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)

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	Mid-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
	Audit Course 7													
										Total Credit	**12**	**06**	**02**	**20**

Elective III:

- Quantum Artificial Intelligence
- Industrial Internet of Things
- Enterprise Architecture and Components
- Bioinformatics

Elective IV:

- GPU Programming and Architecture
- Information Retrieval
- Design Thinking
- Optimization Algorithms

Computer Laboratory I:

It is based on two compulsory subjects:

- Machine Learning
- Data Modeling & Visualization

Computer Laboratory II:

It is based on two Elective subjects:

- Elective III
- Elective IV

Audit Course 7:

- Block Chain
- Entrepreneurship Development
- Botnet of Things
- Foreign Language
- MOOC-Learn New Skills

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	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral/ Presentation	Total	Lecture	Practical	Tutorial	Total
417529	Computational Intelligence	03	-	-	30	70	-	-	-	100	03	--	-	03
417530	Distributed Computing	03	-	-	30	70	-	-	-	100	03	-	-	03
417531	Elective V	03	-	-	30	70	-	-	-	100	03	-	-	03
417532	Elective VI	03	-	-	30	70	-	-	-	100	03	-	-	03
417533	Computer Laboratory III	-	02	-	-	-	50	25	-	75	-	01	-	01
417534	Computer Laboratory IV	-	02	-	-	-	50	25	-	75	-	01	-	01
417535	Project Stage II	-	12	-	-	-	100	-	50	150	-	06	-	06
	Total	12	16	-	120	280	200	50	50	700	12	08		20
	Audit Course 8													
										Total Credit	**15**	**05**	**02**	**20**

Elective V:

- Virtual Reality and Game Development
- Big Data analytics
- Software Development for Portable Devices
- Deep Learning

Elective VI:

- Augmented Reality
- Business Intelligence
- Information Systems Management
- Reinforcement Learning

Computer Laboratory III:

It is based on two compulsory subjects:

- Computational Intelligence
- Distributed Computing

Computer Laboratory IV:

It is based on two Elective subjects:

- Elective V
- Elective VI

Audit Course 8:

- Usability Engineering
- Conversational Interfaces
- Social Media and Analytics
- Foreign Language
- MOOC-Learn New Skills

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

Prerequisites Courses: Statistics (), Computer Graphics (), Database Management Systems ()

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	07 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	07 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**	**07 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**	**07 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**	**07 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**	**07 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 Editors Handbook of Data Visualization, Springer
2. Visualizing Data Ben Fry Beijing , Published by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
3. Fundamentals of Data Visualization - A Primer on Making Informative and Compelling Figures , Clous O.Wilke , Published by O'Reilly Media, Inc.
4. Data Visualization - A Practical Introduction by Kieran Healy
5. McKinney, W.(2017). 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 ed. 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 ed. 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 ed. Cambridge, UK: Cambridge University Press, 2006. ISBN: 9780521867061
2. Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin. Bayesian Data Analysis. 2nd ed. New York, NY: Chapman & Hall, 2003. ISBN: 9781584883883
3. David Dietrich, Barry Hiller, "Data Science and Big Data Analytics", EMC education services, Wiley publication, 2012, ISBN0-07-120413-X
4. Trent Hauk, "Scikit-learn Cookbook", Packt Publishing, ISBN: 9781787286382
5. Chirag Shah, "A Hands-On Introduction To Data Science", Cambridge University Press, (2020), ISBN: 978-1-108-47244-9
6. S.C. Gupta, V.K. Kapoor,"Fundamentals of Mathematics Statistics (A Modern Approach) " Sultan Chand & Sons Educational Publishers, Tenth revised edition , ISBM: 81-7014-791-3
7. Medhi "Statistical Methods: An Introductory Text", Second 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)

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	07 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	07 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**	**07 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**	**07 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**	**07 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**	**07 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. (2002): "Quantum Computation and Quantum Information"
2. Lipton and Reagan's Quantum Algorithms via Linear Algebra: A Primer
3. Kaye, LaFlamme and Mosca's "Introduction to Quantum Computing"
4. Biamonte, J. et al. (2017): Quantum Machine Learning. Nature, 549(7671):195-202
5. Andreas Wichert " Principles Of Quantum Artificial Intelligence"

Reference Books:

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

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)

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)	07 Hours

Introduction to IIOT, History of IIOT, IOT Vs. IIOT, The Various Industrial Revolutions, Role of Internet of Things (IoT) & Industrial Internet of Things (IIoT) in Industry, Smart Factories, Role of IIOT in Manufacturing Processes, Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges, Benefits in implementing IIOT, Applications of IIOT

#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	07 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, Communication and Networking of IIoT-Wireless Sensor nodes with Bluetooth, WiFi, and LoRa Protocols and IoT Hub systems, Zigbee, Z wave, Bacnet, BLE, Modbus, SPI , I2C, The field bus, Industrial automation: PLC and SCADA ICS Protocol: Ethernet IP, Modbus TCP/IP, ProfiNet, DNP3, EtherCAT, CCLink IE and OPC UA		
#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**	**07 Hours**
Overview of IIOT components including Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT, Architecture of Industrial IoT: Business Model and Reference Architecture, 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**	**07 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: IoT Analytics, Role of 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**	**07 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. Security model for IoT, Trust–Trust and Trust Models for the IoT, IoT security tomography and layered attacker model, 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**	**07 Hours**

Applications: - Smart Robotics, Smart Metering, Smart Irrigation, Smart Manufacturing (Lean manufacturing).

Use Cases: - Healthcare, Smart Office, Smart Logistics, IOT Innovations in Retail, Cyber Manufacturing Systems.

