Savitribai Phule Pune University, Pune
Faculty of Science and Technology

Syllabus

Master of Artificial Intelligence
ME (AI)
(2017 Course)

(With effect from Academic Year 2024-25)

Preface

It is with great pleasure and honor that I present the syllabus for Master of Artificial Intelligence on behalf of the Board of Studies (BoS), Computer Engineering. We, members of BoS are giving our best to streamline the processes and curricula design.

While designing the syllabus, honest and sincere efforts are put to tune the curriculum for Post Graduate (PG) program in Artificial Intelligence in tandem with the objectives of Higher Education of India, AICTE, UGC and affiliated University- Savitribai Phule Pune University (SPPU) by keeping an eye on the recent technological advancements and wide scope in industrial requirements globally in the field of Artificial Intelligence.

Projects to be evolved in the field of artificial intelligence, the primary emphasis is put on several exciting projects on the horizon, promising to push the boundaries of what AI can achieve. Key areas of focus include advancing Natural Language Processing (NLP) to enable more subtle and context-aware interactions between humans and machines, enhancing computer vision systems for more accurate object recognition and autonomous navigation. Additionally, there is a growing emphasis on ensuring ethical AI practices by designing algorithms that lessen bias and promote fairness, while also exploring ways to integrate AI with emerging technologies like quantum computing to solve previously intractable problems. These projects collectively aim to create more intelligent, reliable, and ethical AI systems that can positively impact various aspects of society.

While framing each course contents, Course advisor, Course Coordinators and Team Members have put great efforts in meeting the standard of the Courses at PG level. Everybody in the team has precisely stuck to the guidelines and recommendations to materialize the team efforts. The execution is only due to sincere efforts, active participation, expert opinions, and suggestions from domain professionals.

I am sincerely obliged to all the minds and hands who work resourcefullyand synchronously to materialize the huge task.
Thanks.

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

Savitribai Phule Pune University, Pune
Master of Engineering - Artificial Intelligence

Semester I

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks					Credit	
		Theory	Practical	In-Sem	End-Sem	TW	OR/PRE	Total	TH	TW & PR
510101	Research Methodology*	04	--	50	50	--	--	100	04	--
510501	Artificial Intelligence@	04	--	50	50	--	--	100	04	--
510502C	Data Preparation and Analysis@	04	--	50	50	--	--	100	04	--
610303E	Data Modeling and Visualization@	04	--	50	50	--	--	100	04	--
510701	Elective I	05	--	50	50	--	--	100	05	-
510702	Laboratory Proficiency I	--	08	--	--	50	50	100	-	02 +02
	Total Credit								21	04
	Total	**21**	**08**	**250**	**250**	**50**	**50**	**600**	**25**	
510114	Non-Credit Course I								Grade	

Elective I

510701A	Mathematical Foundation of Data Science	510701C	Data Mining
510701B	Real Time Analytics	510701D	Network Design and Analysis
510701E	Open Elective		

*ME(Computer Engineering) @ME(AIDS)

Semester II

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks					Credit	
		Theory	Practical	In-Sem	End-Sem	TW	OR/PRE	Total	TH	PR
510102	Bio-Inspired Optimization Algorithms*	04	--	50	50	--	--	100	04	--
510309	Machine Learning@	04	--	50	50	--	--	100	04	--
510504	Virtual Reality Augmented Reality@	04	--	50	50	--	--	100	04	--
510703	Elective II	05	--	50	50	--	--	100	05	--
510704	Seminar I		04	--	--	50	50	100	--	04
510705	Laboratory Proficiency II	--	08	--	--	50	50	100	--	04
	Total Credit								17	08
	Total	**17**	**12**	**200**	**200**	**100**	**100**	**600**	**25**	
510107	*Non-Credit Course II								Grade	

Elective II

510703A	Web Intelligence	510703C	Business Analytics
510703B	Image Processing	510703D	Network Security
510703E	Open Elective		

*ME(Computer Engineering) @ME(AIDS)

Abbreviations: TW: Term Work , **TH:** Theory, **OR:** Oral, **PRE**: Presentation, **Sem:** Semester

Savitribai Phule Pune University, Pune **Master of Artificial Intelligence**									

Savitribai Phule Pune University, Pune
Master of Artificial Intelligence

Semester III

Course Code	Course	Teaching Scheme Hours / Week		Examination Scheme and Marks					Credit	
		Theory	Practical	In-Sem	End-Sem	TW	OR/PRE	Total	TH	PR
610501	Soft Computing and Deep Learning@	04	--	50	50	--	--	100	04	--
610102	Information Retrieval*	04	--	50	50	--	--	100	04	--
610706	Elective III	05	--	50	50	--	--	100	05	--
610707	Seminar II	--	04	--	--	50	50	100	--	04
610708	Dissertation Stage I	--	08	--	--	50	50	100	--	08
							Total Credit		13	12
Total		**13**	**12**	**150**	**150**	**100**	**100**	**500**	**25**	
610106	Non-Credit Course III								Grade	

Elective III

610706D	Pattern Recognition		610706B	GPU Computing
610706C	Mobile Ad-hoc Network		610706A	Cloud Security
610706E	Open Elective			

Semester IV

Course Code	Course	Teaching Scheme Hours / Week	Examination Scheme and Marks			Credit
		Practical	TW	OR/PRE	Total	PR
610709	Seminar III	05	50	50	100	05
610710	Dissertation Stage II	20	150	50	200	20
Total		**25**	**200**	**100**	**300**	**25**

Non-Credit Courses

Typically curriculum is constituted by credit, non-credit and audit courses. These courses are offered as compulsory or elective. Non Credit Courses are compulsory. No grade points are associated with noncredit courses and are not accounted in the calculation of the performance indices SGPA & CGPA. However, the award of the degree is subject to obtain a PP grade for non-credit courses. Conduction and assessment of performance in said course is to be done at institute level. The mode of the conduction and assessment can be decided by respective course instructor. Recommended but not limited to- (one or combination of) seminar, workshop, MOOC Course certification, mini project, lab assignments, lab/oral/written examination, field visit, field training. Examinee should submit report/journal of the same. Reports and documents of conduction and assessment in appropriate format are to be maintained at institute. Result of assessment will be PP or NP. Set of non-credit courses offered is provided. The Examinee has to select the relevant course from pool of courses offered. Course Instructor may offer beyond this list by seeking recommendation from SPPU authority. The selection of 3 distinct non-credit courses, one per semester (Semester I, II & III).

Open Elective: The open elective is to invite the attention to multidisciplinary, interdisciplinary, exotic, employability or update to technology course. The institute may design the syllabus accordingly. However such designed syllabus needs to be approved by SPPU authority before implementation.

Recommended Set of Non-Credit Courses (510107, 510114, 610106):

NCC1: Game Engineering	NCC2: Advanced Cognitive Computing
NCC3: Reconfigurable Systems	NCC4: Convergence Technology
NCC5: Machine Learning	NCC6: Storage Area Networks
NCC7: Search Engine Optimization	NCC8: Virtual Reality
NCC9: Machine Translation	NCC10: Infrastructure Management

Savitribai Phule Pune University
Master of Artificial Intelligence Engineering (2017 Course)
510101: Research Methodology

Teaching Scheme: TH: 04 Hours/Week	Credit 04	Examination Scheme: In-Sem : 50 Marks End-Sem : 50 Marks

Course Objectives :
- To understand the philosophy of research in general
- To understand basic concepts of research and its methodologies
- To learn the methodology to conduct the Literature Survey
- To acquaint with the tools, techniques, and processes of doing research
- To learn the effective report writing skills and allied documentations
- To become aware of the ethics in research, academic integrity and plagiarism

Course Outcomes:
After completion of the course, students should be able to
- Carry out Literature Survey
- Identify appropriate topics for research work in computer engineering
- Select and define appropriate research problem and parameters
- Design the use of major experimental methods for research
- Use appropriate tools, techniques, and processes of doing research in Computer science
- Demonstrate own contribution to the body of knowledge
- Become aware of the ethics in research, academic integrity and plagiarism
- Write a research report and thesis

Course Contents

Unit I	Introduction	08 Hours

Evolution of Research Methodology: Meaning, nature, scope, and significance of research; Research paradigm; The purpose and outcomes of Research; Objectives of research, Motivation for research; Postulates underlying scientific investigations; Types of research; Research process and work flow.

Engineering Research-Why? Research Questions, Engineering Ethics, conclusive proof-what constitutes, A research project-Why take on?

Case Study- Code of Ethics, IEEE Code of Ethics, ACM Software Engineering Code of Ethics and Professional Practice, Code of Ethics especially covering Engineering discipline, various aspects-environment, sustainable outcomes, employer, general public, and Nation, Engineering Disasters.

Unit II	Literature Search and Review, Developing Research Plan	08 Hours

Archival Literature, Why should engineers be ethical? Types of publications- Journal papers, conference papers, books, standards, patents, theses, trade magazine, newspaper article, infomercials, advertisement, Wikipedia & websites, Measures of research impact, Literaturereview, publication cost.

Case Study- Engineering dictionary, Shodhganga, The Library of Congress, Research gate,Google Scholar, Bibliometrics, Citations, Impact Factor, h-index, I-index, plagiarism, copyright infringement.

Developing Research Plan: Research Proposals, Finding a suitable research questions, The

elements of research proposals-title, details, budget, Design for outcomes-1D data, 2D data, 3D data, N-D data, The research tools- Experimental measurements, numerical modeling, theoretical derivations & Calculations, curve matching.
 Case Study- Various Research grants and funding resources

Unit III	Statistical Analysis	08 Hours

Statistical Analysis: Introduction, Sources of error and uncertainty, One-Dimensional Statistics: combining errors and uncertainties, t-test, ANOVA statistics, example, Two-Dimensional Statistics: example, Multi-Dimensional Statistics: partial correlation coefficients, example, Null hypothesis testing. **Case Study-** GNU PSPP Tool, SOFA, NOST-Dataplot

Unit IV	Optimization Techniques	08 Hours

Optimization Techniques: Introduction, Two-parameter optimization methods: sequential uniform sampling, Monte Carlo optimization, Simplex Optimization method, Gradient Optimization method, Multi-parameter optimization methods, The cost function.
Case Study- Google Optimization Tools, OpenMDAO

Unit V	Survey Research Methods	08 Hours

Survey Research Methods: Why undertake a survey, Ergonomics and human factors, Ethics approval, General survey guidelines, Survey statements, Survey delivery, Respondent selection, Survey timelines, Statistical analysis, Reporting.
Case Study- Qualitative Analysis Tools- AQUAD, CAT

Unit VI	Research Presentation	08 Hours

Research presentation: Introduction, Standard terms, Standard research methods and experimental techniques, Paper title and keywords, Writing an abstract, Paper presentation and review, Conference presentations, Poster presentations, IPR, Copyright, Patents.

Reporting Research: Thesis, Structure and Style for writing thesis, Dissemination of research findings; Reporting and interpretation of results; cautions in interpretations, Type of reports,Typical report outlines.

The path forward: Publication trends, Getting started in research, Quality assurance (QA) Occupational health and safety.

Case Study: Intellectual Property India- services, InPASS - Indian Patent Advanced Search System, US patent, IEEE / ACM Paper templates.

A glimpse into the future of Engineering Research.

Books:

Text:
1. David V Thiel, "Research Methods- for Engineers", Cambridge University Press, ISBN:978-1-107-61019-4
2. Kothari C.R., "Research Methodology. New Age International, 2004, 2nd Ed; ISBN:13: 978-81-224-1522-3.

References:
1. Caroline Whitbeck, "Ethics in Engineering Practice and Research", 2nd Ed., Cambridge University Press; ISBN :978-1-107-66847-8
2. Gordana DODIG-CRNKOVIC, "Scientific Methods in Computer Science", Department of Computer Science Malardalen University, Vasteas, Sweden; ISBN: 91-26-97860-1

Savitribai Phule Pune University, Pune **ME Artificial Intelligence (2017 Course)** **510501: Artificial Intelligence**		
Teaching Scheme:	Credit	Examination Scheme:
TH: 04 hr/week	04	In Semester: 50 Marks End Semester: 50 Marks

Prerequisite Courses: Data structure, Algorithms

Companion Course: Machine Learning, Soft Computing, Deep learning

Course Objectives:

The aim of the course is to introduce to the field of Artificial Intelligence (AI) with emphasis on its use to solve real world problems for which solutions are difficult to express using the traditional algorithmic approach. It explores the essential theory behind methodologies for developing systems that demonstrate intelligent behavior including dealing with uncertainty, learning from experience and following problem solving strategies found in nature.

1. To introduce the concepts of Artificial intelligence and methods
2. To provide the knowledge representation and Learning techniques to problem solving strategy
3. To design and solve real world problems using AI approaches
4. To implement AI techniques in different fields

Course Outcomes:

On completion of the course, the learner will be able to–Able to Demonstrate knowledge of the fundamental principles of Artificial intelligent systems and would be able to analyze and compare the relative merits of a variety of AI problem solving techniques.

CO1: Identify the need of Intelligent agents in problem solving
CO2: Compare and analyze different search techniques applied for problem solving
CO3: Apply the knowledge representation method and reasoning for given decision problem
CO4: Design and analyze a learning technique for a given system in different AI application domains like marketing, healthcare, banking, finance, education.

Selection of Modules: **Modules 1 to 3 are compulsory and select any one from modules 4, 5 and 6.**

Unit I	Introduction and Intelligent Agents	7 hrs

Introduction: What is AI? Foundations History of Artificial Intelligence, The State of the Art Intelligent Agents: Agents and Environments, Good Behavior: The Concept of Rationality, The Nature of Environments, and The Structure of Agents.

Case Studies (if any)	Intelligent agents in autonomous systems
Mapping of Course Outcomes	CO1

Unit II	Problem-solving	7 hrs

Solving Problems by Searching: Problem-Solving Agents, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Heuristic Functions, Beyond Classical Search

Local Search Algorithms and Optimization Problems, Local Search in Continuous Spaces, Searching with Nondeterministic Actions, Searching with Partial Observations, Online Search Agents and Unknown Environments

Case Studies(if any)	Search techniques for a sliding tile problem
Mapping of Course Outcomes	CO2

Unit III	Knowledge, reasoning, and planning	6 hrs

Knowledge based Agents, First-Order Logic and Its Inference, Classical Planning, Planning and Acting in the Real World, Knowledge Representation

Mapping of Course Outcomes	CO3	
Unit IV	**Uncertain knowledge and reasoning**	**6 hrs**

Quantifying Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Making Simple Decisions, Making Complex Decisions

Case Studies(if any)	Application of planning to a production system	
Mapping of Course Outcomes	CO3	
Unit V	**Learning**	**6 hrs**

Learning from Examples, Knowledge in Learning, Learning Probabilistic Models, Reinforcement Learning

Case Studies(if any)	E mail filtering with learning method	
Mapping of Course Outcomes	CO4	
Unit VI	**Applications with case studies**	**7 hrs**

AI Applications in various fields in marketing, healthcare, banking, finance, etc.
Case Studies: Credit card Fraud Analysis, Sentiment Analysis, Recommendation Systems and Collaborative filtering, Uber Alternative Routing

Case Studies (if any)	Application of AI and Machine Learning in e commerce	
Mapping of Course Outcomes	CO4	

Books & Other Resources:

Text Books:
1. Russell S. and Norvig P. (2009). Artificial Intelligence: A Modern Approach. Prentice-Hall, 3rd edition.
2. Elaine Rich, Kevin Knight and Nair, "Artificial Intelligence", TMH,ISBN-978-0-07-008770-5

Reference Books:
1. Luger G.F. and Stubblefield W.A. (2008). Artificial Intelligence: Structures and strategies for Complex Problem Solving. Addison Wesley, 6th edition
2. Nilsson Nils J , "Artificial Intelligence: A new Synthesis, Morgan Kaufmann Publishers Inc. San Francisco, CA, ISBN: 978-1-55-860467-4
3. Patrick Henry Winston, "Artificial Intelligence", Addison-Wesley Publishing Company, ISBN: 0- 201-53377-4

MOOC Courses

- https://nptel.ac.in/courses/106/102/106102220/
- https://nptel.ac.in/courses/106/105/106105077/
- https://nptel.ac.in/courses/106/106/106106140/

E-books

- https://www.amazon.in/Artificial-Intelligence-As-AICTE-Intelligent/dp/8126579943

Important links:
- https://ieeexplore.ieee.org/
- https://en.wikipedia.org/wiki/Artificial_intelligence
- https://indiaai.in/

Savitribai Phule Pune University, Pune ME Artificial Intelligence (2017 Course) 510502C: Data Preparation and Analysis		
Teaching Scheme:	**Credit**	**Examination Scheme:**
TH: 04 hr/week	**04**	**In Semester: 50 Marks** **End Semester: 50 Marks**

Prerequisite Courses: Introduction to Probability theory, statistics, Python/R

Companion Course: Laboratory Proficiency-I

Course Objectives:
1. To understand the importance of data and data preprocessing
2. To understand data cleaning and conditioning
3. To understand an ETL – Extract, Transform and Load – process and ETL tools
4. To get acquainted with data visualization techniques for exploratory analysis

Course Outcomes:

On completion of the course, learner will be able to–
CO1: Apply ETL process with ETL tools to datasets for data processing.
CO2: Prepare conditioned and preprocessed datasets using normalization method for data
CO3: Draw insights into the datasets using exploratory mechanism.
CO4: Demonstrate use of visualization tools for data preparation and analysis

Selection of Modules: Modules 1 to 3 are compulsory and select any one from modules 4, 5 and 6.

