information security community has developed a variety of resources, methods, and best practices to help modern enterprises address the challenge. Unfortunately, employing thesetools demands a high degree of commitment, understanding, and skill attributes that must be sustained through constant awareness and training.

Course Objectives:

- To understand the basics of conversation
- To know the interactive environments for conversational skills
- To acquaint with the speech to text and text to speech techniques

Course Outcomes:

After completion of the course, learners should be able to-
CO1: Develop an effective interface for conversation
CO2: Explore advanced concepts in user interface

Course Contents

1. **Introduction to Conversational Interface:** Preliminaries, Developing a speech based Conversational Interface, Conversational Interface and devices.

2. **A technology of Conversation:** Introduction, Conversation as Action, The structure of Conversation, The language of Conversation.

3. **Developing a Speech-Based Conversational Interface:** Implementing Text to Speech: Text Analysis, Wave Synthesis, Implementing Speech Recognition: Language Model, Acoustic Model, Decoding. Speech Synthesis Markup Language.

4. A**dvanced voice user interface design**

References:

1. Cathy Pearl, "Designing Voice User Interfaces: Principles of Conversational Experiences"
2. Michael McTear, Zoraida Callejas, David Griol, "The Conversational Interface: Talking to Smart Devices"
3. Martin Mitrevski, "Developing Conversational Interfaces for iOS: Add Responsive Voice Control"
4. Srini Janarthanam, "Hands-On Chatbots and Conversational UI Development: Build chatbots"

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417537: Audit Course 8
AC8-III: Social Media and Analytics

Course Objectives:
- To identify and classify social media data to undergo a situation Analysis
- To Understand and apply key concepts in social media metrics that shall improve decision-making
- To analyze Social Media databases to enable the development of new predictive models
- To develop strategy and measure for social media campaign effectiveness
- To create a better business decision by leveraging social media data

Course Outcomes:
After completion of the course, learners should be able to-
   CO1: Recall the fundamental social media metrics ideas
   CO2: Identify social media analytics software
   CO3: Study the data from social media
   CO4: Maintain an eye on customers and rivals to gather deeper consumer insights through sophisticated social media data modelling

Course Contents

1. Introduction to Social Media
      Describe the various types of data that can often be found on social media networks. Recognize ethical issues to consider when gathering and using social data.
2. Modeling Building in Social Media
      Get an extensive social media database loaded. Create summary statistics for an extensive data of social media.
3. Visualizing Social Media Networks
      Get an extensive social media database loaded. Create summary statistics for an extensive data of social media. Case Study: Twitter/Facebook/

References:
1. Gohar F. Khan, "Creating Value with Social Media Analytics: Managing, Aligning, and Mining Social Media Text, Networks, Actions, Location, Apps, Hyperlinks, Multimedia, & Search Engines Data"
2. Randy Bartlett, "A Practitioner's Guide to Business Analytics: Using Data Analysis Tools to Improve Your Organization's Decision Making and Strategy", IGBC Green New Buildings Rating System, Version 3.0, Abridged Reference Guide,   2014
3. By Matt Taddy, "Business Data Science: Combining Machine Learning and Economics to Optimize, Automate, Accelerate Business Decisions"

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417537: Audit Course 8
AC8-IV: Foreign Language

Course Objectives:

- Get introduced to the Culture, Routine of the Foreign Society through language
- Meet the needs of ever growing foreign industry with respect to language support

Course Outcomes:

After completion of the course, learners-

CO1: Will have the ability of basic communication

CO2: Will have the knowledge of Language script

CO3: Will get introduced to reading, writing and listening skills

CO4: Will develop interest to pursue profession in Foreign Industry

Course Contents

Instructions:

All course contents should be completed in only one language (German, French, Japanese and any other suitable foreign language)

1. **Introduction to the Foreign Language:** Introduction of Alphabets, Spell the names, Addresses, Numbers, Telephone numbers, OrdinalNumbers, Pin code Numbers, Dates, Birthdates, Age, days of the week, Months.
2. **Communication Part 1:** Basic Greetings, Personal Pronouns, Possessive Pronouns.
3. **Communication Part 2:** Self-Introduction, Introducing other people, about family, friends, course mates, seasons, and seasons in Other countries and in neighboring countries.