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. Industrial Internet of Things Technologies and Research Directions, Anand Sharma, Sunil Kumar Jangir, Manish Kumar, Dilip Kumar Choubey, Tarun Shrivastava, S. Balamurugan, CRC press
2. Veneri, Giacomo, and Antonio Capasso- Hands-on Industrial Internet of Things: Create a Powerful Industrial IoT Infrastructure Using Industry 4.0, 1stEd., Packt Publishing Ltd, 2018
3. Industry 4.0: The Industrial Internet of Things Alasdair GilchristPublications: Apress

Reference Books:

1. Alasdair Gilchrist- Industry 4.0: The Industrial Internet of Things, 1st Ed., Apress, 2017. 2. Reis, Catarina I., and Marisa da Silva Maximiano, eds.- Internet of Things and advanced application in Healthcare, 1st Ed., IGI Global, 2016
2. S. Misra, C. Roy, and A. Mukherjee, 2020. Introduction to Industrial Internet of Things and Industry 4.0. CRC Press
3. Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance, R. Anandan, Suseendran Gopalakrishnan, Souvik Pal, Noor Zaman, 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. 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	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:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

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

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	07 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	07 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**	**07 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**	**07 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**	**07 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**	**07 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. "Enterprise Architecture at Work: Modeling, Communication and Analysis" by Marc Lankhorst and others
2. Enterprise Architecture "The Art and Practice of Business " by Neal McWhorter
3. Metadata Management for Information Control and Business Success" Author: David Marco, Publisher: Wiley Year: 2013

Reference Books:

1. “Collaborative Enterprise Architecture”, by Stefan Bente, Uwe Bombosch, Shailendra Langade
2. “Enterprise Architecture at Work”, Lankhorst, Marc
3. “Enterprise Architecture for Digital Business" by Neal McWhorter
4. An Introduction to Enterprise Architecture: Third Edition" by Scott A. Bernard

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. https://www.udemy.com/course/the-practice-of-enterprise-architecture-part-i/
3. 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)

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	07 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	07 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	07 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**	**07 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**	**07 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**	**07 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 Ed”, CBS Publishing, 2016. ISBN: 9788123914824
2. Cynthia Gibas and Per Jambeck (2001), “Developing Bioinformatics Computer Skills” O’Reilly press, Shorff Publishers and Distributors Pvt. Ltd., Mumbai
3. Mario Cannataro, Pietro Hiram Guzzi, & others(2022), “Artificial Intelligence in Bioinformatics”, Elsevier Science
4. Bourne PE, Weissig H (2003) Structural Bioinformatics (Methods of Biochemical Analysis, V. 44). Wiley-Liss Publisher

Reference Books:

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

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

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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:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	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	07 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	07 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	07 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**	**07 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**	**07 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**	**07 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)”, First 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, Third 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:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

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

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: To 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	
***Mapping of Course Outcomes for Unit I**	CO1

Unit II	Dictionaries and Query Processing	07 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	07 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**	**07 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		
***Mapping of Course Outcomes for Unit IV**	CO4	
Unit V	**Web Retrieval and Web Crawling**	**07 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**	**07 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

Learning Resources

Text Books:

1. C. Manning, P. Raghavan, and H. Schütze, ―Introduction to Information Retrieval‖, Cambridge University Press, 2008, -13: 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", Cambridge University Press(2011), 1st ed.

Reference Books:

1. Manouselis N., Drachsler H., Verbert K., Duval E., "Recommender Systems For Learning", Springer (2013), 1st ed.
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

@The CO-PO Mapping Matrix

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): Design Thinking

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

Prerequisites Courses: Artificial Intelligence (310253), Human Computer Interface

Course Objectives:

- Understand the concepts of design thinking approaches
- Create design thinking teams and conduct design thinking sessions
- Apply both critical thinking and design thinking in parallel to solve problems
- Demonstrate Design Thinking for Creativity and Innovation
- Inculcate the fundamental concepts of design thinking
- Develop the students as a good designer by imparting creativity and problem-solving ability

Course Outcomes:

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

CO1: Understand the fundamentals of Design Thinking concepts, process, and principles

CO2: Identify the methods to empathize and define the problem

CO3: Apply the ideation techniques for problem solving

CO4: Construct the prototype to evaluate a design

CO5: Interpret various techniques for testing to improve the performance

CO6: Analyse the Design Thinking approach and model to real world situations

Course Contents

Unit I	Introduction to Design Thinking and Design Mindset Transformation	07 Hours

Introduction to Design Thinking, What is Design, Elements of a Good Design, Various Approaches to Design, The Laws of Design Thinking, Power of Visualization, Impediments in achieving visualized state, Methods to overcome, “Design the Thinking®” Framework (13 Musical Notes) for Design Mindset Transformation, ‘5 Minds Framework©’ for developing leadership mindset, Introduction to the Design Thinking Process.

#Exemplar/Case Studies	Design Thinking to enhance urban redevelopment. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/how-singapore-is-harnessing-design-to-transform-government-services https://www.mygreatlearning.com/blog/how-is-singapore-reshaping-using-design-thinking/
***Mapping of Course Outcomes for Unit I**	CO1

Unit II	Developing Empathy & Defining the Problem	07 Hours

Importance of Empathy, Methods to get user-insights, Empathy Mapping, Persona Tool for better understanding of end-users, Journey Mapping to enhance the end-user experience, User Needs, LORD

Framework for cultivating Empathy, Asking the Right Questions, Reformulation / Redefining the problem, Root Cause Analysis for correct diagnosis of the problem

#Exemplar/Case Studies	The Good Kitchen Case Study https://static1.squarespace.com/static/590a5acf15d5dba8afd18da5/t/594abe1536e5d33ac51e674a/1498070559056/Rotman+Good+Kitchen.pdf
***Mapping of Course Outcomes for Unit II**	CO2

Unit III	**Idea Generation & Importance of Storytelling**	**07 Hours**

Importance of Brainstorming, Visual metaphors, Random Association Techniques, Leveraging Constraints for Creative Outcomes, Additional Idea Generation Techniques (Signs, Humor, Words, Language, Shapes), Evaluation of Ideas using Theory of Prioritization, QBL Classification of Ideas, Storytelling & Communication, Elevator Pitches, Techniques for Storytelling

#Exemplar/Case Studies	Tackling the insurgency problem in Columbia applying Design Thinking https://dtleadership.my/wp-content/uploads/2019/02/solvingproblemswithdesignthinking_preview.pdf
***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Prototype**	**07 Hours**

Prototype Phase - Lean Startup Method for Prototype Development, Visualization and presentation techniques, Ideas to presentable concepts, Storyboards, Developing mock-ups, models and prototypes, Quick and Dirty Prototyping

#Exemplar/Case Studies	Developing environmentally sustainable strategy https://www.oecd.org/dac/environment-development/2669958.pdf
***Mapping of Course Outcomes for Unit IV**	CO4

Unit V	**Testing and Validation**	**07 Hours**

Test Phase – Technique for interviews and surveys, Kano Model, Desirability Testing, Presenting Prototypes, testing prototypes, obtaining feedback to refine product Usability and Ergonomic testing

#Exemplar/Case Studies	Verify your idea in real life with actual users. Get feedback. Ask questions on how to improve it.
***Mapping of Course Outcomes for Unit V**	CO5