Course Contents

Module I	**Data Gathering and Data Discovery**	**06**
Identifying potential data sources, Gathering data, Data discovery- understanding the data, assessing data, data formats, Parsing, Selecting features, Transformation, Scalability and real-time issues		
Mapping of Course Outcomes	CO1	
Module II	**Cleaning and Conditioning Data**	**07**
Data Preparation Basic Models: Data Integration, Data Cleaning, Data Normalization, Min-Max Normalization, Z-score Normalization, Decimal Scaling Normalization, Consistency checking, Heterogeneous and missing data, Dealing with missing values, Duplicate values, Noise, Inconsistent data, Outliers		
Mapping of Course Outcomes	CO2	
Module III	**ETLT**	**07**
Transform and enrich data: Data Transformation, Linear Transformations, Quadratic Transformations, Non-polynomial Approximations of Transformations, Polynomial Approximations of Transformations, Rank Transformations, Box-Cox Transformations, Spreading the Histogram, Nominal to Binary Transformation, Transformations via Data Reduction, ETL tools		
Mapping of Course Outcomes	CO1	
Module IV	**Exploratory Analysis**	**06**
Formulating Hypothesis, Data Terminology, Data Exploration, Data Exploration through Summary Statistics, Data Exploration through Plots, Feature Engineering, Feature selection, Feature transformation, Dimensionality reduction		
Mapping of Course Outcomes	CO3	

Module V	Data Visualization	06
Visualization techniques, Different types of plots, Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, Interactivity		
Mapping of Course Outcomes	CO3, CO4	
Module VI	Advanced Tools for Data Preparation	07
Web scraping, Data from social networks, Open-source tools for data preparation: Open Refine, R/Python libraries for data preparation and visualization		
Mapping of Course Outcomes	CO3, CO4	
Books & Other Resources:		
Textbooks:		

Textbooks:

1. Glenn J. Myatt, "Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining"
2. Salvador García, JuliánLuengo, Francisco Herrera, "Data Preprocessing in Data Mining"

Reference Books:

1. Mark Gardner, "Beginning R: The Statistical Programming Language", Wrox Publication, ISBN: 978-1-118-16430-3
2. David Dietrich, Barry Hiller, "Data Science and Big Data Analytics", EMC education services, Wiley publications, 2012, ISBN0-07-120413-X
3. Ruben Verborgh; Max De Wilde, "Using OpenRefine : the essential OpenRefine guide that takes you from data analysis and error fixing to linking your dataset to the Web"

MOOC Courses:

- **NPTEL course: Python for Data Science : https://swayam.gov.in/nd1_noc19_cs59/preview**

E-books:

- Jacqueline Kazil, Katharine Jarmu, "Data Wrangling with Python: Tips and Tools to Make Your Life Easier"
- Hector Cuesta and DrSampath Kumar, "Practical Data Analysis", 2nd Edition

Important links:

- https://openrefine.org/
- https://www.youtube.com/playlist?list=PLh2mXjKcTPSACrQxPM2_1Ojus5HX88ht7

Savitribai Phule Pune University, Pune ME Artificial Intelligence (2017 Course) 610303E: Data Modeling and Visualization		
Teaching Scheme:	**Credit**	**Examination Scheme:**
TH: 04 hr/week	**04**	**In Semester: 50 Marks** **End Semester: 50 Marks**

Prerequisite Courses: Computer Graphics, Data mining, Image processing, Statistical methods

Course Objectives:
1. To map element of visualization well to perceive information well
2. To learn different types of data and its visualization
3. To study quantitative and non quantitative data visualization.
4. To study the pattern for static and moving data

Course Outcomes:
 On completion of the course, learner will be able to
CO1:Understand types of data and data visualization methods
CO2:Understand the need of data visualization.
CO3:Apply visualization technique well for quantitative data
CO4:Understand patterns in motion
CO5:Evaluate the performance of visualization technique
CO6:Apply data visualization using open source tool Tableau

Unit I	Introduction to Data Visualization	6 Hours

Need for data visualization. Types of Data, Stages of Data visualization, Fitts Law, Human visual perception and cognition

Case Studies	Installation of Tableau Public and analysing different types of data.
Mapping of Course Outcomes	**CO1,CO2**

Unit II	Visualization of numerical data	7 Hours

Types of Data visualization: Basic charts, scatter plots, Histogram ,advanced visualization Techniques like streamline and statistical measures

Case Studies	Perform constellation modelling of high dimensional data. And analyse the Properties
Mapping of Course Outcomes	**CO2**

Unit III	Visualization of non-numeric data	7 Hours

Plots , Graphs, networks, Hierarchies, symbol and shaded maps, treemap

Case Studies(if any)	A roadmap with symbols representing cities and colored lines representing roads between the cities. Provide node-link diagram. Perform search to find the node symbol and extract the alternate paths.
Mapping of Course Outcomes	**CO2**

Unit IV	High dimensional data	7 Hours

Mapping of high dimensional data into suitable visualization method- Principal component analysis, multidimensional, clustering study of High dimensional data visualization in R, Python , Google chart API

Case Studies	Make use of IMDB movie dataset and apply classification and use suitable data visualization techniques.

Mapping of Course Outcomes	CO3,CO1	
Unit V	**Static and moving data**	**6 Hours**
Gestalt laws, texture theory and data mapping, perception of transparency/; overlapping data, perceiving patterns in multidimensional discrete data, patterns in motion		
Case Studies	**Take the example of traffic signal, analyse the pattern and use suitable method to visualize pattern in motion.**	
Mapping of Course Outcomes	**CO1,CO4**	
Unit VI	**Evaluation and visualization tools**	**6 Hours**
Evaluation of visualization, Tableau , Desktop workspace in Tableau , visual control, data analytics		
Case Studies	Data analytics in Tableau	
Mapping of Course Outcomes	**CO5,CO6**	
Books & Other Resources:		
Text Books: 1. Information visualization perception for design, colin ware, MK publication		

Reference Books:
    1. Big data black book, Dream tech publication
    2. Handbook for visualizing : a handbook for data driven design by Andy krik		

MOOC Courses: Coursera course on data visualization		

Savitribai Phule Pune University, Pune
ME Artificial Intelligence (2017 Course)
Elective I - 510701A: Mathematical foundation for Data Science

Teaching Scheme:	Credit	Examination Scheme:
TH: 05 hr/week	**05**	**In Semester: 50 Marks** **End Semester: 50 Marks**

Prerequisites: Basic Mathematics

Companion Course: Basics of Artificial Intelligence and Data Science

Course Objectives:

1. To understand role of discrete mathematics in data science.
2. To learn probability and apply it for real life problems in Artificial Intelligence and Data Science.
3. To understand basis of descriptive statistics measures and hypothesis.
4. To learn linear algebra and calculus concepts and applicability in Artificial Intelligence and Data Science.
5. To learn different linear regression methods used in machine learning

Course Outcomes:

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

CO1: Apply measures of central tendency to analyze a payroll dataset.
CO2: Apply probabilistic model for credit card fraud detection.
CO3: Evaluate covariance and correlation of between two variables.
CO4: Demonstrate use eigenvalues and eigenvectors for a reducing dimension of a healthcare dataset
CO5: Apply simple regression model to predict the near future sales based on a time series data.

Course Contents

Unit I	Discrete mathematics for Data Science	(07 Hours)

Concept of set, cardinality of set, finite, infinite and uncountably infinite sets, Basic set operations, Principal of inclusion Exclusion, **Graph:** Basic terminologies, representation of graph, path and circuit, graph traversal, travelling salesperson problem, **Trees:** Basic terminologies, search tree: Binary & M-ary tree.

# Exemplar / Case Studies	Discuss algorithm / program for Salesman problem
*Mapping of Course Outcomes	CO1

Unit II	Data Analysis & Probability Theory	(06 Hours)

Data Representation, Average, Spread, Experiments, Outcomes, Events, Probability, Permutations and Combinations, Random Variables, Probability Distributions, Mean and Variance of a Distribution, Binomial, Poisson, and Hyper geometric Distributions, Normal Distribution, Distributions of Several Random Variables.

#Exemplar/Case Studies	Discuss probabilistic model for predicting relations in social websites system
*Mapping of Course Outcomes	**CO3**

Unit III	Statistical Inference I	(07 Hours)

Types of Statistical Inference, Descriptive Statistics, Inferential Statistics, Importance of Statistical Inference in Machine Learning, Descriptive Statistics, Measures of Central Tendency: Mean, Median, Mode, Mid- range, Measures of Dispersion: Range, Variance, Mean Deviation, Standard Deviation.

Coefficient of variation: Moments, Skewness, Kurtosis, One sample hypothesis testing, hypothesis, Testing of Hypothesis, Binomial distribution and normal distribution, Chi-Square Tests, t-test, ANOVA. Pearson
Correlation.

#Exemplar/Case Studies	For a payroll dataset create Measure of central tendency and its measure of dispersion for statistical analysis of given data.
*Mapping of Course Outcomes	CO2

Unit IV	**Statistical Inference II**	**(06 Hours)**

Measure of Relationship: Covariance, Karl Pearson's Coefficient of Correlation, Measures of Position: Percentile, Z-score, Quartiles, Bayes' Theorem, Bayes Classifier, Bayesian network, **Probabilistic models with hidden variables**

Exemplar/Case Studies	Create a probabilistic model for credit card fraud detection
Mapping of Course Outcomes	CO3

Unit V	**Linear Algebra and Calculus**	**(7 Hours)**

Linear Algebra: Matrix and vector algebra, systems of linear equations using matrices, linear independence, Matrix factorization concept/LU decomposition, Eigen values and eigenvectors, **Understanding of calculus:** concept of function and derivative, Multivariate calculus: concept, Partial Derivatives, chain rule, the Jacobian and the Hessian

#Exemplar/Case Studies	1. Demonstration of dimensionality reduction using eigenvalues and eigenvector (PCA) 2. Discussion of Page rank algorithm using eigenvalues and Eigenvector
*Mapping of Course Outcomes	CO4

Unit VI	**Regression Model**	**(07 Hours)**

Introduction, types of regression. Simple regression- Types, Making predictions, Cost function, Gradient descent, Training, Model evaluation.

Multivariable regression: Growing complexity, Normalization, making predictions, initialize weights, Cost function, Simplifying with matrices, Bias term, Model evaluation

Exemplar/Case Studies	Create a probabilistic model for credit card fraud detection
Mapping of Course Outcomes	CO5

Textbooks:
1. Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python, Bruce, Peter, Andrew Bruce, and Peter Gedeck, O'Reilly Media, 2020.
2. Liu, Chung Laung. Elements of discrete mathematics. Tata McGraw-Hill Education, 1987.
3. Introduction to Statistics and Data Analysis With Exercises, Solutions and Applications in R Authors: Heumann, Christian, Schomaker, Michael, Shalabh, Publisher" Springer 2016

Reference Books:
1. Applied Statistics and Probability for Engineers, Douglas C. Montgomery, George C. Runger, 2018,

Savitribai Phule Pune University **Master of Artificial Intelligence Engineering (2017 Course)** **Elective I – 510701C : Data Mining**	

Teaching Scheme: TH: **05 Hours/Week**	**Credit** **05**	**Examination Scheme:** **In-Sem : 50 Marks** **End-Sem : 50 Marks**

Course Objectives:
- To understand the fundamentals of Data Mining
- To identify the appropriateness and need of mining the data
- To learn the preprocessing, mining and post processing of the data
- To understand various methods, techniques and algorithms in data mining

Course Outcomes:

On completion of the course the student should be able to-
- Apply basic, intermediate and advanced techniques to mine the data
- Analyze the output generated by the process of data mining
- Explore the hidden patterns in the data
- Optimize the mining process by choosing best data mining technique

Selection of Modules:

Kindly note that unit 1, 2, 3 are compulsory and select any one module from module number- 4 to 10.

Course Contents

Unit 1	**Introduction**	**01**

Data: Data, Information and Knowledge, Attribute Types: Nominal, Binary, Ordinal and Numeric attributes, Discrete versus Continuous Attributes, Introduction to Data Preprocessing, Data Cleaning, Data integration, data reduction, transformation and Data Descritization.

Concept of class: Characterization and Discrimination, basics /Introduction to: Classification and Regression for Predictive Analysis, Mining Frequent Patterns, Associations, and Correlations, Cluster Analysis.

Unit 2	Central Tendency	**01**

Measuring the Central Tendency: Basics of Mean, Median, and Mode, Measuring the Dispersion of Data, Variance and Standard Deviation. Measuring Data Similarity and Dissimilarity, Data Matrix versus Dissimilarity Matrix, Proximity Measures for Nominal Attributes and Binary Attributes

Unit 3	Numeric Data	**01**

Dissimilarity of Numeric Data: Minkowski Distance, Euclidean distance and Manhattan distance, Proximity Measures for Ordinal Attributes, Dissimilarity for Attributes of Mixed Types, Cosine Similarity.

Book:

1. Han, Jiawei Kamber, Micheline Pei and Jian, "Data Mining: Concepts and Techniques" Elsevier Publishers Third Edition/Second Edition, ISBN: 9780123814791, 9780123814807

Unit 4	Classification	02

Basic Concepts, General Approach to Classification, Decision Tree Induction, Attribute Selection Measures, Tree Pruning, Scalability and Decision Tree Induction, Visual Mining for Decision Tree Induction, Bayes Classification Methods, Baye's Theorem, Naive Bayesian Classification, Rule-Based Classification, Using IF-THEN Rules for Classification, Rule Extraction from a Decision Tree, Rule Induction Using a Sequential Covering Algorithm, Model Evaluation and Selection: Metrics for Evaluating Classifier Performance, Holdout Method and Random Sub sampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves, Techniques to Improve Classification Accuracy: Introducing Ensemble Methods, Bagging, Boosting and Ada Boost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data.
Study of open source/Commercial tool (WEKA/MEKA/Mulan/Panthalo), open source is desirable)

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

Unit 5	Content Classification	02

Bayesian Belief Networks, Concepts and Mechanisms, Training Bayesian Belief Networks, Classification by Back propagation, A Multilayer Feed-Forward Neural Network, Defining a Network Topology, Back propagation, Inside the Black Box: Back propagation and Interpretability, Support Vector Machines: The Case When the Data Are Linearly Separable, The Case When the Data Are Linearly Inseparable, Classification Using Frequent Patterns, Associative Classification, Discriminative Frequent Pattern–Based Classification, Lazy Learners (or Learning from Your Neighbors), k-Nearest-Neighbor Classifiers, Case-Based Reasoning, Other Classification Methods, Genetic Algorithms, Rough Set Approach, Fuzzy Set Approaches, Additional Topics Regarding Classification: Multiclass Classification, Semi- Supervised Classification Active Learning, Transfer Learning, Reinforcement learning, Systematic Learning, Holistic learning and multi-perspective learning.
Study of open source/Commercial tool (WEKA/MEKA/ Mulan/ Panthalo), open source is desirable)

Book:
1. Han, Jiawei Kamber, Micheline Pei and Jian, "Data Mining: Concepts and Techniques" Elsevier Publishers Third Edition/Second Edition, ISBN: 9780123814791, 9780123814807
2. Parag Kulkarni, "Reinforcement and Systemic Machine Learning for Decision Making." Wiley-IEEE Press, ISBN: 978-0-470-91999-6.