Text Books:

1. The Everything Learning German Book: Speak, write, and understand basic German in no time (Everything®) Kindle Edition with Audio/Video by Edward Swick (Author)
2. NETZWERK Deutsch als Fremdsprache A1(Goyal, New Delhi, 2015)
3. Japanese from Zero!, Book 1 by George Trombley, Yukari Takenaka

References:

1. Best Books for Learning French By David Issokson
2. Easy Spanish Step-By-Step By Barbara Bregstain

MOOC Courses:

1. https://onlinecourses.nptel.ac.in/noc21_hs30/preview
2. https://nptel.ac.in/courses/109106166
3. https://nptel.ac.in/courses/109106085

e-Resources:

1. https://www.coursera.org/browse/language-learning
2. https://alison.com/?utm_source=google&utm_medium=cpc&utm_campaign=PPC_Tier-4_First-Click_Courses-_Broad_&utm_adgroup=Product_Courses&gclid=CjwKCAjwhdWkBhBZEiwA1ibLmIZPl30Tg6Zd7UDPSU2vcB2J1doDOAi9SnBCElqJWK2_Hhdfo2iCSRoCGwkQAvD_BwE
3. FACTS ABOUT GERMANY   https://www.tatsachen-ueber-deutschland.de/en
4. ONLINE GERMAN-ENGLISH DICTIONARY www.leo.org
5. PRACTICE MATERIAL https://www.goethe.de/en/spr/kup/prf/prf/sd1/ueb.html

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417537: Audit Course 8
AC8-V: MOOC-Learn New Skills

Course Objectives:
- To promote interactive user forums to support community interactions among students, professors, and experts
- To promote learn additional skills anytime and anywhere
- To enhance teaching and learning on campus and online

Course Outcomes:

After completion of the course, learners should be able to-

CO1: To acquire additional knowledge and skill

CO2: Explore new areas of interest in a relevant field

Course Contents

MOOCs (Massive Open Online Courses) provide affordable and flexible ways to learn new skills, pursue lifelong interests and deliver quality educational experiences at scale. Whether you're interested in learning for yourself, advancing your career or leveraging online courses to educate your workforce, SWAYAM, NPTEL, edx or similar ones can help. World's largest SWAYAM MOOCs, a new paradigm of education for anyone, anywhere, anytime, as per your convenience, aimed to provide digital education free of cost and to facilitate hosting of all the interactive courses prepared by the best more than 1000 specially chosen faculty and teachers in the country. SWAYAM MOOCs enhance active learning for improving lifelong learning skills by providing easy access to global resources. SWAYAM is a programme initiated by the Government of India and designed to achieve the three cardinal principles of Education Policy viz., access, equity and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. This is done through an indigenous developed IT platform that facilitates hosting of all the courses, taught in classrooms from 9th class till post-graduation to be accessed by anyone, anywhere at any time. All the courses are interactive, prepared by the best teachers in the country and are available, free of cost to the residents in India. More than 1,000 specially chosen faculty and teachers from across the Country have participated in preparing these courses. The courses hosted on SWAYAM are generally in 4 quadrants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multimedia and state of the art pedagogy / technology. In order to ensure best quality content is produced and delivered, seven National Coordinators have been appointed: They are NPTEL for engineering and UGC for post-graduation education. Guidelines: Instructors are requested to promote students to opt for courses (not opted earlier) with proper mentoring. The departments will take care of providing necessary infrastructural and facilities for the learners. Learning can also be more interesting by knowledge sharing through different blogs, learning communities and social media platforms.

References:
1. https://swayam.gov.in/
2. https://onlinecourses.nptel.ac.in/
3. https://www.edx.org
4. https://www.mygreatlearning.com/academy
5. https://www.simplilearn.com

Guidelines for Conduction and Assessment (Any one or more of following but not limited to):

• Lectures/ Guest Lectures	• Surveys
• Visits (Social/Field) and reports	• Mini-Project
• Demonstrations	• Hands on experience on focused topic

A report of 15-20 pages contains any of the activity details mentioned above.

Task Force Curriculum Design

Advisory Members and Members of Board of Studies

Dr. Nilesh J. Uke (Chairman)	Dr. Amol D. Potgantwar	Dr. Sachin D. Babar
Dr. Pramod D. Patil	Dr. Vandana Dhingra	Dr. Deepali M. Ujalambkar
Dr. Sachin R. Sakhare	Dr. Balwant A. Sonkamble	Dr. Dipti D. Patil,
Dr. Vaishali V. Vikhe	Dr. Pradip M. Jawandhiya	Dr. Suhasini A. Itkar
Dr. Dhananjay B. Kshirsagar	Dr. Dipak V. Patil	Dr. Sandip G. Deshmukh