Unit VI	**Design Thinking for Strategic Innovation**	**07 Hours**

Design and Innovation as an Organizational Strategy: Design Thinking meets the corporation, Design Thinking a systematic approach to innovation, using design thinking to manage an innovation portfolio, Transforming Organization, The New Social Contract, Design Activism, Designing tomorrow

#Exemplar/Case Studies	1) Scaling design thinking in the enterprise https://www.infosys.com/insights/renew-new/Documents/design-thinking.pdf 2) 8012 FinTech Design Center (Design Thinking in Action @ Intellect Design Arena Ltd.) – A Case Study https://www.youtube.com/watch?v=DWpXniAoK6M
***Mapping of Course Outcomes for Unit VI**	CO6

Learning Resources

Text Books:

1. "Design Thinking", Gavin Ambrose, Paul Harris, AVA Publishing
2. "Handbook of Design Thinking - Tips & Tools for how to design thinking", Christian Mueller-Rotenberg.
3. "Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation" by Tim Brown
4. "UnMukt - SCIENCE AND ART OF DESIGN THINKING" by Arun Jain
5. "Designing for growth: A design thinking tool kit for managers", by Jeanne Liedtka and Tim Ogilvie., 2011, ISBN 978-0-231-15838-1
6. John R. Karsnitz, Stephen O'Brien and John P. Hutchinson, "Engineering Design", Cengage learning (International edition) Second Edition, 2013.
7. Roger Martin, "The Design of Business: Why Design Thinking is the Next Competitive Advantage", Harvard Business Press, 2009.

Reference Books:

1. "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", Idris
2. "The design thinking playbook: Mindful digital transformation of teams, products, services, businesses and ecosystems", by Michael Lewrick, Patrick Link, Larry Leifer., 2018, ISBN 978-1-119-46747-2
3. "Presumptive design: Design provocations for innovation", by Leo Frishberg and Charles Lambdin., 2016, ISBN: 978-0-12-803086-8
4. "Systems thinking: Managing chaos and complexity: A platform for designing business architecture.", "Chapter Seven: Design Thinking", by Jamshid Gharajedaghi, 2011, ISBN 978-0-12-385915-0
5. Hasso Plattner, Christoph Meinel and Larry Leifer (eds), "Design Thinking: Understand – Improve– Apply", Springer, 2011
6. Idris Mootee, "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", John Wiley & Sons 2013.

e-Resources:

1. https://www.mindtools.com/brainstm.html
2. https://www.quicksprout.com/how-to-reverse-engineer-your-competitors-backlinks/
3. https://www.vertabelo.com/blog/reverse-engineering/
4. https://support.google.com/docs/answer/179740?hl=en
5. https://dschool.stanford.edu/use-our-methods/
6. https://www.interactiondesign.org/literature/article/5-stages-in-the-design-thinking-process
7. http://www.creativityatwork.com/design-thinking-strategy-for-innovation
8. https://www.nngroup.com/articles/design-thinking

MOOC Courses:

1. https://onlinecourses.nptel.ac.in/noc19_mg60/preview (AICTE Approved FDP)
2. https://executive.mit.edu/course/mastering-design-thinking/a056g00000URaa4AAD.html

The CO-PO Mapping Matrix

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

CO4	1	1	2	2	2	2	2	1	2	1	1	1
CO5	1	1	2	2	2	-	-	1	2	-	1	1
CO6	1	1	2	2	2	-	-	1	2	-	1	1

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

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

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

Course Objectives:

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Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:
CO5:
CO6:

Course Contents

Unit I	Unit	07 Hours
#Exemplar/Case Studies		
*Mapping of Course Outcomes for Unit I	CO1	

Unit II	Unit	07 Hours
#Exemplar/Case Studies		
*Mapping of Course Outcomes for Unit II	CO2	

Unit III	Unit	07 Hours
#Exemplar/Case Studies		

***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Unit**	**07 Hours**

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

Unit V	**Unit**	**07 Hours**

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

Unit VI	**Unit**	**07 Hours**

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

Learning Resources

Text Books:

1.

Reference Books:

1.

e-Resources:

1.

MOOC Courses:

1.

@The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												

CO2												
CO3												
CO4												
CO5												
CO6												

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

Teaching Scheme: Practical: 4 Hours/Week	Credit: 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 50 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: ***On completion of the course, learners should be able to***

- Implement regression, classification and clustering models
- Integrate multiple machine learning algorithms in the form of ensemble learning.
- Apply reinforcement learning and its algorithms for real world applications.
- Analyze the characteristics, requirements of data and select an appropriate data model.
- Apply data analysis and visualization techniques in the field of exploratory data science
- 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 (Perform any 6 assignments)	
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 (Perform any 6 Assignments)	
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.
Part III: Mini Project (Mandatory Assignments)	
14	**Mini Project (Mandatory- Group Activity)** It is recommended that group of 3 to 5 students should undergo a mini project (considering the Machine Learning and Data modeling and Visualizing concepts) as content beyond syllabus. Some of the problem statements are mentioned below: 1. Development of a happiness index for schools (including mental health and well-being parameters, among others) with self-assessment facilities. 2. Automated Animal Identification and Detection of Species 3. Sentimental analysis on Govt. Released Policies

4. Identification of Flood Prone Roads
5. Identification of Missing Bridges which would increase the connectivity between regions

Note: Instructor can also assign similar problem statements

References:

For Dataset https://data.gov.in/

For Problem statements: https://sih.gov.in/sih2022PS

Learning Resources

Text Books:

1. Ethem Alpaydin, "Introduction to Machine Learning", PHI 2nd Edition-2013
2. Peter Flach: "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, Edition 2012.
3. Chun-houh Chen Wolfgang Härdle Antony Unwin Editors Handbook of Data Visualization, Springer
4. Visualizing Data Ben Fry Beijing, OPublished by O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
5. McKinney, W. (2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython. 2nd edition. O'Reilly Media.
6. O'Neil, C., & Schutt, R. (2013). Doing Data Science: Straight Talk from the Frontline O'Reilly Media.