Unit 6	ANN and Data Mining	02

Deep Feed forward Networks: Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation and Other Differentiation Algorithms. Convolution Networks: The Convolution Operation, Pooling, Variants of the Basic Convolution Function. Recurrent Neural Networks: Recurrent Neural Networks, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, The Long Short-Term Memory and RNNs. Auto- Encoders: Under complete Auto encoders, Regularized Auto encoders, Stochastic Encoders and Decoders, Denoising Auto encoders Applications: Large-Scale Deep Learning, Computer Vision, Speech Recognition, Natural Language Processing.
Study of open source/Commercial tool (like Tensor Flow Lib., Caffé Lib., Theano.), open source is desirable)

References:
1. Ian Goodfellow, Yoshua Bengio, Aaron Courville , "Deep Learning ", MIT Press, ISBN: 9780262337434
2. Online Course: http://cs224d.stanford.edu/syllabus.html

Unit 7	Parallel and Distributed Data Mining	02

Parallel and Distributed Data Mining: Introduction Parallel and Distributed Data Mining, Parallel Design Space: Distributed Memory Machines vs. Shared Memory Systems, Task vs. Data Parallelism, Static vs. Dynamic Load Balancing, Horizontal vs. Vertical Data Layout, Complete vs. Heuristic Candidate Generation.
Algorithms in parallel and distributed data mining: Count Distribution, Data Distribution, Candidate Distribution, Eclat, Algorithms: Parallel Association Rule Mining: a priori-based Algorithms, Vertical Mining, Pattern-Growth Method,
Parallel Clustering Algorithms: Parallel k-means, Parallel Hierarchical Clustering, Parallel HOP: Clustering Spatial Data, Clustering High-Dimensional Data,
Research Issues and Challenges: High dimensionality, Large size, Data Location, data Types, Data Skew, Dynamic Load Balancing, Incremental Methods, Multi-table Mining, Data Layout, and Indexing Schemes, Parallel DBMS/File systems, Interaction, Pattern Management, and Meta-level Mining.
Distributed Mining Frameworks/Architectures: JAM, PADMA, BODHI, APACHE SPARK.
Introduction to CUDA Parallel programming language: Parallel Programming in CUDA C - CUDA Parallel Programming, Splitting Parallel Blocks, Shared Memory and Synchronization, Constant Memory, Texture Memory, CUDA events, Measuring Performance with Events, Parallel Matrix multiplication, Cuda KNN.

Books:
1. Mohammed J. Zaki, Ching-Tien Ho, "Large-Scale Parallel Data Mining",   LCNS, Springer Publishers, ISBN: 978-3-540-46502-7
2. Sanguthevar Rajasekaran and John Reif, "Handbook of Parallel Computing Models Algorithms and Applications", CRC Book Press, **ISBN 9781584886235**
3. Liu, Wei-keng Liao, Alok Choudhary, and Jianwei Li, "Parallel Data Mining Algorithms for Association Rules and Clustering"
4. Kimito Funatsu, "New Fundamental Technologies in Data Mining" , 978-953-307- 547-1
5. Jason Sanders ,Edward Kandrot, "CUDA by Example - An Introduction to General- Purpose GPU Programming", ISBN-10: 0-13-138768-5
6. Addison Wesley, Shane cook,, " CUDA Programming: A Developer's Guide to Parallel Computing with GPUs by, Elsevier Publishers, ISBN: 978-0201000238

Unit 8	Spatial and Multimedia Data Mining	02

Data Objects: Generalization of Structured Data, Aggregation and Approximation in Spatial and Multimedia Data Generalization, Generalization of Object Identifiers and Class/Subclass, Hierarchies, Generalization of Class Composition Hierarchies, Construction and Mining of Object Cubes, Generalization-Based Mining of Plan Databases by Divide-and-Conquer.
Spatial Data Mining: Spatial Data Cube Construction and Spatial OLAP, Mining Spatial Association and Co-location Patterns, Spatial Clustering Methods, Spatial Classification and Spatial Trend Analysis, Mining Raster Databases,
 Multimedia Data Mining: Similarity Search in Multimedia Data, Multidimensional Analysis
of Multimedia Data, Classification and Prediction Analysis of Multimedia Data, Mining Associations in Multimedia Data, Audio and Video Data Mining

Book:

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

9	**Data Mining Applications**	02

Mining Complex Data Types, Mining Sequence Data: Time-Series, Symbolic Sequences, and Biological Sequences, Mining Graphs and Networks, Mining Other Kinds of Data, Other Methodologies of Data Mining, Statistical Data Mining, Views on Data Mining Foundations, Visual and Audio Data Mining, Data Mining Applications, Data Mining for Financial Data Analysis, Data Mining for Retail and Telecommunication Industries, Data Mining in Science and Engineering, Data Mining for Intrusion Detection and Prevention, Data Mining and Recommender Systems, Data Mining and Society, Ubiquitous and Invisible Data Mining, Privacy, Security, and Social Impacts of Data Mining, Data Mining Trends.

Book:

1. Han, Jiawei Kamber, Micheline Pei and Jian, "Data Mining: Concepts and techniques" Elsevier Publishers Second Edition, ISBN: 9780123814791, 9780123814807.

10	**Pattern Discovery and Social Networks Mining**	02

Graph Mining: Methods for Mining Frequent Subgraphs: A priori-based Approach, Pattern-Growth Approach, Mining Variant and Constrained Substructure Patterns: Mining Closed Frequent Substructures Extension of Pattern-Growth Approach: Mining, Alternative Substructure Patterns, Constraint-Based Mining of Substructure Patterns, Mining Approximate Frequent Substructures, Mining Coherent Substructures Mining Dense Substructures, Applications: Graph Indexing with Discriminative Frequent Substructures Substructure Similarity Search in Graph Databases Classification and Cluster Analysis Using Graph Patterns **Social Network Analysis:** Introduction Social Network, Characteristics of Social Networks, Link Mining: Tasks and Challenges, Mining on Social Networks: Link Prediction, Mining Customer Networks for Viral Marketing, Mining Newsgroups Using Networks, Community Mining from Multi relational Networks Multi relational Data Mining: Introduction Multi relational Data Mining ILP Approach to Multi relational Classification Tuple ID Propagation, Multi relational Classification Using Tuple ID Propagation Multi relational Clustering with User Guidance.

Books:

1. Han, Jiawei Kamber, Micheline Pei and Jian, "Data Mining: Concepts and Techniques", Elsevier Publishers Second Edition, ISBN: 9780123814791, 9780123814807.
2. Matthew A. Russell, "Mining the Social Web,:Data Mining Facebook, Twitter, LinkedIn, Google+, GitHub, and More" , Shroff Publishers, 2nd Edition
3. Maksim Tsvetovat,Alexander Kouznetsov, "Social Network Analysis for Startups:Finding connections on the social web", Shroff Publishers , ISBN: 10: 1449306462

Savitribai Phule Pune University, Pune
ME Artificial Intelligence (2017 Course)
Elective I – 510701B: Real Time Analytics

Teaching Scheme:	Credit	Examination Scheme:
TH: 05 hr/week	05	In Semester: 50 Marks End Semester: 50 Marks

Prerequisite Courses: Time series and Forecasting

Companion Course: Real time Analytics with Apache storm

Course Objectives:
1. To teach the fundamental techniques and principles in achieving data analytics with scalability and streaming capability.
2. To provide an overview of an exciting growing field of data analytics.
3. To enable students to have skills that will help them to solve complex real-world problems in decision support.

Course Outcomes:
On completion of the course, learner will be able to--

CO1: Understand & apply appropriate analytical techniques.
CO2:Apply analytics for decision making in healthcare services.
CO3:Learn and understand open source tools like Google Analytics

Selection of Modules: Modules 1 to 3 are compulsory and select any one from modules 4, 5 and 6.

Module I	Fundamentals of Data Analytics	7 Hours

Data Analytics Basics, Data Types, Analytics Types, Data Analytics Steps: Data Pre-Processing, Data Imputation, Data Cleaning, Data Transformation, Data Visualization, and Data Engineering. Descriptive, Predictive, and Prescriptive Analytics.

Case Studies (if any)	Any Exploratory Data Analysis (EDA) can be done here Ex: https://towardsdatascience.com/exploratory-data-analysis-in-python-c9a77dfa39ce
Mapping of Course Outcomes	CO1

Module II	Data Analytics with Python	6 Hours

Data Analytics using Python, Statistical Procedures, Web Scraping in Python, Advanced analytics, NumPy, Pandas, SciPy, Matplotlib.

Case Studies(if any)	Web Scrapping must be emphasized.
Mapping of Course Outcomes	CO1

Module III	Time Series Analysis	7 Hours

Box-Jenkins Methodology for ARIMA models: Examining correlation and stationarity of time series data, ARIMA models for time series data (An Auto-regressive model of order one and a Moving Average Model of order one).

Case Studies(if any)	ARIMA is used for time series analysis to get moving avg,share market analysis can be done here Ex:https://towardsdatascience.com/stock-market-analysis-using-arima-8731ded2447a
Mapping of Course outcome	CO2

Module IV	Streaming Data	6 Hours

Streaming Analytics Architecture: Designing Real-Time Streaming Architectures, Service Configuration and Coordination.

Case Studies(if any)	Real-Time Analytics with Network Data: This section explains Apache Storm based real-time analytics solution, using an example of a telecom service provider. In the network of a telecom service provider, there can be different sources of incoming data, like: 1. Stream of data generated due to use of services by subscribers 2. Performance data of access network, as reported by network probes Data related with new subscription orders, activation and terminate orders.
Mapping of Course Outcomes	**CO2**

Unit V	Streaming Data Analysis	7 Hours

Data-Flow Management in Streaming Analysis, Processing Streaming Data, Storing Streaming Data

Case Studies(if any)	Case study can be done on any social media site Ex: https://www.dataquest.io/blog/streaming-data-python/
Mapping of Course Outcomes	**CO3**

Module VI	Market Basket Analysis, Recommender system	6 Hours

Todays ecommerce system, apriori algorithm. YOLO: real time object Detection

Mapping of Course Outcomes	**CO3**

Books & Other Resources:

Text Books:
1. Anil Maheshwari, "Data Analytics made accessible," Amazon Digital Publication, 2014.
2. Byron Ellis,"Real–Time Analytics:Techniques to Analyze and Visualize Streaming Data", WILEY Publication.
3. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.

Reference Books:
1. Thomas H. Davenport, Jeanne G. Harris and Robert Morison, "Analytics at
   a) Work: Smarter Decisions, Better Results", Harvard Business Press, 2010 .
2. Spyros Makridakis, Steven C.Wheelwright and Rob J. Hyndman. Forecasting
   b) methods and Applications, Third Edition", John Wiley & Sons Inc., New York (Chapters 1, 4 and 7), 2005.

E-books:
- Anil Maheshwari, "Data Analytics made accessible," Amazon Digital Publication, 2014
- Real-Time Analytics, Techniques to analyze and visualize streaming Data by Byron Ellis.

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
Elective I - 510701D : Network Design and Analysis

Teaching Scheme: TH: 05 Hours/Week	Credit 05	Examination Scheme: In- Sem: 50 Marks End- Sem: 50 Marks

Course Objectives :
- To develop a comprehensive understanding of computer Networks
- To study design issues in networks.
- To learn estimation of network requirements.
- To learn Enterprise network design.
- To understand various issues hindering the performance of the network.

Course Outcomes: After completion of the course, students should be able to
- Apply the knowledge to design computer networks
- Analyze the performance of networks based on chosen metrics
- Design routing schemes for optimized routing
- Choose appropriate and advanced techniques to build the computer network

Selection of Modules: All modules 1 to 5 are compulsory.

Course Contents

1	Introduction	01

Overview of network analysis and design process, Network design issues, requirement analysis (user, application, device, network) concepts, Routing and forwarding, resource allocation, general principles of network design, network characteristics, performance metric in networks

2	Physical and Logical network design	01

Topologies, Physical addressing, switching, IP packet format, IP routing method, routing using masks, fragmentation of IP packet, IPv6, advanced features of IP routers: filtering, IP QoS, NAT, routers

3	Queuing Theory	01

Delay Models in Data Networks, Queuing Models- Little's Theorem, Application of Little's Theorem, Queuing Systems: M/M/1, M/M/2, M/M/m, M/M/∞, M/M/m/m, M/M/m/q, M/M/1/N, D/D/1, M/G/1 System, M/G/1 Queues with Vacations, Priority Queuing.

4	Modelling N/W as Graph	01

Graph terminology, representation of networks, fundamental graph algorithms, shortest path, link prediction algorithms-Dijkstra's, Bellman's, Floyd's, Incremental shortest path algorithm.

5	Methods of Ensuring Quality of Service	01

Methods of ensuring quality of service – introduction, applications and QoS, QoS mechanisms, Queue management algorithms, feedback, resource reservation, traffic engineering, IP QoS Next generation networks, cyber physical systems, smart mobiles, cards and device networks,
smart devices and services, network testing, testing tool – wireshark

Books:
1. Aaron Kershenbaum, "Telecommunications Network Design Algorithm", McGraw Hill education (India), Edition 2014, ISBN-10: 0070342288
2. James McCabe, "N/W analysis, Architecture and Design", Elsevier, 978-0-12-370480-1
3. Pablo Pavon Marino, "Optimization of Computer Networks : Modeling and algorithms – A hands on approach", Wiley Publication, ISBN: 9781119013358
4. Olifer, Victor Olifer, "Computer Networks, Principles, Technologies and Protocols for network design", Wiley India, ISBN: 13: 9788126509171.

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
510702 : Laboratory Proficiency I

Teaching Scheme: Practical: 08 Hours/Week	Credit 04	Examination Scheme: Presentation: 50 Marks TW: 50 Marks

Laboratory Proficiency I (LP I) is companion course of theory courses (core and elective) in Semester I. It is recommended that set of assignments or at least one mini-project/study project per course is to be completed. Set of problem statements are suggested. Course/ Laboratory instructor may frame suitable problem statements. Student has to submit a report/Journal consisting of appropriate documents - prologue, Certificate, table of contents, and other suitable write up like (Introduction, motivation, aim and objectives, outcomes, brief theory, requirements analysis, design aspects, algorithms, mathematical model, complexity analysis, results, analysis and conclusions). Softcopy of report /journal and code is to be
maintained by department/ institute in digital repository.

Suitable platform/framework/language is to be used for completing mini-project/assignments.

Guidelines for Term Work Assessment

Continuous assessment of laboratory work is done based on performance of student. Each assignment/ mini project assessment is to be done based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as mini project assessment include- timely completion, performance, innovation, efficient codes, usability, documentation and adhering to SDLC comprehensively.

Guidelines for Examination

It is recommended that examination should be conducted as presentation by student based on one of the mini projects completed and the content understanding of laboratory work.

Suggested List of Laboratory Assignments

A. Research Methodology

1. Use an academic web search to locate a journal paper which describes a design outcome in your field of interest (i.e. your engineering discipline).You must enter several keywords which relate to your topic. Read the paper and, using your own words, demonstrate your understanding of the paper by:
   - Brief Contribution
   - Performance metric, data set, comparative analysis and outcomes
   - Writing out the major conclusions of the paper;
   - Outlining the verification method(s) used to support these conclusions
   - Describing the author's reflective comments on the quality of the design (positive and negative).
   - The positive and negative environmental impacts;

   After reading a published research paper, write down the research question you think the author have addressed in undertaking this research. Do you think the paper adequately supports the conclusions reached in addressing the question?

2.	Consider a journal article in your discipline that was published approximately five years ago. Note the keywords and type them into one of the web-based academic search engines (e.g. googlescholar.com). Does the original article appear in the search results? How many citations does this article have? Have the same authors published further work in this field? Compare the citations of this paper with those from the most highly cited paper in the search results? How many citations does this highly cited article have? If this paper was published before your original article, is it cited in your article? Do you think this high-cited paper should have been listed as a reference in your original article? Give reasons for your decision. Read a journal paper from your discipline. Following the format of patents, write out one or more important outcomes from the paper in terms of one or more Patent Claims 1, 2…. .These claims must not only be new, they must be not-obvious from previous work
3.	a) Literature Review Quality: Using a Journal paper selected in your engineering discipline of interest, write a 400 word evaluation of the quality of Literature Review. In particular, review the quality and relevance of cited papers, the comments made on those papers contribution to the general field, and any omission of papers which are of major importance in the field. b) Develop a new research proposal from a published paper: From selected published Journal paper, read the paper. In particular read the discussion and conclusion section and find Suggestions for further work. Apply one of the question words(How?, Why?, What?, When?) and write one or more research questions arising from this paper. This can be used as guide to help you to develop your own research project proposal
4.	a) Download a set of weather data from the Internet covering the temperature and atmospheric pressure over a four day period. Present the data using 2D and 3D plots, and so deduce if the weather conditions are trending either higher or lower over this four day period. (Possible web sites include http://www.bom. gov.au/climate/ data/ and http://www.silkeborg-vejret.dk/english/ regn.php). b) Numerical modeling: Find a paper in which nunicricil modeling has been used to verify the experimental results. Comment on the differences between the experimental and modeling results. Have the authors commented on the accuracy of the experimental and modeling procedures? What suggestions do you have to improve the quality of the modeling reported in the paper? c) Statistical review: In your engineering discipline review a published paper which includes a statistical analysis. Write a brief report on the statistical methods used. Can you suggest an improved statistical analysis? Suggest some additional parameters that might have been measured during the data acquisition stage and so explain how you would analyze the total data set to deduce the influence (and statistical significance) of these additional measurements.