Compilation
Dr. Darshan Medhane

Teams for Course Design

Name of Course	Team Coordinator	Team Members	
Machine Learning	Dr. M. A. Thalor	Dr. K. R Nirmal Pradnya Bachhav P.A. Puranik S. V. Gavhane A. S. More	Dr. P. A. Bailke V. G. Kshirsagar Kushal Sharma B. C. Garaware Tushar Kute K. A. Patil
Data Modeling & Visualization	Dr. Araddhana Deshmukh	Shubhangi Suryavanshi Nachiket Kulkarni Dr. Sujata Rao	Devyani Bonde Sankalp Giridhar
Elective III: Quantum Artificial Intelligence	Dr. A. Y. Chaudhari	Dr. H. B. Jadhav Sita Yadav P. B. Koli Manjusha Tatiya	Dr. Harsh Sahu Dr. Amit Saxena Uma Karanje Dr. Preeti Mulay Lahare Prasad
Elective III: Industrial Internet of Things	Dr. Suvarna Patil	Pallavi Yevale Dr. M. V. Kadam C. S. Bhosale Rohini Hanchate D. S. Bhadane A. P. Shinde	Swati Tawade Swati Jaiswal Sagar Kharde Dr. M. V. Kadam Dr. Manisha Bhende
Elective III: Enterprise Architecture and Components	Pooja Mishra	Pooja Mishra P. P. Shevatekar Dipesh Agrawal Dr. Sagar Rane	Arpit Yadav Mily Lal Parinita Chate
Elective III: Bioinformatics	Dr. V. V. Puri	Dr. Brijendra Gupta Dr. Yogita Sinkar J. K. Rajput Dr. Monika Rokade N. V. Sharma	Dr. M. Venkatramana Dr. H. N. Singh Dr. P. D. Kunde Dr. S. B. Mane Pritam Ahire
Elective IV: GPU Programming and Architecture	S. A. Agrawal	Dr. J. R. Pansare Dr. Shrinivas Sonkar Shubhangi Suryawanshi D. J. Bonde	Swapnil Ingale V. U. Rathod S. B. Shinde
Elective IV: Information Retrieval	Dr. Naresh Thoutam	Dr. Yogendra Patil Vinay Nalawade Kuldeep Hule Sagar Rajebhosale	Dr. Shraddha Konde Dr. Rajesh Phursule T. Bhaskar

Elective IV: Optimization Algorithms	Digambar Padulkar	Dr. Ajitkumar Shitole Dr Pushkar Joglekar	Santosh Kalegore Dr. Amol Admuthe
Computer Laboratory I	Dr. Meenakshi A.Thalor	N. B. Madke Sneha Salvekar Chetan Patil Shwetal Patil Devyani Bonde	Dr. Araddhana Deshmukh Shubhangi Suryavanshi Nachiket Kulkarni Dr. Sujata Rao Sankalp Giridhar
Computer Laboratory II	Dr. Suvarna Patil	Pallavi Yevale Dr. A. Y. Chaudhari Pooja Mishra Dr. V. V. Puri	Dr. D. V. Medhane S. A. Agrawal Digambar Padulkar Dr. Naresh Thoutam
Audit Course 7	Dr. Latika R. Desai	Dr. Brijendra Gupta	Jameer Kotwal
Computational Intelligence	Dikshendra Sarpate	V. G. Kshirsagar Manjusha Tatiya Sinu Nambiar Dr. Swapnaja Ubale	Milind Ankaleshwar Dipak Pawar Dr. Nilesh Sable Lahare P. A.
Distributed Computing	Dr. Rajiv R. Bhandari	P. B. Koli S. M. Chitalkar Arya Singh Nilesh Sharma Dr. Shivaji Lahane	Rahul Kotecha Sagar Ikhankar Swanand Sathe Dr. Devyani Bhamare Surbhi Pagar
Elective V: Virtual Reality and Game Development	Shubhangi Vairagar	Priyanka Savadekar Deptii Chaudhari	Yogita Hande Sukesh Kohari Sandip Hire
Elective V: Big Data analytics	Dr. Priya Pise	B. A. Khivsara V. R. Vasekar R. N. Wagh Dr. Saurabh Saoji	Ajit Lande Santosh Chavan Manisha R. Patil
Elective V: Software Development for Portable Devices	Dr. Nisha Auti	Kuldeep Hule Pooja Patil Dr. Kalpana Metre	Ishwari Pund T. Bhaskar Renuka Vaidya
Elective V: Deep Learning	Jameer Kotwal	Aparna Kulkarni	Sharad Adsure
Elective VI: Augmented Reality	Lahare P. A.	V. K. Abhang Manisha Patil R. D. Ghode S. G. Chordiya	Abhinandan Satpute Yogesh Kawade A. S. Pingle
Elective VI: Business Intelligence	Kapadnis J. Y.	V. S. Nalawade D. S. Bhadane Sarika Pawar	S. A. Shivarkar B. A. Khivsara Vipin Wani
Elective VI: Information Systems Management	Dr. M. A. Wakchaure	G. P. Mohole P. P. Ghorpade	Deepali Shinde S. B. Patil
Elective VI: Reinforcement Learning	Ingale V. S.	Agrawal R. A.	Kokane C. D.
Computer Laboratory III	Dr. Rajiv R. Bhandari	Dikshendra Sarpate	
Computer Laboratory IV	Dr. M. A. Wakchaure	Shubhangi Vairagar Dr. Priya Pise Dr. Nisha Auti	Ingale V. S. Kapadnis J. Y. Lahare P. A. Jameer Kotwal

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