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. Gelman, Andrew, and Jennifer Hill. Data Analysis Using Regression and Multilevel/ Hierarchical Models. 1st ed. 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 ed. New York, NY: Chapman & Hall, 2003. ISBN: 9781584883883.
5. Gelman, Andrew, and Jennifer Hill. Data Analysis Using Regression and Multilevel /Hierarchical Models. 1st ed. Cambridge, UK: Cambridge University Press, 2006. ISBN: 9780521867061.
6. Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin. Bayesian Data Analysis. 2nd ed. New York, NY: Chapman & Hall, 2003. ISBN: 9781584883883.

e-resources:

1. https://timeseriesreasoning.com/
2. Reinforcement Learning https://www.cs.toronto.edu/~urtasun/courses/CSC411_Fall16/19_rl.pdf
3. 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

MOOCs Courses Links:

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	PO 10	PO 11	PO 12
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: Practical: 4 Hours/Week	Credit: 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite 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 board.
2. Perform total 5 experiments (Group A) and one mini-project (Group B)

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

Group A

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

Group B

Develop any one of following Mini Project-

1. Configure quantum glasses for basic application implementation.
2. Covid 19 detection on IBM computer with classical quantum transfer learning.
3. Use Shor's Algorithm to Factor a Number.
4. Implement Grover's Search Algorithm.
5. or any suitable advanced mini project

Learning Resources

Reference Books:

1. Nielsen, M. & Chuang I. (2002): Quantum Computation and Quantum Information.
2. Biamonte, J. et al. (2017): Quantum Machine Learning. Nature, 549(7671):195-202.
3. Rieffel, E. G., & Polak, W. H. (2011). Quantum computing: A gentle introduction. MIT Press.
4. Kaye, P., Laflamme, R., & Mosca, M. (2007). An introduction to quantum computing. Rinton Press.
5. Farhi, E., Goldstone, J., & Gutmann, S. (2014). A quantum approximate optimization algorithm. arXiv preprint arXiv:1411.4028.

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:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite 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, learner 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: Use the technology behind IIOT to develop real applications and improve them through smart technologies

Instructions:

1. Practical work can be performed on a suitable development board (Arduino/ Raspberry pi)
2. Perform total 5 experiments from Group A and one mini-project from Group B

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

Group A

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

Group B

Develop any one of following Mini Project-

1. Smart Parking System
2. IIoT based smart energy meter
3. Smart Agriculture system
4. Automation using controller via Bluetooth
5. TEMPERATURE CONTROLLED FAN /COOLER USING CONTROLLER
6. Automatic street light
7. Smart Baggage Tracker
8. Build a small sensor network using Raspberry Pis and various sensors (e.g. temperature, humidity, vibration, etc.) to monitor a small manufacturing process. You can use a platform like Node-RED to visualize and analyze the data collected by the sensors.
9. or any suitable advanced mini project to build IIOT system

Learning Resources

Text Books:

1. The Internet of Things in the Industrial Sector, Mahmood, Zaigham (Ed.) (Springer Publication)
2. Industrial Internet of Things: Cybermanufacturing System, Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer Publication)
3. Industrial IoT Challenges, Design Principles, Applications, and Security by Ismail Butun (editor)

Reference Books:

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

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

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

Teaching Scheme:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite Courses:

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, learner will be able to–

CO1: Design Enterprise Architecture framework using tools

CO2: Build various reports based on Enterprise Architecture

Instructions:

1. Perform total 5 experiments Group A and one mini-project (Group B)

List of Assignments

Group A

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

Group B

Develop any one of following Mini Project-

1. Cost reduction analysis for an application landscape in a corporate environment

Mini project consists of the following activities:

- Analysis of the existing EA management practices and status of the current EA
- Project planning
- Meetings with stakeholders
- Information collection
- Creation of EA deliverables (meta models, models, process descriptions, recommendations)

2. Design and implement a metadata and master data management strategy for an organization considering data quality, consistency and integrity

Learning Resources

Text Books:

1. "Modeling Enterprise Architecture with TOGAF: A Practical Guide Using UML and BPMN" , Philippe Desfray , Gilbert Raymond, Morgan Kaufmann; 1st edition (4 August 2014)
2. "Business Architecture: The Art and Practice of Business Transformation" , Neal McWhorter, William Ulrich, Meghan-Kiffer Press,ISBN : 0929652150

Reference Books:

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

Online references:

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:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite Courses: Statistics (), Artificial Intelligence (), Data science ()

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, learner will be able to–

CO1: Evaluate and Apply suitable datasets to various problems.

CO2: Demonstrate and apply appropriate Bioinformatics tools.

Instructions:

Practical can be performed on suitable development board.

Perform total 4 experiments (Group A) and one mini-project (Group B)

List of Assignments

Group A

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.

Group B

Mini Project List Task:

Develop a project proposal in the field of bioinformatics, focusing on a specific research question or problem, and outline the experimental design and analysis approaches.

Deliverable: A written research proposal detailing the research objectives, methodology, expected outcomes, and a timeline for the project. Develop any one of following Mini Project.

1. 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.

2. 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.

3. Bioinformatics in Medical Imaging.

Task: Utilize bioinformatics approaches to analyze medical images, such as MRI or CT scans, for disease diagnosis or treatment response assessment. Deliverable: A report describing the image analysis techniques applied, the findings related to the medical condition, and the potential implications for personalized medicine.

4. Deep Learning-based Clustering Approaches for Bioinformatics.

Learning Resources

Text Books:

1. S.C. Rastogi & others, “Bioinformatics- Concepts, Skills, and Applications 2 nd Ed”, CBS Publishing, 2016. ISBN: 9788123914824.
2. Cynthia Gibas and Per Jambeck (2001), “Developing Bioinformatics Computer Skills”. O’Reilly press, Shorff Publishers and Distributors Pvt. Ltd., Mumbai.

Reference Books:

1. Jean-Michel Claverie and Cedric Notredame (2003) Bioinformatics – A Beginners Guide. Wiley – Dreamtech India Pvt. Ltd.
2. Zoe’Lacroix and critchlow. Bioinformatics: Managing scientific data. Morgan Kaufmann Publishers 2004
3. Discovering Genomics, Proteomics and Bioinformatics Campbell AM and Heyer LJ Perason Education (Low priced Editions) 2003

e-Books:

http://www.bioinformatics.org/

http://www.bioinfo.mbb.yale.edu/mbb452a/intro/

MOOC Courses:

https://archive.nptel.ac.in/courses/102/106/102106065/

https://www.udemy.com/course/genetics-and-next-generation-sequencing-forbioinformatics/

The CO-PO Mapping Matrix

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

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

Teaching Scheme: Practical: 4 Hours/Week	Credit: 02	Examination Scheme and Marks Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite 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, students 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 board.
2. Perform total 5 experiments Group A and one mini-project from Group B

List of Assignments

Group A

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.