B. Software Development & Version Control	
1.	Study of any open source system/application software like Version Control in Linux Kernel
C. Data Modeling and Visualization	
1.	Course instructor is authorized to frame suitable problem statement for Assignments for Data Modelling and Visualization.
E. Elective I	
	Course instructor is authorized to frame suitable problem statement for Assignments/ mini project for the elective I offered in their institute.

Semester II

Savitribai Phule Pune University Master of Artificial Intelligence (2017 Course) 510102 : Bio-Inspired Optimization Algorithms		
Teaching Scheme: **TH: 04 Hours/Week**	**Credit** **04**	**Examination Scheme** **In-Sem: 50 Marks** **End-Sem : 50 Marks**

Course Objectives :
- To learn how natural and biological systems influence computational field
- To understand the strengths and weaknesses of nature-inspired algorithms
- To learn the functionalities of various Bio-inspired optimization algorithms

Course Outcomes:

On completion of the course, student will be able to–
- Describe the natural phenomena that motivate the algorithms
- Apply nature-inspired algorithms to optimization
- Select the appropriate strategy or optimal solution based on bio-inspired algorithms

Course Contents		
Unit I	**Natural Computing**	**08 Hours**
From nature to natural computing, sample idea, Philosophy of natural computing, Natural computing approaches, Conceptualization – general concept, Problem solving as a search track, Hill climbing, Simulated annealing		
Unit II	**Evolutionary Computing**	**08 Hours**
Evolutionary computing : Evolutionary biology, Evolutionary computing – standard evolutionary algorithm; Genetic algorithm, evolutionary strategies, Evolutionary programming		
Unit III	**Swarm Intelligence**	**08 Hours**
Swarm intelligence-biological motivation, from natural to artificial, standard algorithm of Ant colony optimization, Ant clustering algorithm, Particle swarm optimization		
Unit IV	**Biological Motivation**	**08 Hours**
Biological motivation, from natural to artificial, standard algorithm of cuckoo search, bat algorithm, flower pollination, firefly algorithm, framework for self tuning algorithms - case study of firefly algorithm		
Unit V	**Immune Systems**	**08 Hours**
Immune system, Artificial immune systems - biological motivation, Design principles, main types of algorithms - Bone marrow, Negative selection, Clonal selection, Continuous immune network models, Discrete immune network models, Scope of artificial immune systems		
Unit VI	**Artificial Life**	**08 Hours**
The essence of life, Examples of ALife projects- flocks, herds and schools, computer viruses, synthesizing emotional behavior, AIBO robot, Turtles, termites, and traffic jams, framsticks, Scope of artificial life, Current trends and open problems.		
Books:		
Text:		
1. L. N. de Castro, "Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications", 2006, CRC Press, ISBN-13: 978-1584886433		
2. D. Floreano and C. Mattiussi, " Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", 2008, MIT Press, ISBN-13: 978-0262062718		

References:

1. Sam Jones (Editor), "Bio Inspired Computing-Recent Innovations and Applications", Clanrye International; 2 edition (2 January 2015), ISBN-10: 1632400812

2. Yang Xiao (Editor), "Bio-Inspired Computing and Networking", CRC Press,

3. "Machine Nature: The Coming Age of Bio-Inspired Computing", New York: McGraw- Hill, 2002)

4. Adries Engelbrecht, " Computational Intelligence", Wiley, ISBN:978-0-470-03561-0

5. D.Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", 2008, MIT Press, ISBN-13: 978-0262062718

6. Russell C. Eberhart , Yuhui Shi , James Kennedy, " Swarm Intelligence: The Morgan Kaufmann Series in Evolutionary Computation", 1st Edition, ISBN-13: 978- 1558605954

7. M. Goodrich, Tamassia, "Algorithm Design & Applications", Wiley, ISBN:978-1-118-33591-8

Savitribai Phule Pune University, Pune
ME Artificial Intelligence (2017 Course)
510309: Machine Learning

Teaching Scheme:	Credit	Examination Scheme:
TH: 04 hr/week	04	In Semester: 50 Marks End Semester: 50 Marks

Prerequisite Courses: Big Data Analytics

Companion Course: Laboratory Proficiency-II

Course Objectives:
1. To understand Human learning aspects
2. To learn the primitives in learning process by computer
3. To Understand nature of problems solved with Machine Learning
4. To acquaint with the basic concepts and techniques of Machine Learning.
5. To learn the means for categorization of the information

Course Outcomes:
On completion of the course, learner will be able to
CO1:Acquire fundamental knowledge of learning theory
CO2:Design and evaluate various machine learning algorithms
CO3:Use machine learning methods for multivariate data analysis in various scientific fields
CO4: Choose and apply appropriate Machine Learning Techniques for analysis, forecasting, categorization and clustering of the data

Unit I	Machine Learning Concepts	07 Hours

Introduction to Machine Learning, Machine Learning applications, Types of learning: Supervised, Unsupervised and semi-supervised, reinforcement learning techniques, Models of Machine learning: Geometric model, Probabilistic Models, Logical Models, Grouping and grading models, Parametric and non-parametric models, Predictive and descriptive learning, Classification concepts, Binary and multi-class classification.

Mapping of Course Outcomes	CO1-Acquire fundamental knowledge of learning theory	
Unit II	**Learning Theory**	**07 Hours**

Features: Feature Extraction, Feature Construction and Transformation, Feature Selection, Dimensionality Reduction: Subset selection, the Curse of dimensionality, Principle Components analysis, Independent Component analysis, Factor analysis, Multidimensional scaling, Linear discriminant analysis, Bias/Variance tradeoff, Union and chernoff/ Hoeffding bounds, VC dimension, Probably Approximately Correct (PAC) learning, Concept learning, the hypothesis space, Least general generalization, Internal disjunction, Paths through the hypothesis space, model Evaluation and selection

Mapping of Course Outcomes	CO1-Acquire fundamental knowledge of learning theory	
Unit III	**Geometric Models**	**07 Hours**

Regression, Logistic regression , Assessing performance of regression - Error measures, Overfitting, Least square method, Multivariate Linear regression, Regression for Classification, Perceptron, Muli-layer perceptron, Simple neural network, Kernel based methods, Support vector machines(SVM), Soft margin SVM, Support Vector Machines as a linear and non-linear classifier, Limitations of SVM, Concept of Relevance Vector, K-nearest neighbor algorithm

Mapping of Course Outcomes	CO2- Design and evaluate various machine learning algorithms	
Unit IV	**Logical, Grouping And Grading Models**	**07 Hours**

Decision Tree Representation, Alternative measures for selecting attributes, Decision tree algorithm: ID3, Minimum Description length decision trees, Ranking and probability estimation trees, Regression trees, Clustering trees, Rule learning for subgroup discovery, Association rule mining, Distance based clustering- K-means algorithm, Choosing number of clusters, Clustering around medoids – silhouettes, Hierarchical clustering, Ensemble methods: Bagging and Boosting

Mapping of Course Outcomes	CO2-Design and evaluate various machine learning algorithms	
Unit V	**Probabilistic Models**	**07 Hours**

Uncertainty, Normal distribution and its geometric interpretations, Baye's theorem, Naïve Bayes Classifier, Bayesian network, Discriminative learning with maximum likelihood, Probabilistic models with hidden variables, Hidden Markov model, Expectation Maximization methods, Gaussian Mixtures and compression based models

Mapping of Course Outcomes	CO2-Design and evaluate various machine learning algorithms	
Unit VI	**Case Studies on Advanced Machine Learning Techniques**	**07 Hours**

Diagnosis of human disease, Diagnosis of crop disease, Text mining tasks like semantic analysis, author profiling, author identification, language identification, summarization etc., Prediction & forecasting, Fraud detection, Learning to rate vulnerabilities and predict exploits

Mapping of Course Outcomes	1) CO3-Use machine learning methods for multivariate data analysis in various scientific fields 2) CO4-Choose and apply appropriate Machine Learning Techniques for analysis, forecasting, categorization and clustering of the data

Books & Other Resources:

Text Books:

1. Peter Flach, Machine Learning: The Art and Science of Algorithms that make sense of data, Cambridge University Press, 1st Edition, 2012, ISBN No.: 978-1-316-50611-0
2. EthemAlpaydin, Introduction to Machine Learning, PHI, 2nd edition, 2013, 978-0-262-01243-0
3. Kevin Murphy, Machine Learning: a Probabilistic Approach, MIT Press, 1st Edition, 2012, ISBN No.: 978-0262-30616-4

Reference Books:

1. C.M. Bishop, Pattern Recognition and Machine learning, Springer, 1st Edition, 2013, ISBN No.: 978-81-322-0906-5
2. Hastie, Tibshirani, Friedman, Introduction to statistical machine learning with applications in R, Springer, 2nd Edition, 2013, ISBN No.: 978-1-4614-7138-7
3. Tom Mitchell, Machine Learning, McGraw Hill, 1997, 0-07-042807-7
4. ParagKulkarni, Reinforcement and Systemic Machine learning for Decision Making, Wiley-IEEE Press, 2012, 978-0-470-91999-6
5. M. F. Der, L. K. Saul, S. Savage, and G. M. Voelker (2014). Knock it off: profiling the online

storefronts of counterfeit merchandise. In Proceedings of the Twentieth ACM Conference on Knowledge Discovery and Data Mining (KDD-14), pages 1759-1768. New York, NY.

6. J. T. Ma, L. K. Saul, S. Savage, and G. M. Voelker (2011). Learning to detect malicious URLs. ACM Transactions on Intelligent Systems and Technology 2(3), pages 30:1-24.

7. D.-K. Kim, G. M. Voelker, and L. K. Saul (2013). A variational approximation for topic modeling of hierarchical corpora. To appear in Proceedings of the 30th International Conference on Machine Learning (ICML-13). Atlanta, GA.

8. M. Bozorgi, L. K. Saul, S. Savage, and G. M. Voelker (2010). Beyond heuristics: learning to classify vulnerabilities and predict exploits. In Proceedings of the Sixteenth ACM Conference on Knowledge Discovery and Data Mining (KDD-10), pages 105-113. Washington, DC

MOOC Courses :

- Introduction to Machine Learning, By Prof. Balaraman Ravindran

Savitribai Phule Pune University, Pune
ME Artificial Intelligence (2017 Course)
510504: Virtual Reality Augmented Reality

Teaching Scheme:	Credit	Examination Scheme:
TH: **04 hrs/week**	**04**	**In Semester: 50 Marks End Semester: 50 Marks**

Prerequisite Courses: Computer Graphics

Companion Course: Laboratory Proficiency-II

Course Objectives:
1. To introduce the fundamentals of sensation, perception, technical and engineering aspects of virtual reality systems
2. To introduce the fast growing field of AR and make the students aware of the various AR concepts and applications.
3. To learn basic principles of VR applications and encourage students build various AR & VR apps using Unity.

Course Outcomes:
On completion of the course, learner will be able to
CO1: Identify the most suitable technique for a given use case based on the understanding of the similarities and differences between virtual, augmented and mixed reality
CO2: Understand the system of human vision and its implication on perception and rendering.
CO3: Understand the computer vision concepts and softwares for AR and describe AR techniques
CO4: Create 3D scenes with Unity IDE and experiment with various user interface (UI) techniques that are used in VR applications
CO5: Understand, develop and **demonstrate** AR and VR apps in Unity IDE

Unit I	Introduction to AR, VR and MR	7 hrs

Differentiation, Features, use-cases and examples. Milgram's Reality-Virtuality continuum: Reality, Augmented Reality, Augmented Virtuality, Virtual Environment and Mixed Reality.
Taxonomy of Mixed Reality: real, virtual, Extent of Work Knowledge (EWK),
Reproduction Fidelity (RF), Extent of Presence Metaphor (EPM). Geometry of Virtual World and Illumination: Birds-Eye View. Geometric Modeling. Matrix algebra and 2D rotations. 3D rotations and Yaw, Pitch and Roll. Axis angle representation. Quaternions. Converting and multiplying rotations. Homogeneous transforms. The chain of viewing transforms. Eye transforms. Viewport transforms. Three interpretations of light.

Mapping of Course Outcomes	CO1

Unit II	Visual Perception & Rendering	6 hrs

Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information.
Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates

Case Studies(if any)	Automatic stitching of panoramas in Virtual Reality

Mapping of Course Outcomes	CO2

Unit III	Computer Vision for Augmented Reality & AR software	7 hrs

Marker creation and marker tracking. Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, Outdoor Tracking
Augmented Reality Software - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application.

Case Studies(if any)	Study all the available AR toolkits.

Mapping of Course Outcomes	CO3

Unit IV	AR Techniques- Marker based & Markerless tracking	7 hrs

Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication. **Marker types-** Template markers, 2D barcode markers, imperceptible markers. **Marker-less approach**- Localization based augmentation, real world examples. **Tracking methods-** Visual tracking, feature based tracking, hybrid tracking, and initialisation and recovery.

Case Studies(if any)	Study on enhancement and improving markers with Vuforia engine.

Mapping of Course Outcomes	CO3

Unit V	Virtual Reality for Game Development	7 hrs

What is virtual reality?, Types of head-mounted displays, How virtual reality really works, Types of VR experiences, Technical skills that are important to VR, High-Level Concepts of Content Creation, Environmental Design, Affecting Behavior, Transitioning to VR Content Creation, Content Creation: Design Guidelines, Human-Centered Interaction, VR Interaction Concepts, Input Devices, Interaction Patterns and Techniques, Interaction: Design Guidelines, Overview of game development in Unity IDE, Building Your Project and Character, Getting Animated, The Town View, Working with Unity's UI System.

Case Studies(if any)	Study about VR device interaction and working with OS(Windows/Linux) and IDE's (Unity/Unreal)

Mapping of Course Outcomes	CO4

Unit VI	Application Development Using Augmented Reality and Virtual Reality	7 hrs

VR SDK's – VR SDK'S and Frameworks – OpenVR SDK, StreamVR SDK, VRTK, Oculus SDK, Google VR SDK. **VR Concept Integration-** Motion Tracking, Controllers, Camera , Hardware and Software requirements **Setting up Unity with VR-** Framework/SDK Integration with Unity, Debugging VR projects,**Working with AR Tools– ARCore, ARToolkitx ARCore** - Features of ARCore, integration with Unity/Unreal/iOS/Android Studio, augmented reality applications with ARCore. **ARToolkit** – Features of ARToolkit, setting up the environment for application development. **Vuforia-** Features of Vuforia, setting up the environment for application development.

Case Studies(if any)	Use of OpenCV for AR App Development

Mapping of Course Outcomes	CO5

Books & Other Resources:

Text Books:

    1. Tom Dieck, M. Claudia & Timothy Jung "Augmented Reality and Virtual Reality The Power of AR and VR for Business" Springer; 1st ed. 2019 edition ISBN-13: 978-3030062453

    2. Jason Jerald "The VR Book: Human- Centered Design for Virtual Reality, Association for Computing Machinery", Morgan & Claypool Publishers

    3. Steven M. LaValle, "Virtual Reality", Cambridge University Press, 2016

    4. William R Sherman and Alan B Craig, "Understanding Virtual Reality: Interface, Application and Design", (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002

    5. 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:

1. Tony Parisi, Learning Virtual Reality, O'Reilly Media, Inc., 2015, ISBN- 9781491922835

2. Jonathan Linowes, Krystian Babilinski, Augmented Reality for Developers: Build practical augmented reality applications with Unity, ARCore, ARKit, and Vuforia. Packt publishing, 9th October 2017. ISBN-13: 978-1787286436

MOOC Courses:

- https://www.coursera.org/learn/ar
- https://nptel.ac.in/courses/106/106/106106138/
- https://www.coursera.org/learn/introduction-virtual-reality

E-books:

- http://lavalle.pl/vr/book.html

- https://www.amazon.in/Augmented-Reality-Virtual-Business-Progress/dp/3030062457

- https://www.amazon.in/Beginning-iOS-Game-Development-Developing-ebook/dp/B07G2LT4PW

Important links:

- https://www.springer.com/gp/book/9783030062453

Savitribai Phule Pune University, Pune **ME Artificial Intelligence (2017 Course)** **Elective-II – 510703A: Web Intelligence**		
Teaching Scheme	**Credit Scheme**	**Examination Scheme and Marks**
Lecture: 05 Hours/Week	**05**	**In Semester(TH): 50 Marks** **End Semester(TH): 50 Marks**

Prerequisites: Basic Mathematics, algorithms and data Structures

Companion Course :   Laboratory Proficiency-II

Course Objectives:
1. To learn web intelligence basics to build website using intelligent technologies
2. To learn the semantic web technologies.
3. To learn web spiders to create specialized search engines.
4. To study web structure mining methods.
5. To learn Algorithmic Aspects of Web Intelligent Systems
6. To study social network intelligence as link analysis of the web.