Group B

Develop any one of following Mini Project-

1. Implement Huffman Encoding on GPU
2. Image processing Application using CUDA programming
3. Parallel Algorithm for Searching (Min two)
4. Parallel Algorithm for Sorting (Min two)

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 ISBN 978-1-4612-1220-1
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:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite Courses:

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

Course Objectives:

1. To understand the concepts of information retrieval and web mining.
2. 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:
Any 5 assignments from group A and 1 Mini project from group B is mandatory

List of Assignments

Group A

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.

Group B

Develop any one of following Mini Project-

1. Develop Document summarization system.
2. Develop Tweet sentiment analysis system.
3. Develop Fake news detection system.

Learning Resources

Text Books:

1. C. Manning, P. Raghavan, and H. Schütze, ―Introduction to Information Retrieval‖, Cambridge University Press, 2008, -13: 9780521865715
2. Ricardo Baeza-Yates, Berthier Riberio–Neto, Modern Information Retrieval, Pearson Education, ISBN: 81-297-0274-6
3. C.J. Rijsbergen, Information Retrieval, (www.dcs.gla.ac.uk), Second 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: Design Thinking

Teaching Scheme:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite Courses: Artificial Intelligence (), Human Computer Interface ()

Companion Course: Elective IV: Design Thinking (417524(C))

Course Objectives:

- Apply both critical thinking and design thinking in parallel to solve problems
- Conceive, conceptualize, design and demonstrate innovative ideas using prototypes

Course Outcomes:

On completion of the course, learner will be able to–

CO1: Apply the Design Thinking techniques for problem solving

CO2: Construct the prototype to evaluate a design

CO3: Integrate the Design Thinking approach and model to real world situations

Instructions:

1. Practical can be performed on suitable development board.
2. Perform any 6 experiments from Group A and mini-project from Group B

List of Assignments

Group A

1. Pick any mobile application which you frequently use & identify what can be changed in functionality/process/menus OR any other thing so that it becomes an example of good Design. Identify an example of a bad design.
2. Empathetic design-Students (in groups) can visit one area of campus such as the reception lobby/canteen/classroom/main gate and simply observe. Spend a good amount of time in that one area. Come up with what you observed. If possible, interact with a few people and prepare a design of what you have observed using any empathetic design method.
3. Ideation-Students (in groups) can pick any problem in campus OR society and ideate on how to solve it. The group needs to come up with at least 30 ideas.
4. Storytelling-Students (in groups) can visualize themselves as founders of any startup (like Paytm, Google Pay OR MakeMyTrip, OR anything). Think that students (in groups) are going to pitch their idea to their investor. What elevator pitch will they think? Define the story for the same.
5. For any exemplar/case study based on a real-world scenario, identify the category of prototype and perform prototype testing.
6. Assume that you are part of a FinTech company. You can plan to give a short case study of 4-5 pages that explains how Design Thinking has been applied in your company & how you have tried to bring innovation to your organization.

Group B

Mini-project: Design an Intelligent AI Agent for any of the following products using Design Thinking tools like Visualization, Journey mapping (or experience mapping), Value chain analysis, Mind mapping, Rapid concept development, Assumption testing, Prototyping, Customer co-creation, Learning launches, Storytelling, etc.

1. Ceiling Fan Cleaning System
2. Mineral Water Can Lifting
3. Coconut Harvesting Device
4. Water Cooler for Indian Truck Drivers
5. Device for reaching top layers of Modular Kitchen
6. Footwear Cleaning and Polishing Device
7. Mixer Grinder for Rural Area
8. Automatic Toilet Bowl Cleaning System
9. Automatic Wet Floor Marking System
10. Working Mother Friendly Cradle

Note: Instructor should maintain progress report of mini-project throughout the semester by project groups.

Learning Resources

Text Books:

1. "Design Thinking", Gavin Ambrose, Paul Harris, AVA Publishing
2. "Handbook of Design Thinking - Tips & Tools for how to design thinking", Christian Mueller-Rotenberg
3. "Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation" by Tim Brown
4. "UnMukt – Science and Art of Design Thinking" by Arun Jain

Reference Books:

1. "Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School", Idris Mootee, John Wiley and Sons Publication

MOOC Courses:

1. https://onlinecourses.nptel.ac.in/noc19_mg60/preview (AICTE Approved FDP)
2. https://executive.mit.edu/course/mastering-design-thinking/a056g00000URaa4AAD.html

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	2	1	1	1
CO2	1	1	2	2	2	2	2	1	2	1	1	1
CO3	1	1	2	2	2	-	-	1	2	-	1	1

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

Teaching Scheme:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Practical (PR): 50 Marks

Prerequisite Courses:

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, learner 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 board.
2. Perform any 9 assignments (from 1 to 11 any 8 and 9th is compulsory) and one mini project

Virtual Laboratory:

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

List of Assignments

Group A

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/-

Write a python program to maximize the function $f(x) = 2x_1 + 3x_2 - x^2{}_1 + x_2{}^2$ 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

Write a python program to minimize the flow from source **S** to the destination **D** in a multi-stage graph with a property $|v_1| = |v_n| = 1$, Here v_1 and v_2 are the partitions of the graph G and no connecting edge in the same partition. Find out a path from **S** to the **D** with minimum cost.

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

A delivery vehicle delivers the items to the different cities, it starts from his own city and visits all other cities once except his city of residence. You have to suggest a tour of shortest distance using Simulated Annealing

Group B

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.

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.

A CNN based classifier uses a set of images for training and efficient testing of the model, it has the property of self-tuning its parameters such that the classification accuracy reaches to the maximum possible. Use tensorflow, keras or Pytorch to write the program

There are different jobs to be executed on a machine, each of the job comes with a triplet {job, enter_time, exit_time}, Prepare a schedule of the jobs using firefly algorithm to maximize the profit

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.