Course Outcomes:
On completion of the course, learner will be able to–
CO1:Build website using intelligent technologies
CO2:Apply various semantic web technologies for building layered language models.
CO3:Learn and apply web spiders for specialized search engines.
CO4:Apply web structure mining methods for mining the data.
  CO5:Use algorithmic aspects of web intelligent systems for web document pre-fetching on the Internet
 CO6: Apply Social Network Intelligence for identifying fractal nature of the web and knowledge
        management.

Module I	**Web Intelligence and Information Retrieval**	**(07 Hours)**

What is web intelligence? Towards an Intelligent web, knowledge, Web mining, Building better websites using intelligent technologies, benefits of intelligent web.
Information Retrieval: Introduction, document representation, retrieval models, evaluation of retrieval performance, public domain information retrieval systems.

Mapping of Course Outcomes	CO1

Module II	**Semantic Web**	**(07 Hours)**

Semantic Web technologies, Introduction, layered-language model, metadata and ontologies, ontology language for web, ontologies for knowledge management-ontology usage scenario, ontologies as RDBMS schema, Topic ontology versus schema ontologies, proton ontology, Semantic web services- WSMO aproach, OWL-s approach, SWSF approach, WSDLS approach,
The link between SWS and existing Web services standards.

Mapping of Course Outcomes	CO2

Module III	**Web Content Mining**	**(07 Hours)**

Introduction, Web Spiders for Personal Search- Personal Web Spiders
Using Web Spiders to Create Specialized Search Engines- Specialized Search Engines, Focused Spidering Algorithms for Specialized Search Engines,
Web Content Mining- opinion mining, structure mining.
social Networks- Finding communities, usage mining, example: query log analysis, advanced example- web spam detection

Mapping of Course Outcomes	CO3

Module IV	**Web Structure Mining**	**(07 Hours)**

Introduction, Hyper link structure, Web search and hyper link, Modeling web topology: Page rank algorithm, Hyperlink induced topic search (HITS), comparison of Page rank and HITS, Random walks on the web, Other approaches to study web link structure—Social Networks, Reference and index pages.

Mapping of Course Outcomes	CO4

Module V	**Algorithmic Aspects of Web Intelligent Systems**	**(07 Hours)**

An Overview of the System- User Interface, Performance, Users and Authentication Techniques, Agent's Inference Engine

Algorithms- Data Characteristics and Generic Handling Techniques, Choosing the Next Document, Finding Interesting Object Collections and Predicting Votes by Matching Users, Finding an Interesting Documents Collection and Predicting Votes Using Na'ive Bayes Analysis, Matching Related Documents

Web Document Prefetching on the Internet- Introduction: Prefetching at Different Stages, Conditions of Content Prefetching, Classifying Prefetching Methods, Prefetching Structure and Optimization, Performance Evaluations on Prefetching, Other Variants of Prefetching, Related Applications .

Mapping of Course Outcomes	CO5

Module VI	**Social Network Intelligence**	**(07 Hours)**

Social Networks: From the Web to Knowledge Management - Link Analysis of the Web, Communities on the Web, Connectivity and the Diameter of the Web, Fractal Nature of the Web, Social Networks for Knowledge Management,
A Ranking Algorithm Based on Graph Topology to Generate Reputation or Relevance- Social Networks, Ranking Algorithm, Experiments About Ranking, Reputation, and Relevance

Case Studies(if any)	

Mapping of Course Outcomes	CO6

Books

Text Books:
1) NingZhong, JimingLiu, Yiyu Yao, " Web Intelligence", Springer, ISBN: 978-3-642-07936-8

2) John Davies, Rudy Studer, Paul Warren, Semantic Web Technologies: Trends and Research in Ontology-based Systems, ISBN: 978-0-470-02596-3
3) PawanLingras, RajendraAkerkar, "Building an Intelligent Web: Theory and Practice", *ISBN*- 10: 076374137X

Reference Books:
1. Dallas Marks, Heather Sinkwitz, Jim Brogden, Gabriel Orthous , "SAP Business Objects Web Intelligence: The Comprehensive Guide", 3rd edition , Galileo Press
2. Akerkar, R. &Lingras, "Building an Intelligent Web: Theory and Practice, Jones and Bartlett Publishers, Sudbury, Massachusetts. ISBN-13: 978-0-7637-4137-2
3. Ian H. & Frank, E," Data Mining: Practical Machine Learning Tools and Techniques", 2nd Edition, Morgan Kaufman. ISBN 0120884070, 9780120884070

Savitribai Phule Pune University, Pune ME Artificial Intelligence (2017 Course) Elective-II – 510703C: Business Analytics		
Teaching Scheme:	**Credit**	**Examination Scheme:**
TH: 05 hr/week	**05**	**In Semester: 50 Marks** **End Semester: 50 Marks**

Prerequisite Courses: Basic Statistics, Basic Mathematics, Basic Management and Basics of Data Mining

Companion Course:

Course Objectives:
1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. Understanding insights of managers to solve business problems and to support managerial decision making.
4. Survey the processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.

Course Outcomes:
On completion of the course, learner will be able to

 CO1:Analyze and visualize data in different industries such as manufacturing, service, retail, software, banking and finance, sports etc.
CO2:Use technical skills in descriptive modeling to support business decision-making.
CO3:Use technical skills in predictive modeling to support business decision-making.
CO4:Usetechnical skills in prescriptive modeling to support business decision-making.
CO5: Demonstrate decision making with and without Risk for solving problems in different industries.

Selection of Modules: Modules 1 to 3 are compulsory and select any one from modules 4, 5 and 6.

Module I	**Overview of Business analytics**	**7 Hours**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Database Analytics

Mapping of Course Outcomes	**CO1**	
Module II	**Descriptive Analytics**	**7 Hours**

Descriptive Analytics :
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Case Studies(if any)	Tableau – Data visualization tool

Mapping of Course Outcomes	**CO2**	
Module III	**Predictive Analytics**	**7 Hours**

Trendlines and Regression Analysis Learning Objectives : Modeling Relationships and Trends in Data , Simple Linear Regression, Residual Analysis and Regression Assumptions , Multiple Linear Regression,

Building Good Regression Models, Regression with Categorical Independent Variables, Regression Models with Nonlinear Terms. **Forecasting Methods:** Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Case Studies(if any)	Healthcare data analysis	
Mapping of Course Outcomes	**CO3**	
Module IV	**Prescriptive Analytics**	**7 Hours**

Linear Optimization : Optimization Models, Linear Optimization in Bank Financial Planning, Analytics in Practice: Using Optimization Models for Sales Planning at NBC, Developing Linear Optimization Models, Identifying Decision Variables, the Objective, and Constraints , Developing a Mathematical Model ,Implementing Linear Optimization Models, Solving Linear Optimization Models , Graphical Interpretation of Linear Optimization with Two Variables , Applications of Linear Optimization, Integer Linear Optimization Models , Models with Binary Variables, Nonlinear Optimization Models.

Case Studies(if any)	Portfolio Analysis	
Mapping of Course Outcomes	**CO4**	
Module V	**Simulation and Risk Analysis**	**7 Hours**

Model-Building Strategies: Building Models Using Logic and Business Principles ,Building Models Using Influence Diagrams, Building Models Using Historical Data,Model Assumptions, Complexity, and Realis. Analysing uncertainty. Introduction of simulation and Risk Analysis, Types of simulations, Risk Management, Risk Assessment, Impact Analysis, Monte Carlo Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Mapping of Course Outcomes for Unit V	**CO5**	
Unit VI	**Decision Analysis**	**7 Hours**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism, Decision Tree and Risk

Mapping of Course Outcomes	**CO5**	

Books & Other Resources:

Text Books:
1) Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2) Business Analytics: Methods, Models and Decisions by James Evans, persons Education, 3rd Edition

3) **Reference Books:**
4) R. Sharda, D. Delen, and E. Turban, Business Intelligence and Analytics. Systems for Decision Support,10th Edition. Pearson/Prentice Hall, 2015. ISBN-13: 978-0-13-305090-5, ISBN-10: 0-13-305090-4;
5) Carlo Vercellis, "Business Intelligence - Data Mining and Optimization for Decision Making", Wiley Publications, ISBN: 9780470753866

MOOC Courses : Syllabus covered(90%)

1)   Business Analytics for Management Decision : 12 weeks NPTEL course
2)   Series of Coursera course on Business Analytics
E-books:

1. Business Analytics A Practitioner's Guide by **Rahul Saxena, AnandSrinivasanInternational Series in Operations Research & Management Science**, Springer New York, December 5, 2012,ISBN: 9781461460800.

	Savitribai Phule Pune University **ME Artificial Intelligence (2017 Course)** **Elective II – 510703B : Image Processing**	
Teaching Scheme: TH: 05 **Hours/Week**	**Credit** **05**	**Examination Scheme:** **In- Sem: 50 Marks** **End- Sem : 50 Marks**

Course Objectives :
- To study image processing concepts
- To study mathematics and algorithms for image processing
- To study various methods of image processing in spatial and frequency domain
- To understand various image processing applications

Course Outcomes :

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

- Apply relevant mathematics required for image processing
- Perform and analyze various image processing methods using appropriate tools
- Use various image processing methods in spatial and frequency domain
- Explore current trends and future scope in image processing applications

Selection of Modules:

Kindly note that modules 1, 2are compulsory and select any three (03) modules from remaining modules 3 to 11.

	Course Contents	
Module No.	**Module Title**	**Credit**
1	**Image Processing Fundamentals**	**01**
Light, Brightness adaption and discrimination, Pixels, coordinate conventions, Imaging Geometry, Perspective Projection, Spatial Domain Filtering, sampling and Quantization, Image types, Image file formats, Human visual system, Elements of an image processing system, Fundamental steps in image processing, Component labeling algorithm, Morphological image processing	
2	**Image Processing Fundamentals**	**01**
Image Enhancement by Spatial domain image enhancement: Intensity transformations, contrast stretching, histogram equalization, Correlation and convolution, Smoothing filters, sharpening filters, gradient and Laplacian **Image Enhancement by Frequency domain Image enhancement :** Low pass filtering in frequency domain (Ideal, Butterworth, Gaussian), High pass filter in frequency domain (ideal, Butterworth, Gaussian). **Case Study: Open Source image processing software**: Octave, OpenCV, Scilab	
3	**Image segmentation**	**01**
Classification of image segmentation techniques, thresholding based image segmentation, edge based segmentation, edge detection, edge linking, Hough transform, watershed transform, clustering techniques, region approach	
4	**Image restoration**	**01**
Image degradation, Image restoration model, linear and non-linear image restoration, image denoising	
5	**Multi resolution analysis**	**01**
Image Pyramids, Multi resolution expansion ,Fast Wavelet Transforms, Lifting scheme	
6	**Feature extraction**	**01**

Shape Descriptors- Classification of shape descriptor techniques, contour based (Boundary following , chain code, signature, Polygon approximation), region based- (Euler number, shape matrix, statistical moments), feature extraction in transform domain(Fourier descriptor)
Relational descriptor, Use of Principal components for description

7	**Image Compression**	01

Need and classification of image compression techniques, run-length coding, Shannon Fano coding, Huffman coding, Scalar and vector quantization, Compression Standards-JPEG/MPEG, Video Compression

8	**Steganography and Watermarking**	01

Information hiding, Steganography: introduction, properties, models, stegnoanalysis, Watermarking : introduction, properties, models, security, content authentication

9	**Satellite Image Processing**	01

Concepts and Foundations of Remote Sensing, GPS, GIS, Elements of Photographic Systems, Basic Principles of Photogrammetry, Multispectral, Thermal, and Hyper spectral Sensing, Earth Resource Satellites Operating in the Optical Spectrum

10	**Medical Image Processing**	01

Introduction, Medical Image Enhancement, Segmentation, Medical Image Analysis (Images of Brain MRI or Cardiac MRI or Breast Cancer Risk) Validation of registration accuracy

11	**Object Recognition**	01

Introduction, Computer Vision, Tensor Methods in Computer Vision, Classifications Methods and Algorithm, Object Detection and Tracking, Object Recognition

Books :

Text:
1. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image processing", Pearson Education , Fourth Impression, 2008, ISBN: 978-81-7758-898-9.
2. A. K. Jain, "Fundamentals of Digital Image Processing", PHI, ISBN-978-81- 203-0929-6.
3. S. Annadurai, R. Shanmugalakshmi, "Fundamentals of Digital Image Processing", Pearson Education, First Edition, 2007, ISBN-8177584790.
4. Boguslaw Cyganek, "Object Detection and Recognition in Digital Images: Theory and Practice", Wiley, First Edition, 2013, ISBN: 978-0-470-97637-1.
5. Ingemar Cox, Matthew Miller, Jeffrey Bloom, Jessica Fridrich, Ton Kalker, "Digital Watermarking and Steganography", Morgan Kaufmann (MK), ISBN : 978-0-12-372585-1.
6. Thomas Lillesand, Ralph W. Kiefer, Jonathan Chipman," Remote Sensing and Image Interpretation", Wiley, Seventh Edition, 2015, ISBN: 978-1-118-91947-7

Reference:
1. Isaac Bankman, "Handbook of Medical Imaging", Academic Press, Second Edition, 2008, ISBN: 9780080559148.
2. Jayaraman, Esakkirajan,Veerakumar," Digital image processing", Mc Graw Hill, Second reprint-2010, ISBN(13): 978-0-07-01447-8, ISBN(10):0-07-014479-6
3. NPTEL Video Lecturers: Title: Digital Image Processing, Prof. P. K. Biswas, IIT Khargapur, A joint venture by IISc and IITs, funded by MHRD, Govt of India, url: http://nptel.ac.in/courses/117105079

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
Elective II - 510703D : Network Security

Teaching Scheme: TH: 05 Hours/Week	Credit 05	Examination Scheme: In Sem :: 50 Marks End-Sem: 50 Marks

Course Objectives:
- To understand the concept of security and its applications.
- To learn various vulnerabilities, threats and attacks
- To know various detection and prevention techniques in diversified environments
- To study different algorithms for network security

Course Outcomes:

After completion of the course, students should be able to
- Design and choose appropriate security model
- Apply security means to various applications
- Apply security algorithms in various environments for network security
- Design network security solutions
- Select appropriate tools to thwart network attacks

Selection of Modules:

Kindly note that modules 1, 2 are compulsory and select any three (03) modules from modules 3 to 9.

Course Contents

Module No	Module Title	Credit
1	**Classification of Network Attacks**	01
Basic Security Concepts, History of Network Security, Data Security Vs. Network Security, Computer And Network Attacks, Introduction To Vulnerabilities, Threats And Attacks, Layers Of Attacks, Counter Measure Of Different Attacks Counter Measures For Various Attacks Case Study: How To Detect And Prevent Black Hole Attack In Mobile Ad Hoc Network		
2	**WSN attacks**	01
Review of WSN Attacks. Challenges on Detection of WSN Attacks, Approaches for Securing WSN		
3	**Hacking & Sniffing**	01
Hacking tools, The hacking process, Ethical hacking issues, Current technologies, Recent events and statistics of network attacks, Wi-Fi vulnerabilities What is network sniffing? Why network sniffing is important, Scan a single IP, Scan a host, Scan a range of Ips, Scan a subnet		
4	**Port Scanning and Spoofing**	01
Nmap port selection : Scan a single port, Scan a range of ports, Scan 100 most common ports (fast), Scan all 65535 ports, Scanning a subnet : Spoofing and decoy scans, Evading firewalls Nmap port scan types : Scan using TCP SYN scan (default), Scan using TCP connect		
5	**Browser Exploitation, MITM attacks**	01

Gathering version info : UDP scan, The reason switch, Using a list, Output to a file Commands, Starting the listener, Countermeasures, Social Engineering Toolkit and Browser Exploitation: Social engineering , What are web injections? How SQL injections work Cross site scripting (XSS) attacks: Preventative measures against XSS attacks How to reduce your
chances of being attacked, Browser exploitation with BeEF : Browser hijacking, BeEF with BetterCap, BeEF with man-in-the-middle framework (MITMF), BeEF with SET

6	Advanced Attacks	01

Advanced Network Attacks :What is an MITM attack?Related types of attacks, Examples o MITM, Tools for MITM attacks, Installing MITMF using Kali Linux, Passing and Cracking the Hash, What is a hash? Authentication protocols, Cryptographic hash functions: How do hackers obtain the hash? What tools are used to get the hash? How are hashes cracked? How do pass the hash attacks impact businesses? What defenses are there against hash password
attacks?

7	Web Content Attacks	01

SQL Injection: Examples of SQL injection attacks, Ways to defend against SQL injection attacks, Attack vectors for web applications, Bypassing authentication, Bypasms blocked and filtered websites, Finding vulnerabilities from a targeted sites, Extracting data with SQLmap, Hunting for web app vulnerabilities with Open Web Application Security Project (OWASP)
ZAP

8	Specialized Attacks	01

Malformed packets: Ping of death, Teardrop attack (aka Nestea), ARP cache poisoning, ARP poisoning commands, ACK scan, TCP port scanning, VLAN hopping, Wireless sniffing, OS fingerprinting ISN Sniffing, Passive OS detection

9	Intrusions and Remedies	01

Web application exploits, What tools are used for web application penetration testing?
Evil Twins and Spoofing : What is an evil twin? What is address spoofing? What is DNS spoofing? What tools are used for setting up an evil twin? The dangers of public Wi-Fi and evil twins, How to detect an evil twin? Detection Systems : IDS, IPS, Host based, Network- based, Physical Threat hunting platforms

Books:

Text :
1. Dileep Kumar G.; Manoj Kumar Singh; M.K. Jayanthi, "Network Security Attacks and Countermeasures", IGI Global, ISBN-13: 978-1-4666-8761-5
2. Arthur Salmon, Warun Levesque, Michael McLafferty, "Applied Network Security", Packt Publishing, ISBN-13**:** 978-1-78646-627-3

Reference:
1. William Stallings, 'Cryptography and Network Security: Principle and Practice', 5th Edition, Pearson, ISBN: 978-81-317-6166-3.
2. Bernard Menezes, 'Network Security and Cryptography', Cengage Learning, ISBN: 978-81-315-1349-1.
3. Matt Bishop, Sathyanarayana, S. Venkatramanayya, " Introduction to Computer Security", Pearson Education, ISBN: 978-81-7758-425-7.
4. Bruce Schneier, "Applied Cryptography", Wiley, ISBN:978-1-1119-09672-6

<table>
<tr><td colspan="3">Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
510113- Laboratory Proficiency II</td></tr>
</table>

Teaching Scheme: TH: 05 Hours/Week	Credit 04	Examination Scheme: Presentation: 50 Marks TW : 50 Marks

Laboratory Proficiency II (LP II) is companion course of theory courses (core and elective) in Semester II. It is recommended that set of assignments or at least one mini-project/study project per course is to be completed. Set of problem statements is suggested. Course/ Laboratory instructor may frame suitable problem statements. Student has to submit a report/Journal consisting of appropriate documents - prologue, Certificate, table of contents, and other suitable write up like (Introduction, motivation, aim and objectives, outcomes, brief theory, requirements analysis, design aspects, algorithms, mathematical model, complexity analysis, results, analysis, and conclusions). Softcopy of report /journal and code is to be maintained at department/institute in digital repository.

Suitable platform/framework/language is to be used for completing mini-project/assignments.

Guidelines for Term Work Assessment

Continuous assessment of laboratory work is done based on performance of student. Each assignment/ mini project assessment to be done based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as mini project assessment include- timely completion, performance, innovation, efficient codes, usability, documentation and adhering to SDLC comprehensively

Guidelines for Examination

It is recommended that examination should be conducted as presentation by student based on one of the mini projects completed and the content understanding of laboratory work.

Laboratory Assignments

The laboratory course teacher has to design the assignment based on Machine Learning, Bio Inspired Optimization Algorithms and Elective II offered in their institute. Students need to use R , Python or any other programming language for developing the assignments.

Semester III

<table>
<tr><td colspan="3">**Savitribai Phule Pune University, Pune**
ME Artificial Intelligence (2017 Course)
610501: Soft Computing and Deep Learning</td></tr>
<tr><td>**Teaching Scheme:**</td><td>**Credit**</td><td>**Examination Scheme:**</td></tr>
<tr><td>**TH:**   **04 hrs/week**</td><td>**04**</td><td>**In Semester: 50 Marks**
End Semester: 50 Marks</td></tr>
</table>

Prerequisite Courses: Machine Learning, Artificial Intelligence

Companion Course: Scalable Data Science

Course Objectives:
1. To develop Intelligent systems with soft computing
2. To provide effective and efficient problem solving with soft computing methodologies
3. To introduce major deep learning algorithms
4. To introduce optimization techniques to training deep neural networks
5. To introduce Convolutional Neural Networks and its applications
6. Learn deep recurrent and memory networks

Course Outcomes:
 On completion of the course, learner will be able to
CO1: Identify the components of soft computing and compare soft computing techniques.
CO2:Design a fuzzy inference system for a given system with set of fuzzy rules
CO3:Apply genetic algorithm for solution of an optimization function
CO4:Design a neural network solution for a classification problem
CO5:Implement deep learning algorithms and solve real-world problems in computer vision.
CO6:Implement deep learning algorithms and solve real-world problems in Natural Language
Processing

Unit I	**Introduction to Soft Computing and Fuzzy logic**	**7 hrs**

Introduction to soft computing: , Paradigms soft computing, Features, Components, Techniques, Applications, Neural Networks, Fuzzy logic, Genetic Algorithms, Hybrid systems, Introduction to Fuzzy logic: Classical and Fuzzy sets, operations, properties, Fuzzy Relations.

Case Studies (if any)	Selection of Fuzzy membership to temperature sensor control system
Mapping of Course Outcomes	CO1

Unit II	**Fuzzy Systems and Genetic Algorithms**	**6 hrs**

Membership Functions, Fuzzification and Methods, Defuzzification and Methods, Fuzzy Logic, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making. Fuzzy Control Systems, Fuzzy Classification.
Genetic Algorithms: Introduction to Genetic Algorithms (GA), Search space, Working Principle, Simple GA, Operators, Fitness function, Multi-level Optimization.

Case Studies(if any)	1. Fuzzy inference system for air conditioner 2. Application of GA for resource planning problem
Mapping of Course Outcomes	CO2 & CO3

Unit III	**Introduction to Neural Networks**	**6 hrs**

Perceptrons, Perceptron Learning Algorithm, Sigmoid Neuron, Shallow neural networks, Deep neural networks, Feedforward Neural networks, Gradient descent and the backpropagation algorithm

Case Studies(if any)	Backpropogation algorithm for disease detection

Mapping of Course Outcomes	CO4	
Unit IV	**Deep Learning**	**6 hrs**

Learning Parameters of a feedforward neural network, the vanishing gradient problem, and ways to mitigate it, RelU Heuristics for avoiding bad local minima, Heuristics for faster training, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Momentum.Adagrad, Principal Component Analysis and its interpretations, Singular Value Decomposition.

Case Studies(if any)	Neural Network system for weather forecasting	
Mapping of Course Outcomes	CO4	
Unit V	**Neural Networks and its variants**	**7 hrs**

Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks

Case Studies(if any)	Image classifier for identifying cat vs dogs using CNN	
Mapping of Course Outcomes	CO5	
Unit VI	**Sequence Models:**	**7 hrs**

RNN, LSTM, GRU models, Application to NLP, language models, machine translation, image captioning, video processing, visual question answering, video processing, learning from descriptions, Attention Mechanism, Attention over images

Case Studies(if any)	Hybrid system for customer segmentation	
Mapping of Course Outcomes	CO6	

Books & Other Resources:

Text Books:
1. S. N. Sivanandam & S.N.Deepa "Principles of Soft computing", John Wiley & Sons,
2. S. Rajasekaran, G. A. Vijayalakshami, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, PHI.
3. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016.
4. David E. Goldberg., Genetic Algorithms: in Search and Optimization,PHI
5. Jyh: Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:Hall of India, 2003

Reference Books:
1. Timothy J. Ross, Fuzzy Logic with Engineering Applications (Wiley)
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall,
3. An Introduction to Genetic Algorithm Melanic Mitchell (MIT Press)
4. Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)
5. Neural Networks and Learning Machines Simon Haykin (PHI).
6. Neural Networks, Fuzzy logic, and Genetic Algorithms, S. Rajasekaran& G. A. V. Pai, PHI.

MOOC Courses

- https://swayam.gov.in/nd1_noc20_cs17/preview

E-books:

- https://www.amazon.com/Soft-Computing-Neuro-Fuzzy-Genetic-Algorithms-ebook/dp/B00LOBIAPG
- https://bookboon.com/en/introduction-to-soft-computing-ebook
- http://freecomputerbooks.com/Introduction-to-Soft-Computing.html

Important links:

- https://www.journals.elsevier.com/applied-soft-computing
- http://www.soft-computing.de/linkC.html

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
610102: Information Retrieval

Teaching Scheme: TH: 04 Hours/Week	Credit 04	Examination Scheme: In-Sem: 50 Marks End- Sem : 50 Marks

Course Objectives:
- To study concepts of Information Retrieval;
- To understand the data in the form of XML
- To study and Evaluate retrieved information
- To understand classification and clustering

Course Outcomes:

On completion of the course the student should be able to-
- Implement the concept of Information Retrieval
- Evaluate and Analyze retrieved information
- Generate quality information out of retrieved information
- Apply clustering and classification algorithms to analyze the information

Course Contents		
Unit I	**Dictionaries and tolerant retrieval**	**08 Hours**

Search structures for dictionaries, , Wildcard queries :General wildcard queries ,k-gram indexes for wildcard queries, Spelling correction: Implementing spelling correction, Forms of spelling correction, Edit distance, k-gram indexes for spelling correction, Context sensitive spelling
correction, Phonetic correction

Unit II	**Index Construction index compression scoring**	**08 Hours**

Index compression, Searching, Sequential Searching and Pattern Matching, Hardware basics, Types of indexes, Statistical properties of terms in information retrieval: Heaps' law: Estimating the number of terms, Zipf's law: Modeling the distribution of terms, Dictionary compression: Dictionary as a string ,Blocked storage, Postings file compression :Variable
byte codes, Gamma codes.

Unit III	**Scoring, term weighting & the vector space model:**	**08 Hours**

Parametric and zone indexes: Weighted zone scoring, Learning weights, The optimal weighting, Term frequency and weighting: Inverse document frequency, Tf- idf weighting, The vector space model for scoring :Dot products, Queries as vectors, Computing vector scores, Variant tf-idf functions: Sub-linear tf scaling Maximum tf normalization, Document and query weighting schemes, Pivoted normalized document length

Unit IV	**XML Retrieval**	**08 Hours**

Basic XML concepts, Challenges in XML retrieval, A vector space model for XML retrieval, Evaluation of XML retrieval, Text-Centric vs. Data-Centric XML retrieval. Language models for information retrieval, Language models, The query likelihood model, Language modeling versus other approaches in IR, Extended language modeling approaches.

Unit V	Language models for information retrieval	08 Hours

Language models: Finite automata and language models, Types of language models, Multinomial distributions over words, The query likelihood model: Using query likelihood language models in IR ,Estimating the query generation probability ,Ponte and Croft's Experiments , Language modeling versus other approaches in IR ,Extended language modeling
approaches.

Unit VI	Classification & clustering searches	08 Hours

Text Classification and Naïve Bayes ,Vector Space Classification, Support vector machines, and Machine learning on documents. Flat Clustering , Hierarchical Clustering ,Matrix decompositions and latent semantic indexing ,Fusion and Meta learning, Searching the Web Structure of the Web IR and web search

Books :

Text
1. C. Manning, P. Raghavan, and H. Schütze, "Introduction to Information Retrieval" , Cambridge University Press, 2008, -13: 9780521865715
2. Ricardo Baeza -Yates and Berthier Ribeiro – Neto, "Modern Information Retrieval: The Concepts and Technology behind Search" 2nd Edition, ACM Press Books 2011.
3. Bruce Croft, Donald Metzler and Trevor Strohman, Search Engines: Information Retrieval   in Practice, 1st Edition Addison Wesley, 2009, ISBN: 9780135756324.

Reference :
1. S. Buttcher, C. Clarke and G. Cormack, "Information Retrieval: Implementing and Evaluating Search Engines", MIT Press, 2010, ISBN: 0-408-70929-4.
2. C.J. Rijsbergen, "Information Retrieval", (http://www.dcs.gla.ac.uk/Keith/Preface.html)
3. W.R. Hersh, "Information Retrieval: A Health and Biomedical Perspective", Springer, 2002.
4. G. Kowalski, M.T. Maybury. "Information storage and Retrieval System" , Springer, 2005
5. W.B. Croft, J. Lafferty, "Language Modeling for Information Retrieval", Springer, 2003.

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
Elective III - 610103A : Cloud Security

Teaching Scheme: TH: 05 Hours/Week	Credit 05	Examination Scheme: In- Sem: 50 Marks End- Sem : 50 Marks

Course Objectives:
- To study concepts of Cloud Computing;
- To learn and Explore Cloud Infrastructures
- To study cloud Security Fundamentals
- To know various issues related to the security of information in cloud environment

Course Outcomes:
- Use various services offered for cloud environment
- Apply computing security fundamentals confined to cloud environment
- Analyze the cloud system for vulnerabilities, threats and attacks
- Propose feasible security solution for cloud security

Course Contents

Selection of Modules: Module 1 is compulsory and select any four(04) modules from 2 to 7.

Module No.	Module Title	Credit
1	Introduction	01

Cloud Computing Fundamentals, Essential Characteristics, Architectural Influences, Technological Influences, Operational Influences, Outsourcing, IT Service Management, Cloud Computing Architecture, Cloud Delivery Models, Cloud Deployment Models, Alternative Deployment Models, Expected Benefits.
Understanding Abstraction and Virtualization, Capacity Planning, Exploring Platform as a Service, Using Google Web Services, Using Amazon Web Services, Using Microsoft Cloud Services.

2	Cloud Security	01

Cloud Information Security Objectives, Confidentiality, Integrity, and Availability, Cloud Security Services, Relevant Cloud Security Design Principles, Secure Cloud Software Requirements, Approaches to Cloud Software Requirements Engineering, Cloud Security Policy Implementation and Decomposition, Secure Cloud Software Testing, Testing for Security Quality Assurance, Cloud Penetration Testing, Regression Testing, Cloud
Computing and Business Continuity Planning/Disaster Recovery

3	Cloud Computing Risk Issues	01

The CIA Triad, Privacy and Compliance Risks, Threats to Infrastructure, Data, and Access Control, Common Threats and Vulnerabilities, Cloud Access Control Issues, Cloud Service Provider Risks, Cloud Computing Security Challenges, Security Policy Implementation, Policy Types, Computer Security Incident Response Team (CSIRT), Virtualization Security
Management.

4	Cloud Computing Security Architecture	01

Architectural Considerations, General Issues, Trusted Cloud Computing, Secure Execution Environments and Communications, Identity Management and Access Control, Identity Management, Access Control, Autonomic Security.

5	Cloud Computing Life Cycle Issues	01

Standards, The Distributed Management Task Force (DMTF), The International Organization for Standardization (ISO), The European Telecommunications Standards Institute (ETSI), The Organization for the Advancement of Structured Information Standards (OASIS), Storage Networking Industry Association (SNIA), Open Grid Forum (OGF), The Open Web Application Security Project (OWASP), Incident Response, Encryption and Key

Management, VM Architecture, Retirement

6	Cloud storage Security	01

Who wants your data? Legal issues, criminals and authorization. Government and friends, legal responsibility, US Federal Law and regulations affecting cloud storage. Cloud storage

provider and compliance. Laws and regulations of other countries.

7	Privacy Tools and Best Practices	01

Privacy Tools and Best Practices, 2-factor authentication, secure email for cloud storage, Deletion of private data, security as service, distributed cloud storage, what are best practices,

cloud data security and check list, Future of cloud data security.

Books:

1. Tim Mather, Shahed Latif, Subra Kumaraswamy, "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance", O'Reilly Media, SBN-13: 978- 0596802769, ISBN-10: 0596802765
2. Ronald L Krutz and Russell Dean Vines , "Cloud Security: A Comprehensive Guide to Secure Cloud Computing", ISBN:0470938943

References:

1. Vic (J.R.) Winkler , "Securing the Cloud: Cloud Computer Security Techniques and Tactics", ISBN:159749593X
2. Imad M. Abbadi, "Cloud Management and Security", ISBN: 1118817079
3. Sumner Blount, Rob Zanella, "Cloud Security and Governance: Who's on Your Cloud?", ISBN: 1849280908
4. Ryan Ko, Raymond Choo, "The Cloud Security Ecosystem: Technical, Legal, Business", ISBN: 0128017805

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
Elective III - 610103C :Mobile Ad-hoc Networks

Teaching Scheme: TH: 05 Hours/Week	Credit 05	Examination Scheme: In-Sem : 50 Marks End-Sem : 50 Marks

Course Objectives :
- To study the concepts of Ad hoc Networks
- To learn the concepts of Mobility and Mobility Prediction
- To understand the functionalities of various Protocols in MANET
- To know the technological advancements in wireless networks

Course Outcomes :
- Assess Quality of Service in MANET
- Evaluate the performance of various Protocols in MANET
- Choose appropriate constituents and parameters to build MANET
- Analyze the performance of MANET

Selection of Modules:

Note that modules 1, 2, 3 are compulsory and select any two (02) from modules 4 to 8.