Group C

A machine learning task requires a dataset D, has m features, not necessarily all the features to be used during training and testing of the algorithm/model. Select an optimization technique like Firefly algorithm to choose the important features to be used during training of an algorithm. Write a python program with suitable libraries to carry out mentioned task

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. Practical optimization Algorithms and Engineering Applications, Andreas Antoniou and Wu-Sheng Lu Springer
2. Nature-Inspired Optimization Algorithms-Xin-She Yang Elsevier Publication
3. OPTIMIZATION Algorithms and Applications- Rajesh Kumar Arora 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:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	In-Sem (Paper): 30 Marks End-Sem (Paper): 70 Marks

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

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:
CO5:
CO6:

Course Contents

Unit I	Unit	07 Hours
#Exemplar/Case Studies		
*Mapping of Course Outcomes for Unit I	CO1	

Unit II	Unit	07 Hours
#Exemplar/Case Studies		
*Mapping of Course Outcomes for Unit II	CO2	

Unit III	Unit	07 Hours
#Exemplar/Case Studies		

***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Unit**	**07 Hours**

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

Unit V	**Unit**	**07 Hours**

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

Unit VI	**Unit**	**07 Hours**

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

Learning Resources

Text Books:

1.

Reference Books:

1.

e-Resources:

1.

MOOC Courses:

1.

@The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												

CO2												
CO3												
CO4												
CO5												
CO6												

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417528: MOOC

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

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

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:
CO5:
CO6:

Course Contents

Unit I	Unit	07 Hours
#Exemplar/Case Studies		
*Mapping of Course Outcomes for Unit I	CO1	

Unit II	Unit	07 Hours
#Exemplar/Case Studies		
*Mapping of Course Outcomes for Unit II	CO2	

Unit III	Unit	07 Hours
#Exemplar/Case Studies		

***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Unit**	**07 Hours**

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

Unit V	**Unit**	**07 Hours**

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

Unit VI	**Unit**	**07 Hours**

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

Learning Resources

Text Books:

1.

Reference Books:

1.

e-Resources:

1.

MOOC Courses:

1.

@The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												

CO2												
CO3												
CO4												
CO5												
CO6												

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

The CO-PO Mapping Matrix

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

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

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

1.

Text Books:

1.

References:

1.

MOOC Courses:

1.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

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

Course Contents

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. Threat Modeling, Frank Swiderski and Window Snyder, 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.

The CO-PO Mapping Matrix

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

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

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

1.

Text Books:

1.

References:

1.

MOOC Courses:

1.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

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

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

1.

Text Books:

1.

References:

1.

MOOC Courses:

1.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Semester VIII

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

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	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**	**07 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. Computational Intelligence an introduction, (second edition) Andreis P. Engelbrecht, Wiley publication
2. Computational Intelligence, Synergies of Fuzzy logic, Neural Networks and Evolutionary computing, Nazmul Siddique, Hojjat Adeli, Wiley publication
3. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S. Rajasekaran, G. A. Vijayalakshami, PHI, 2007

Reference Books:

1. Seyedali Mirjalili, ―Evolutionary Algorithms and Neural Networks Theory and Applications, Studies in Computational Intelligence‖, Vol 780, Springer, 2019, ISBN 978-3-319-93024-4Press, 1998
2. Computational Intelligence in Medical Decision Making and Diagnosis Techniques and Applications, Edited By Sitendra Tamrakar, Shruti Bhargava Choubey, Abhishek Choubey, CRC Press ,2023
3. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press, 2000.
4. Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation, James M. Keller, Derong Liu, David B. Fogel, John Wiley & Sons, 13-Jul-2016
5. Getting Started with Google BERT, Build and train state-of-the-art natural language processing models using BERT, Sudharsan Ravichandiran, Packt Publishing, 2021, ISBN 9781838826239.
6. An Introduction to Genetic Algorithms, Mitchell Melanie, The MIT Press Cambridge, Massachusetts, Fifth printing, 1999 First MIT Press paperback edition, 1998
7. Nature-Inspired Metaheuristic Algorithms, Xin-She Yang, Second Edition, University of Cambridge, United KingdomLuniver Press

e-Resources:

1.

MOOC Courses:

1. https://nptel.ac.in/courses/108104157
2. https://youtu.be/xwUKQcT1bKc
3. https://onlinecourses.nptel.ac.in/noc21_me43/preview
4. https://nptel.ac.in/courses/112105235
5. https://nptel.ac.in/courses/106105173
6. 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)
417530: 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)

Prerequisites Courses: Computer Laboratory III ()

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	07 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	07 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**	**07 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**	**07 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**	**07 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**	**07 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. Distributed Computing and Artificial Intelligence, 12th International Conference: 373 (Advances in Intelligent Systems and Computing) Paperback by Sigeru Omatu (Editor), Qutaibah M. Malluhi (Editor), Sara Rodríguez Gonzalez (Editor), Grzegorz Bocewicz (Editor), Edgardo Bucciarelli (Editor), Gianfranco Giulioni (Editor), Farkhund Iqba (Editor)
2. Distributed Systems, Concepts and Design, George Coulouris, J Dollimore and Tim Kindberg, Pearson Education, 5th Edition
3. Distributed Systems, Principles and paradigms, Andrew S.Tanenbaum, Maarten Van Steen, Second Edition, PHI
4. Distributed Artificial Intelligence by Michael Huhns Volume I 1st Edition - January 1, 1987

Reference Books:

1. Distributed OS by Pradeep K. Sinha (PHI)
2. Tanenbaum S.: Distributed Operating Systems, Pearson Education
3. George Coulouris, Jean Dollimore. Tim Kindberg: Distributed Systems concepts and design
4. Distributed Systems, An Algorithm Approach, Sikumar Ghosh, Chapman & Hall/CRC, Taylor & Francis Group, 2007.
5. Distributed Computing: Principles, Algorithms, and Systems by Ajay D. Kshemkalyani, Mukesh Singhal

e-Resources:

1. George-Coulouris-Distributed Systems-5th-Edition.pdf (google.com)
2. ds-solutions.pdf (distributed-systems.net)
3. Distributed Systems: Principles and Paradigms (fsinf.at)
4. Distributed Systems (wordpress.com)
5. https://eclass.uoa.gr/modules/document/file.php/D245/2015/DistrComp.pdf

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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Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Elective V 417531 (A): Virtual Reality and Game Development

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

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

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	07 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**	**07 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", Second Edition, Wiley-IEEE Press, 2003/2006
2. Game Development Essentials" Jeannie Novak, Third Edition Cengage Learning
3. Blender Basics Classroom Tutorial Book 5th Edition, James Chronister

Reference Books:

1. "Introduction to Game Design, Prototyping, and Development - From Concept to Playable Game with Unity and C#" Jeremy Gibson Bond, Second Edition Pearson Publication
2. "The Art of Game Designing - A Book of Lenses" Jesse Schell Morgan Kaufmann Publishers
3. Beginning Blender: Open Source 3D Modeling, Animation, and Game Design, Lance Flavell
4. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
5. Millington, Ian, Artificial Intelligence for Games, CRC Press, 2019. 3rd Edition
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. https://www.codecademy.com/learn/introduction-to-game-development
2. https://www.coursera.org/learn/game-design
3. 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 417531 (B): Big Data Analytics

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

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

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" Ist Edition
3. Han, Jiawei Kamber, Micheline Pei and Jian, "Data Mining: Concepts and Techniques", Elsevier Publishers, ISBN:9780123814791, 9780123814807

Reference Books:

1. Manovich, Lev. (2012). Trending: The Promises and the Challenges of Big Social Data. Debates in the Digital Humanities, edited by Matthew K. Gold. The University of Minnesota Press.
2. Raj, Pethuru, "Handbook of Research on Cloud Infrastructures for Big Data Analytics", IGI Global, 2014
3. Big Data Fundamentals: Concepts, Drivers & Techniques Author: Wajid Khattak, Paul Buhler, Thomas Erl Publisher: John Wiley & Sons, Inc 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. https://onlinecourses.nptel.ac.in/noc20_cs92/preview
2. https://onlinecourses.nptel.ac.in/noc23_ee99/preview
3. 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 417531 (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. 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 1119050863, 9781119050865

Reference Books:

1. Android Application Development, Programming with the Google SDK, by, Rick Rogers, John Lombardo, Zigurd Mednieks, Blake Meike, SPD, Oreilly, ISBN10: 81-8404-733-9, ISBN13:978-81-8404-733-2
2. Hello Android, Introducing Google's Mobile Development Platform, 3rd Edition, by Ed Burnette, Pragmatic Programmers, LLC.ISBN-10: 1-934356-56-5, ISBN-13: 978-1-934356-56-2

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 417531 (D): Deep Learning

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	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	07 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)	07 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)**	**07 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)**	**07 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**	**07 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‖, A textbook
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. https://nptel.ac.in/courses/106106184
2. 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 417532 (A): Augmented Reality/ Research Methodology

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

Prerequisites Courses:

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:
CO5:
CO6:

Course Contents

Unit I	Unit	07 Hours

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

Unit II	Unit	07 Hours

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

Unit III	Unit	07 Hours

#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit III**	CO3	
Unit IV	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit IV**	CO4	
Unit V	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit V**	CO5	
Unit VI	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit VI**	CO6	
Learning Resources		
Text Books: 1.		
Reference Books: 1.		
e-Resources: 1.		
MOOC Courses: 1.		
@The CO-PO Mapping Matrix		

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

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

Teaching Scheme:	Credit	Examination Scheme:
TH: 03 Hours/Week	03	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 BI 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	**Unit Data Provisioning and Data Visualization**	**07 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. Business Intelligence: Data Mining and Optimization for Decision Making, Carlo Vercellis, 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 417532 (C): Information Systems Management

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

Prerequisites Courses: Operating Systems (), Management Information System (), Database Management Systems ()

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	Unit Organizations and Information Systems	07 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	Unit Ethical and Social Issues in Information Systems	07 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**	**07 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**	**07 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**	**07 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**	**07 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. Management Information Systems: Managing the Digital Firm, 13th Edition, Kenneth C. Laudon, New York University, Jane P. Laudon, New York University, 2014, Pearson
2. James A O'Brien, George M Marakas and Ramesh Behl. (2009). Management Information Systems, 9th Edition, Tata McGraw Hill Education, New Delhi
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, (2003). Reengineering the Corporation: A Manifesto for Business Revolution,1st Edition, HarperCollins

Reference Books:

1. Turban, E., McLean, E. and Wetherbe, J. (2000). Information Technology for Management: Making Connections for Strategic Advantage, 2nd Edition, John Wiley and Sons
2. D.P.Goyal. (2006). Management Information Systems-Managerial Perspectives, 2nd Edition, Macmillan, New Delhi. 3. S.A.Kelkar. (2009). Management Information Systems-A concise Study, 2nd Edition, Prentice Hall of India
3. S.A.Kelkar. (2009), Management Information Systems-A concise Study, 2nd Edition, Prentice Hall of India
4. NirmalyaBagchi, (2010). Management Information Systems, 1st Edition, Vikas Publishing House, New Delhi

e-Resources:

1. Information Systems for Business and Beyond, David T. Bourgeois Biola University, James L. Smith Shouhong Wang, Joseph Mortati

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 417532 (D): Reinforcement Learning

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

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

Companion Course: Computer Laboratory IV (417534)

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:
CO5:
CO6:

Course Contents		
Unit I	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit I**	CO1	
Unit II	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit II**	CO2	
Unit III	**Unit**	**07 Hours**

#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit III**	CO3	
Unit IV	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit IV**	CO4	
Unit V	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit V**	CO5	
Unit VI	**Unit**	**07 Hours**
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit VI**	CO6	
Learning Resources		
Text Books: 1.		
Reference Books: 1.		
e-Resources: 1.		
MOOC Courses: 1.		
@The CO-PO Mapping Matrix		

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

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
417533: Computer Laboratory III

Teaching Scheme:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		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. Computational Intelligence, Synergies of Fuzzy logic, Neural Networks and Evolutionary computing, Nazmul Siddique, HojjatAdeli, Wiley publication.
2. Computational Intelligence an introduction, (second edition) Andreis P. Engelbrecht, Wiley publication

Reference Books:

1. George Coulouris, Jean Dollimore, Tim Kindberg, & Gordon Blair, "Distributed Systems – Concept and Design", 5th Edition, Publisher: Pearson, ISBN – 978-13-214301-1.
2. Randay Chow, Theodore Johnson, "Distributed Operating System and Algorithm Analysis", Publisher: 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. Computational Intelligence in Medical Decision Making and Diagnosis Techniques and Applications, Edited By Sitendra Tamrakar, Shruti Bhargava Choubey, Abhishek Choubey, 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

MOOCs Courses Links:

1. https://onlinecourses.nptel.ac.in/noc22_cs80/preview
2. 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)
417534: Computer Laboratory IV

Teaching Scheme:	Credit: 02	Examination Scheme and Marks
Practical: 4 Hours/Week		Term Work (TW): 50 Marks Oral (OR): 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

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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.