Course Contents

Module No.	Module Title	Credit
1	**Introduction**	01

Fundamentals of Wireless Communication, Characteristics of Wireless channel, IEEE 802 Networking Standard, 802.3, 803.11, 802.15, 802.16, HIPERLAN Standard, HIPERACCESS, Wireless Internet, TCP in Wireless Domain, WAP, ADHOC Wireless Network, Issues in ADHOC Wireless Network.

Recent Advances in Wireless Networks: Ultra Wide-Band Radio Communication, Wireless Fidelity, Optical Wireless Networks, Multimode 802.11, Meghadoot Architecture.

2	**MAC Protocols**	01

Design issues, goals and classification. Contention based protocols, Contention based protocols with reservation mechanisms, scheduling mechanisms, protocols using directional antennas, other protocols. Routing Protocols: Design Issues, Classification, Table Driven, On-Demand, Hybrid, Efficient Flooding Mechanism, Hierarchical, Power-Aware Routing Protocols.

3	**Multicast Routing**	01

Design Issues, Architecture Reference Model, Classification, Tree-Based, Mesh-Based, Energy Efficient, Application Dependent, Multicasting with QOS-Guarantees. Transport layer: Design Issues and Design Goals, Classification, TCP over Ad Hoc Networks, Transport Layer protocols. Network Security Attacks, Key Management, Secure Routing.

4	**Quality of Service**	01

Issues and Challenges, Classification, MAC Layer Solutions, Network Layer Solutions, QOS Frame work. Energy Management: Need, Classification, Schemes for: Battery Management, Transmission Power Management, System Power Management.

5	**Wireless Sensor Networks**	01

Introduction, Sensor network Architecture, Data Dissemination, Data Gathering, MAC Protocols for WSN, Quality of WSN. Hybrid Wireless Networks: Introduction, Next Generation Hybrid Wireless Architectures, Routing, Pricing in Multi-hop Wireless Network, Power Control Schemes, Load Balancing.

6	Algorithms for Mobile Ad-hoc Networks	01

Hierarchical routing and clustering, routing with virtual coordinates, relative location determination, overview and classification of NWB algorithms, Robustness control, NWB robustness solutions.

7	Encoding for Data Distribution& Power Control Protocols	01

Erasure codes, Network coding, Design principles for power control, single layer approach, the systematic approach, energy oriented perspective.

8	Vehicular Ad-hoc Networks	01

VANET, characteristics, Connectivity, Dynamic transmission range assignment, routing applications, vehicle mobility, VANET vs MANET.

Books:

Text:
1. C. Siva Ram Murthy and B.S. Manoj, "Ad hoc Wireless Networks Architectures and protocols", 2nd edition, Pearson Education. 2007, ISBN: 9788131706886, 8131706885
2. Charles E. Perkins, "Ad hoc Networking", Addison–Wesley, 2000, ISBN: 0201309769

Reference:
1. Stefano Basagni, Marco Conti, Silvia Giordano and Ivan stojmenovic, "Mobile ad hoc networking", Wiley-IEEE press, 2004, ISBN: 978-0-471-65688-3.
2. Mohammad Ilyas, "The handbook of ad hoc wireless networks", CRC press, 2002, ISBN: 0-8493-1332-5
3. T. Camp, J. Boleng, and V. Davies "A Survey of Mobility Models for Ad Hoc Network Research", Wireless Communication. and Mobile Comp., Special Issue on Mobile Ad Hoc Networking Research, Trends and Applications, vol. 2, no. 5, 2002, pp. 483–502, ISBN:
4. Fekri M. Abduljalil, "A survey of integrating IP mobility protocols and Mobile Ad hoc networks"., ISBN: 10 : 0750675993

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
Elective III - 610706 D : Pattern Recognition

Teaching Scheme: TH: 05 Hours/Week	Credit 05	Examination Scheme: In-Sem : 50 Marks End- Sem: 50 Marks

Course Objectives:

- To learn the basic concept of Pattern recognition
- To study different approaches of pattern recognition
- To learn various pattern classification techniques
- To survey on recent advances and applications in pattern recognition

Course Outcomes:

On completion of the course, student will be able to-

- Analyze various type of pattern recognition techniques
- Identify and apply various pattern recognition and classification approaches to solve the problems
- Evaluate statistical and structural pattern recognition
- Percept recent advances in pattern recognition confined to various applications

Selection of Modules:

Kindly note that modules 1,2,3 and module 9 are compulsory and select any two (02) modules from remaining modules.

Course Contents

Module No.	Module Title	Credit
1	Pattern Recognition	01

Introduction of Pattern Recognition with its application, Pattern Recognition system, Design cycle of pattern recognition, Learning and adaption, Representation of Patterns and classes, Feature Extraction, pattern recognition models/approaches.

2	Error Estimation	01

Introduction, Error estimation methods, various distance measures (Euclidean, Manhattan, cosine, Mahalanobis) and distance based classifier, Feature selection based on statistical hypothesis testing, ROC curve.

3	Decision Theory	01

Introduction, Bayesian decision theory-continuous and discrete features, two- category classification, minimum error rate classification, discriminant functions,
Parametric Techniques:- Maximum Likelihood Estimation, Bayesian Parameter Estimation, Sufficient Statistics; Problems of dimensionality.
Non-Parametric Techniques:-Density estimation, Parzen Window, Metrics and Nearest-Neighbor classification; Fuzzy classification.

4	Non Metric and structural pattern recognition	01

Tree Classifiers-Decision Trees, Random Forests, **Structural Pattern recognition:** Elements of formal grammars ,String generation as pattern description ,Recognition of syntactic description ,Parsing ,Stochastic grammars and applications ,Graph based structural representation, **Stochastic method:** Boltzmann Learning.

5	Clustering	01

Introduction, Hierarchical Clustering, agglomerative clustering algorithm, the single linkage, complete, linkage and average, linkage algorithm. Ward's method ,Partition clustering, , K- means algorithm, clustering algorithms based on graph theory(Minimum spanning tree algorithm),Optimization methods used in clustering: clustering using simulating Annealing.

6	Template Matching	01

 Measures based on Optimal Path Searching techniques: Bellman's optimality principle and dynamic programming, The Edit distance, Dynamic time Warping, Measures based on correlations, Deformable template models

7	Unsupervised Learning	01

Neural network structures for pattern recognition, Unsupervised learning in neural pattern recognition , deep learning ,Self-organizing networks

8	Fuzzy Logic and Pattern Recognition	01

Fuzzy logic ,Fuzzy pattern classifiers, Pattern classification using Genetic Algorithms

9	Applications	

Pattern recognition applications: Application of pattern recognition techniques in object recognition, biometric, facial recognition, IRIS scanner, Finger prints, 3D object recognition.

Books:

Text :

1. R. O. Duda, P. E. Hart, D. G. Stork, "Pattern Classification", 2nd Edition, Wiley- Inter-science, John Wiley &Sons, 2001
2. S. Theodoridis and K. Koutroumbas, "Pattern Recognition", 4th Edition, Elsevier, Academic Press, ISBN: 978-1-59749-272-0
3. B.D. Ripley, "Pattern Recognition and Neural Networks", Cambridge University Press. ISBN 0 521 46086 7

Reference :

1. Devi V.S.; Murty, M.N. (2011) Pattern Recognition: An Introduction, Universities Press, Hyderabad.
2. David G. Stork and Elad Yom-Tov, "Computer Manual in MATLAB to accompany Pattern Classification", Wiley Inter-science, 2004**,** ISBN-10: 0471429775
3. Malay K. Pakhira, "Digital Image Processing and Pattern Recognition", PHI, ISBN- 978-81-203-4091-6
4. eMedia at NPTEL : http://nptel.ac.in/courses/106108057/33

Savitribai Phule Pune University, Pune
ME Artificial Intelligence (2017 Course)
Elective III - 510505B: GPU Computing

Teaching Scheme:	Credit	Examination Scheme:
TH: 05 hr/week	**05**	**In Semester: 50 Marks** **End Semester: 50 Marks**

Prerequisite Courses: Parallel programming concepts, languages, and Platforms

Companion Course: Soft Computing & Deep Learning, Laboratory Proficiency-II

Course Objectives:
1. To understand the different approaches of parallel programming.
2. To study massively parallel computing hardware and programming models.
3. To be conversant with GPGPU programming with CUDA.
4. To develop parallel programs in heterogeneous environments with OpenCL.
5. To understand machine learning using GPU.

Course Outcomes:
  On completion of the course, learner will be able to
CO1:Analyze and measure performance of modern parallel computing systems.
CO2:Design and Implement parallel programs on GPUs.
CO3:Develop a high-performance parallel application in CUDA.
CO4:Buildparallel programming logic on current system architectures using OpenCL.
CO5:Implement machine learning using GPU.

Selection of Modules: Modules 1 to 3 are compulsory and select any one from modules 4, 5 and 6.

Module I	Understanding Parallelism with GPUs.	7 Hours

Review of traditional computer architecture – basic five stage RISC pipeline, cache memory, register file, SIMD instructions, and GPU architectures - streaming multi processors, cache hierarchy, the graphics pipeline, parallel programming languages and models. Understanding Parallelism with GPUs.

Mapping of Course Outcomes	CO1

Module II	Grids, Blocks, and Threads	7 Hours

Grids, Blocks, and Threads Introduction to Data Parallelism and CUDA C, Data-Parallel Execution Model, CUDA Memories-Memory types and memory Access Efficiency, Performance Considerations- Warps ,Thread Execution, Global Memory Bandwidth, Dynamic Partitioning of Execution Resources, Instruction Mix and Thread Granularity, the CUDA extensions to the C language, and the basic programming/debugging tools.

Case Studies(if any)	Prefix Sum

Mapping of Course Outcomes	CO1 , CO2

Module III	Memory Handling and Synchronization	7 Hours

Memory Handling with CUDA- The basic CUDA memory/threading model, floating-point considerations in parallel computing and common data-parallel programming patterns needed to develop a high- performance parallel application.Programs for concurrent Data Structure such as Worklists, Linked-lists. Synchronization across CPU and GPU.

Case Studies(if any)	Graph algorithms, Simulations,

Mapping of Course Outcomes	CO2 , CO3

Module IV	Designing GPU-Based Systems.	7 Hours

Parallel Programming and Computational Thinking, MPI-CUDA programming in a heterogeneous computing cluster. Dynamic parallelism, Unified Virtual Memory, CPU vs GPU, GPU hardware overview, GPU memory architecture, GPU properties, compute capability of GPU, multi- GPU solution. Multi-GPU processing, Peer access, Heterogeneous processing

Case Studies(if any)	Molecular Visualization and Analysis
Mapping of Course Outcomes	**CO3**

Module V	**Introduction to OpenCL**	**7 Hours**

Introduction to OpenCL-The OpenCL Platform Model , The OpenCL Execution Model, Kernels and the OpenCL Programming Model, The OpenCL Memory Model, OpenCL basics with Examples. OpenCL for Heterogeneous Computing-Memory performance considerations in OpenCL. OpenCL runtime and concurrency model-Commands and the Queuing Model, Multiple Command- Queues,The Kernel Execution Domain-Work Items, Work-Groups, NDRanges ,Naive and Built-In Kernels

Case Studies(if any)	Dissecting OpenCL on a Heterogeneous System on AMD FX-8350 CPU, AMD Radeon R9 290X GPU or as per available latest configuration of CPU.
Mapping of Course Outcomes	**CO4**

Module VI	**Machine learning applications with CUDA**	**7 Hours**

Containerization on GPU-Enabled Platforms, concept of Containerization, working of open and closed environments as local and cloud containers **Accelerated Machine learning on GPUS**, Exploring the Pytorch and Neural networks.

Case Studies(if any)	GPU Enabled Machine Learning
Mapping of Course Outcomes	**CO5**

Books & Other Resources:
http://www.cs.columbia.edu/~m-reed/gpu.html
https://developer.nvidia.com/udacity-cs344-intro-parallel-programming

Text Books:
1. "Programming Massively Parallel Processors" - David Kirk and Wen-meiHwu
2. " Heterogeneous Computing with OpenCL" -- Benedict Gaster,LeeHowes, David R. Kaeli
3. Hands-On GPU Computing with Python: (Kindle Edition) by Bandyopadhyay, Avimanyu

Reference Books:
1) Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs", Morgan Kaufmann Publishers Inc. San Francisco, CA, USA 2013 ISBN: 9780124159884
2) CUDA BY EXAMPLE by Jason Sanders,EdvardKandrot

MOOC Courses- https://swayam.gov.in/nd1_noc20_cs41/preview

E-books -Hands-On GPU Computing with Python: Explore the capabilities of GPUs for solving high performance computational problems Kindle Edition

Important links:

https://developer.nvidia.com/ https://www.khronos.org/opencl/

Savitribai Phule Pune University **ME Artificial Intelligence (2017 Course)** **610707 : Seminar II**		
Teaching Scheme: **Practical: 4 Hrs/week**	**Credit** **04**	**Examination Scheme:** **TW: 50 Marks** **Presentation: 50 Marks**

Course Objectives:

- To explore the basic principles of communication (verbal and non-verbal) and active, empathetic listening, speaking and writing techniques.
- To Identify, understand and discuss current, real-world issues, new technologies, research, products, algorithms, services.

Course Outcomes:

On completion of the course, student will be able –

- To use multiple thinking strategies to examine real-world issues and explore creative avenues of expression,.
- To acquire, articulate, create and convey intended meaning using verbal and non- verbal method of communication.
- To learn and integrate, through independent learning in sciences and technologies, with disciplinary specialization and the ability to integrate information across

The student shall have to deliver the seminar II in semester III on a topic approved by guide and authorities.

It is appreciated if student has already selected the domain of his/her dissertation work and identified the literature confined to the domain and thorough literature study based on identified topic has been carried out. This practice will eventually lead to convergence of the efforts for the dissertation work. The meticulous analyses of the literature can be part of seminar.

The relevant literature then be explored as state-of-the-art, exotic, recent technological advancements, future trends, applications and research & innovations. The student shall submit the duly approved and certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute. The student will be assessed based on his/her presentation and preparations by the panel of examiners out of them one has to be an external examiner.

The students are expected to validate their study undertaken by publishing it at standard platforms.

The student has to exhibit the continuous progress through regular reporting and presentations and proper documentation the frequency of the activities in the sole discretion of the PG coordination.

The continuous assessment of the progress need to be documented unambiguously. For standardization and documentation, follow the guidelines circulated / as in seminar logbook approved by Board of Studies.

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
610708 : Dissertation Stage I

Teaching Scheme: Practical: 08 Hrs/week	Credit 08	Examination Scheme: TW: 50 Marks Presentation: 50 Marks

Course Objectives:
- To identify the domain of research
- To learn to communicate in a scientific language through collaboration with guide.
- To understand the various means of technical publications and terminologies associated with publications
- To categorize the research material confined to the domain of choice
- To formulate research problem with the help of the guide/mentor elaborating the research.
- To Acquire information independently and assessing its relevance for answering the research questions.

Course Outcomes:
On completion of the course the student should be able to-
- Conduct thorough literature survey confined to the domain of choice
- Develop presentation skills to deliver the technical contents
- Furnish the report of the technical research domain
- Analyze the findings and work of various authors confined to the chosen domain

Dissertation Stage – I is an integral part of the Dissertation work. In this, the student shall complete the partial work of the Dissertation which will consist of problem statement, literature review, design, scheme of implementation (Mathematical Model/SRS/UML/ERD/block diagram/ PERT chart,) and Layout & Design of the Set-up.

The student is expected to complete the dissertation at least up to the design phase. As a part of the progress report of Dissertation work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic. The student shall submit the duly approved and certified progress report of Dissertation Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

The examiner will be assessed by a panel of examiners of which one is necessarily an external examiner. The assessment will be broadly based on literature study, work undergone, content delivery, presentation skills, documentation and report.

The students are expected to validate their study undertaken by publishing it at standard platforms.

The investigations and findings need to be validated appropriately at standard platforms – conference and/or peer reviewed journal.

The student has to exhibit the continuous progress through regular reporting and presentations and proper documentation the frequency of the activities in the sole discretion of the PG coordination.

The continuous assessment of the progress need to be documented unambiguously. For standardization and documentation, it is recommended to follow the formats and guidelines circulated / as in dissertation workbook approved by Board of Studies. Follow guidelines and formats as mentioned in Dissertation Workbook.

Semester IV

Savitribai Phule Pune University **ME Artificial Intelligence (2017 Course)** **610709 : Seminar III**		
Teaching Scheme: **Practical: 05 Hrs/week**	**Credit** **20**	**Examination Scheme:** **TW: 50 Marks** **Presentation: 50 Marks**

Course Objectives:

- To explore the basic principles of communication (verbal and non-verbal) and active, empathetic listening, speaking and writing techniques.

- To Identify, understand and discuss current, real-world issues, new technologies, research, products, algorithms, services.

Course Outcomes:

On completion of the course, student will be able–

- To use multiple thinking strategies to examine real-world issues and explore creative avenues of expression,.

- To acquire, articulate, create and convey intended meaning using verbal and non- verbal method of communication.

- To learn and integrate, through independent learning in sciences and technologies, with disciplinary specialization and the ability to integrate information across

The student shall have to deliver the seminar III in semester IV on a topic approved by guide and authorities. Preferably the seminar III may be extension of seminar II. The relevant literature then be explored as state-of-the-art, exotic, recent technological advancement, future trend, application and research & innovation. The student shall submit the duly certified seminar report in standard format, for satisfactory completion by the concerned Guide and head of the department/institute. The student will be assessed based on his/her presentation and preparations by the panel of examiners out of them one has to be an external examiner.

The students are expected to validate their study undertaken by publishing it at standard platforms.

The student has to exhibit the continuous progress through regular reporting and presentations and proper documentation the frequency of the activities in the sole discretion of the PG coordination.

The continuous assessment of the progress need to be documented unambiguously. For standardization and documentation, the department will follow the seminar guidelines circulated / as in logbook approved by Board of Studies.

Savitribai Phule Pune University
ME Artificial Intelligence (2017 Course)
610710 : Dissertation Stage II

Teaching Scheme: Practical: 20 Hrs/week	Credit 20	Examination Scheme: TW: 150 Marks Presentation: 50 Marks

Course Objectives:
- To follow SDLC meticulously and meet the objectives of proposed work
- To test rigorously before deployment of system
- To validate the work undertaken
- To consolidate the work as furnished report

Course Outcomes:

On completion of the course the student shall be able to-
- Show evidence of independent investigation
- Critically analyze the results and their interpretation ; infer findings
- Report and present the original results in an orderly way and placing the open questions in the right perspective.
- Link techniques and results from literature as well as actual research and future research lines with the research.
- Appreciate practical implications and constraints of the specialist subject

Guidelines:

In Dissertation Work Stage–II, the student shall consolidate and complete the remaining part of the dissertation which will consist of Selection of Technology, Installations, UML implementations, testing, Results, measuring performance, discussions using data tables per parameter considered for the improvement with existing/known algorithms/systems, comparative analysis, validation of results and conclusions. The student shall prepare the duly certified final report of Dissertation in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

The students are expected to validate their study undertaken by publishing it at standard platforms.

The investigations and findings need to be validated appropriately at standard platforms – conference and/or peer reviewed journal.

The student has to exhibit the continuous progress through regular reporting and presentations and proper documentation the frequency of the activities in the sole discretion of the PG coordination.

The continuous assessment of the progress need to be documented unambiguously.

It is recommended to continue with guidelines and formats as mentioned in Dissertation Workbook approved by Board of Studies.

Non Credit Courses

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC1: Game Engineering

Course Contents

1. Introduction to Unity 3D Game Engines
- Introduction to game industry ,Unity Basic (Interface Intro), Intro to tools & navigation, The Main Windows, Game Objects , Scenes ,Cameras and Types, Theassets store, Intro to Asset Work flow

2. Basic Photoshop
- File types, size and resolution, Cropping and Editing sprite sheet

3. C# programming in unity

4. 2D Game Development Using Unity 3D
- Intro to 2D Game system in unity, Sprite Editor in Unity, Sprite Animation in Unity
- 2D Physics in Unity

5. 3D Game Development Using Unity 3D
- UI system in Unity, Artificial Intelligence for 3D Game
- Object Oriented Design & Programming for 3D Games
- Multiplayer Game in unity, Creating 3D Game For PC

Books

1. Fabian Birzele, "The Java Game Development Tutorial
2. Sean M. Tracey, "Make Games with Python on Raspberry Pi"

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC2: Advanced Cognitive Computing

Course Contents

1. The Foundation of Cognitive Computing
Interdisciplinary Nature of Cognitive Science, Cognitive Computing Systems, Representations for Information and Knowledge, Principal Technology Enablers of CognitiveComputing, Cognitive Computing Architectures and Approaches, Cognitive Computing Resources

2. Cognitive Computing and Neural Networks: Reverse Engineering the Brain
Brain Scalability, Neocortical Brain Organization, The Concept of a Basic Circuit, Abstractions of Cortical Basic Circuits, Large-Scale Cortical Simulations, Hardware Supportfor Brain Simulation, Deep Learning Networks

3. The Relationship Between Big Data Analytics and Cognitive Computing
 Evolution of Analytics and Core Themes, Types of Learning, Machine Learning Algorithms, Cognitive Analytics: A Coveted Goal, Cognitive Analytics Applications

4. Applications of Cognitive Computing
Applications in expert systems, Natural language programming, neural networks, robotics,virtual reality, Future applications

Books

1. **'Cognitive Computing and Big Data Analytics', by** Judith Hurwitz, Marcia Kaufman, Adrian Bowles, Wiley publications, ISBN: 978-1-118-89662-4
2. '**Cognitive Computing: Theory and Applications**', by Vijay Raghvan, Venu Govindaraju, C.R. Rao, Elsevier publications, eBook ISBN: 9780444637512, Hardcover ISBN: 9780444637444
3. **https://www.research.ibm.com/software/IBMResearch/multimedia/Computing_ Cognition_WhitePaper.pdf**

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC3: Reconfigurable Systems

Course Contents

1. Introduction to reconfigurable systems:- Reconfigurable system (RS), Reconfigurable computing (RC), Architectural components of a configurable computer, primary methods in conventional computing: Application Specific Integrated Circuit (ASIC), software- programmed microprocessors,
2. Reconfigurable computing:-,Theories:-Tredennick's Classification, Hartenstein's Xputer, High-performance computing, Partial re-configuration, Current systems Computer emulation, COPACOBANA, Mitrionics, National Instruments, Xilinx, Intel,
3. Advanced Applications and Technologies:- Reconfigurability mechanisms, Reconfigurable devices and fabrics, Programmable pathways, Reconfigurability enablers,
4. The Future of Reconfigurable Systems:- Introduction, Multi-million gate FPGA Architectures, future Field Programmable System-on-a-Chip (FPSC), FPGA Architectures for Reconfigurable Computing, CAD Support for Reconfigurable Systems, Applications

Books

1. Gokhale, Maya, B., Graham, Paul S., " Reconfigurable Computing Accelerating Computation with Field-Programmable Gate Arrays", 2005, 238 p., Springer Netherland, Hardcover ISBN: 0-387-26105-2
2. Bobda Ch, " Introduction to Reconfigurable Computing Architectures, Algorithms,and Applications", Springer Netherlands, 2007, ISBN 978-1-4020-6088-5, 5 (Print)978-1-4020-6100-4 359 3. Papers on the web page of the course Reconfigurable Circuits
3. Katherine Compton and Ccott Hauck, " Reconfigurable Computing: A Survey of Systems and Software", ACM Computing Surveys, Vol. 34, No. 2, June 2002, pp.171–210.

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC4: Convergence Technology

Course Contents

1. Introduction-Convergence continues to gain momentum Worldwide, Responding to convergence, Thinking Strategies about ICT Convergences

2. Security Convergence Types of convergence, Security convergence collaboration, Categories of Convergence Convergence Trends: Value of technology, Convergence in design

3. Security Planning Convergence Initiatives, Convergence and Layers of Security, Levelsof Security Need of Technology roadmap

4. Convergence in Practice The Nimble Giants: How converged business models drive successful large enterprises The New face of public sector Small Enterprises Benefits fromStrategic Investment management

Books

1. Rajendra Singh and Siddhartha Raja, "Convergence in Information and Communication Technology", World Bank, ISBN, 0821381695, 9780821381694
2. Faisal Hoque, "The power of Convergence", AMACOM, *ISBN*-10: 0814416950,
3. Richard Baldwin, "The Great Convergence", Harvard University Press, ISBN-13:978-0674660489
4. Ray Bernard "Security Technology Convergence Insights", Ray Bernard., ISBN: 9780128030011.

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC5: Machine Intelligence

Course Contents

1. Introduction to Machine Intelligence, What is MI?, Background/history, Spin-offs, High- level overview, State of the art.
2. Representation of Knowledge- Knowledge Representation, Knowledge Representation using predicate logic, introduction to predicate calculus, resolution, Knowledge Representation using other logic-structured Knowledge Representation.
3. Planning and Machine Learning- Basic Plan generation systems-strips, Advanced Plan generation systems-K strips, Strategic explanations,Machine learning, Adaptive Learning
4. Expert Systems- Architecture of Expert Systems, Roles of Expert Systems, Konwledge acquisition-Meta knowledge heuristics.

Books

1. Stefan Edelkamp and Stefan Schroedl. Heuristic Search: Theory and Applications,Morgan Kaufmann, 2011.
2. John Haugeland, Artificial Intelligence: The Very Idea, A Bradford Book, The MITPress, 1985.
3. Judea Pearl. Heuristics: Intelligent Search Strategies for Computer Problem Solving,Addison-Wesley, 1984.

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC6: Storage Area Networks

Course Contents

1. **Introduction to Information Storage Technology, Storage System Environment and Data protection:** Evolution, Key Challenges in Managing Information, Information Lifecycle Components, Disk Drive Components & Performance,
2. **Different Storage Technologies and Virtualization**
Introduction to **Networked Storage**, Overview of FC-SAN, NAS, and IP-SAN. Network- Attached Storage (NAS) & its Components, File Sharing, I/O operations, Performance andAvailability. Content Addressed Storage, Storage Virtualization
3. **Content-Addressed Storage, Business Continuity, Backup and Recovery, Local Replication, Remote Replication:**
BC Terminology, Failure Analysis, Business Impact Analysis, Solutions, Backup Granularity, Recovery Considerations, Backup Methods, Process & Topologies, Backup in NAS Environments, Local Replication Technologies,
4. **Securing & Managing the Storage Infrastructure:**
Storage Security Framework, Risk Triad, Storage Security Domains, Security Implementations in Storage Networking Monitoring the Storage Infrastructure, Storage Management Activities, Storage Infrastructure Management Challenges,

Books
1. Robert Spalding, "Storage Networks: The Complete Reference", Tata McGraw Hill,Osborne, 2003. 2. Marc Farley, "Building Storage Networks", Tata McGraw Hill, Osborne, 2001. 3. EMC Educational Services, "Information Storage and Management", Wiley India 4. Meet Gupta, "Storage Area Network Fundamentals", Pearson Education Limited

Savitribai Phule Pune University **Master of Artificial Intelligence (2017 Course)** **NCC7: Search Engine Optimization**
Course Contents

1. **Basics for SEO, SEO Research & Analysis**
   Basic Knowledge of Domain & World Wide Web, Difference between Portal and Search Engines, need of SEO, Types of SEO Techniques: Black hat techniques & White Hat techniques, Search Engine working Process, Keyword Research and Analysis, Keyword opportunity, Competitors Website Analysis, SWOT, On-page Optimization & Off-page Optimization

2. **On-page Optimization**: Meta Descriptions & Meta Keywords, Headings, Bold Text, Domain Names & Suggestions, Canonical Tag, Meta Tags, Images and Alt Text, InternalLink Building, Server and Hosting Check, Robots Meta Tag, 301 Redirects, 404 Error , Duplicate content

3. **Off-page Optimization**: Page Rank, Link Popularity, Link Building in Detail, Directory Submission, Blog Submission, Links Exchange, Reciprocal Linking, Posting to Forums, RSS Feeds Submissions, Competitor Link Analysis

4. **Analytics & SEO Tools**
   Study of Google Analytics, How Google Analytics can Help SEO, Webmaster Central &Bing/Yahoo; Website Analysis using various SEO Tools available : Keyword Density Analyzer Tools, Google Tools, Yahoo / Bing Tools, Rich Snippet Text Tools, Comparison Tools, Link Popularity Tools, search Engines Tools, Site Tools

5. **SEO Reporting**
   Google analysis, Tracking and Reporting, Reports Submission, Securing Ranks

Books
1. Jason McDonald Ph.D, *"SEO Fitness Workbook: The Seven Steps to Search Engine Optimization Success"* 2. Caimin Jones, "SEO Step-by-Step: The Complete Beginner's Guide to GettingTraffic" 3. Bruce Clay, " *Search Engine Optimization All-in-One for Dummies* 4. Adam Clarke, " SEO 2017: Learn search engine optimization with smart internetmarketing strategies"

Savitribai Phule Pune University **Master of Artificial Intelligence (2017 Course)** **NCC8:Virtual Reality**
Course Contents

1. Introduction and Background
   What VR is and why it is so different from other mediums. Its history and different forms of reality, ranging from the real world to fully immersive VR. Its various hardware and components, which composes those realities.
2. Perception
   Understanding the human brain and how we perceive real and virtual worlds, real-world examples that prove reality is not always what we think it is, explanations of perceptual models and processes, the physiology of the different sensory modalities, theories of how we perceive space and time, and a discussion of how perception relates to action.
3. Designing in VR
   Fundamentals of VR design including ergonomics, user testing, interface design, scale and scene setting, graphical user interfaces, and motion mechanics for mobile VR, simulator sickness, its causes.
4. VR Platforms and Applications
   Understand what is happening in the VR industry, surveying current trends and technology in VR, the hardware: Mobile Performance & 360 Media, High-Immersion Unity, or High-Immersion Unreal.

Books

1. Jason Jerald, The VR Book: Human-Centered Design for Virtual Reality, Association for Computing Machinery and Morgan & Claypool New York, NY, USA©2016, ISBN: 978-1-97000-112-9
2. John Vince, Virtual Reality Systems, Pearson Prentice Hall, ISBN 10: 0201876876 or ISBN 13: 9780201876871
3. Grigore C. Burdea, Philippe Coiffet, Virtual Reality Technology, 2nd Edition, ISBN: 978-0-471-36089-6

Savitribai Phule Pune University **Master of Artificial Intelligence (2017 Course)** **NCC9: Machine Translation**
Course Contents

1. Introduction:
   Concept and translation process. Approaches viz rule based, statistical, Example based, hybrid and neural MT.
2. Learning and inference for translation models:
   Maximum likelihood, Expectation maximization, Discriminative learning, Stochastic methods, Dynamic programming, Approximate search.
3. Linguistic phenomena and their associated modeling problems:
   Morphology, syntax and semantics.
4. Applications & Evaluation:
   Scaling, approximation and efficient data structures

Books

1. P. Koehn, " Statistical Machine Translation", Cambridge University Press
2. Pushpak Bhatacharyya, "Machine Translation" , 2015
3. John Hutchines, " Milestone in Machine Translation"

Savitribai Phule Pune University
Master of Artificial Intelligence (2017 Course)
NCC10: Infrastructure Management

Course Contents

1. Introduction to Infrastructure Management

What is Infrastructure Management, Basic Framework, Policy Issues, Types of Infrastructure Management: Systems Management, Network Management, Storage Management, Objectives, Benefits of Infrastructure Management system

2. IT Infrastructure Management

Components of IT Infrastructure, Hardware resources, Data storage, Input-output Technologies used in Businesses, Types of Computer Softwares used for InfrastructureManagement in Business, Principle Issues, Foundations of Business Intelligence: Databases and Information Management, Telecommunications, Wireless Technology, Security

3. Key System Applications for the Digital Age

Achieving Operational Excellence and Customer Intimacy: Enterprise Applications, E- Commerce: Digital Markets, Digital Goods, Improving Decision Making and Managing Knowledge

4. Building and Managing Systems

 Building Information Systems, Ethical and Social Issues in Information Systems

Books

1. Jane P. Laudon, Azimuth, "Essentials of Business Information Systems", Pearson,ISBN-10: 0132277816,13: 9780132277815

2. Barbara Klein, Richard Alan Long, Kenneth Ray Blackman, "Introduction to IMS, An: Your Complete Guide to IBM Information Management System", IBM Press, ISBN-10: 0132886871, ISBN-13: 9780132886871

3. David Boddy, Albert Boonstra, "Managing Information Systems: Strategy and Organization", Financial Times Press,ISBN-10: 0273716816, ISBN-13: 9780273716815

***