Group B (Mini Project)

1. Create a virtual environment for any use case. The application must include at least 4 scenes which can be changed dynamically, a good UI, animation, and interaction with game objects. (e.g. VR application to visit a zoo)

2. Virtual Room Design: Create a virtual room using Blender where users can customize the furniture, textures, and lighting. Allow users to navigate and interact with the virtual room in virtual reality.

3. Create any one of the following games using the gaming engine of your choice. The game should keep track of score, no. of chances/lives, levels (created using different scenes), involve interaction, animation, and immersive environment.

1. A pseudo-3d racing game
2. A multiplayer combat game
3. A multiplayer spaceship game
4. A multiplayer online chess game
5. A Wheel of Fortune Casino game
6. A Snakes and Ladders board game
7. A clone of the original Pacman game
8. A word game similar to Wordle
9. A game to rearrange letters from a clue and jumbled mess of letters.
10. A VR Golf Game

Note: -Prepare game design documentation containing following details

- Purpose of design document
- Game Layout
- Level Design
- Technical Design
- Game Production

417531(B): Big Data Analytics

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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.

Group B (Mini Project)

1. Write a program to implement Facebook Sentiment Analysis System where we populate real-time sentiments for crisis management, service adjusting and target marketing using PYSpark
2. Write a program to implement Medical Insurance Fraud Detection, Traffic control using Big Data, Data Warehouse Design for an E-Commerce Site using Map Reduce techniques.
3. Write a program to implement Disease Prediction Based on Symptoms/ Recommendation System/ Smart Cities Using Big Data

417531(C): Software Development for portable devices

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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.

Group B (Mini Project)

1. Build apps for the wrist watch with Wear OS
2. Develop an app to demo Audio, Video and Camera Features
3. Develop an app using various sensors in portable devices

417531(D): Deep Learning

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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.

Group B (Mini Project)

1. Gender Recognition Using Voice.
2. Crop Disease detection
3. Music Genre Classification system.

417531(E): Open Elective

Suitable set of Programming assignments/mini-projects for Open elective Opted.

PART II (417532): ELECTIVE VI

417532(A): Augmented Reality

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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

Group B (Mini Project)

1. Create a treasure hunt AR application which should the following features:
i) A help button for instruction box to appear.
ii) A series of markers which would give hints on being scanned.
iii) Involve interaction, sound, and Good UI.
2. Product video promotion app using augmented reality.
3. AR Board Game

417532(B): Business Intelligence

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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

Group B (Mini Project)

Detailed case study of any one BI tool (open-source tools like Pentaho can be used). A BI Report must be prepared outlining the following steps:

1. Problem Definition, identifying which data mining task is needed
2. Identify and use a standard data mining data set available for the problem

417532(C): Information Systems Management

Any 4 Assignments and 1 Mini Project are compulsory

Group A

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
Group B (Mini Project)
1. Implement mini project using open-source front end and back end (Example Python/PHP – MongoDB/MYSQL). Prepare a complete CRM report from Kick off meeting to Customer support which shows the information management in development of any project.
2. Prepare the Documentation and report using JIRA for the same mini project.
417532(D): Reinforcement Learning
Any 4 Assignments and 1 Mini Project are compulsory
Group A
Group B (Mini Project)
417532(E): Open Elective
Suitable set of Programming assignments/mini-projects 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 1119050863, 9781119050865

Virtual & Augmented Reality

1. Steve Aukstakalnis- Practical Augmented Reality: A Guide to the Technologies, Applications and Human Factors for AR and VR, Addison-Wesley Professional, September 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

Reference Books:

Virtual & Augmented Reality

1. Learning C# by Developing Games with Unity 3D Beginner's Guide Terry Norton Pack Publication Packt publishing, 9th October 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. Google Data Studio for Beginner, Start Making Your Data Actionable, Grant Kemp Gerry White, Published by A press Media LLC, ISBN-13 (electronic): 978-1-4842-5156-0
2. HANDBOOK OF CRM: Achieving Excellence in Customer Management, Adrian Payne, Published by Elsevier Ltd, IBN-13: 978-07506-6437-0 ISBN-10: 07506-6437-1
3. Customer Relationship Management Concepts and Technologies, Francis Buttle Published by 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

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

The CO-PO Mapping Matrix

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)
417535: Project Stage II

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

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

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:
CO5:
CO6:

Course Contents

Unit I	Unit	07 Hours
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit I**	CO1	

Unit II	Unit	07 Hours
#Exemplar/Case Studies		
***Mapping of Course Outcomes for Unit II**	CO2	

Unit III	Unit	07 Hours
#Exemplar/Case Studies		

***Mapping of Course Outcomes for Unit III**	CO3

Unit IV	**Unit**	**07 Hours**

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

Unit V	**Unit**	**07 Hours**

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

Unit VI	**Unit**	**07 Hours**

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

Learning Resources

Text Books:

1.

Reference Books:

1.

e-Resources:

1.

MOOC Courses:

1.

@The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												

CO2												
CO3												
CO4												
CO5												
CO6												

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Audit Course 8: Usability Engineering

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

1.

References:

1.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Audit Course 8: Conversational Interfaces

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

3.

References:

1.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Audit Course 8: 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 – BTL 1, 2 ,3
   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: BTL 3, 4
   Get an extensive social media database loaded. Create summary statistics for an extensive data of social media.
3. Visualizing Social Media Networks BTL 3,4,5
   Get an extensive social media database loaded. Create summary statistics for an extensive data of social media. Case Study: Twitter/Facebook/

References:

2. Creating Value with Social Media Analytics: Managing, Aligning, and Mining Social Media Text, Networks, Actions, Location, Apps, Hyperlinks, Multimedia, & Search Engines Data By Gohar F. Khan
3. A Practitioner's Guide to Business Analytics: Using Data Analysis Tools to Improve Your Organization's Decision Making and Strategy By Randy BartlettIGBC Green New Buildings Rating System, Version 3.0, Abridged Reference Guide September2014
4. Business Data Science: Combining Machine Learning and Economics to Optimize, Automate, Accelerate Business Decisions, By Matt Taddy

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.

The CO-PO Mapping Matrix

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

CO4	2	2	-	-	1	1	2	-	2	1	1	1

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Audit Course 8: Foreign Language

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

References:

1.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

Savitribai Phule Pune University
Fourth Year of Artificial Intelligence and Data Science (2020 Course)
Audit Course 8: MOOC-Learn New skills

Course Objectives:

-

Course Outcomes:

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

CO1:
CO2:
CO3:
CO4:

Course Contents

4.

References:

2.

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.

The CO-PO Mapping Matrix

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												