NEW SCHEME FOR M. Sc. (Artificial Intelligence and Machine Learning) COURSE

SEMESTER - III (M.Sc. (AI & ML)) Applicable from July 2020 onwards

Sr. No.	UBJECT NO.	NAME OF THE SUBJECT	TEACHING SCHEME			EXAMINATION SCHEME							
			THEORY TUTO Hr	PRACT. Hr.	ESSIONAL M.Hr.	THEORY M.	Hr	PRACT. M	H			T.W. TOTAL MARKS	
1	MSCAI 211	Deep Learning Fundamentals	3	1	-	25	2	100	3	-	0	25	150
2	MSCAI 212	Elective-I	4	-	-	25	2	100	3	-	0	25	150
3.	MSCAI 213	Elective-II	4	-	3	25	2	100	3	50	3	25	200
4	MSCAI 214	Project-III	-	4	15	100	-	-	-	250	-	100	450
	T O T A L		11	5	18	175	-	300	-	300	-	175	950

Elective-I

- Reinforcement Learning
- Recommendation Systems
- MOOCs

Elective-II

- Natural Language Processing
- Internet of Things
- SQL for Machine Learning

Course Name: Deep Learning Fundamentals

Course Code: MSCAI 211

Objectives:

Deep Learning is at the core of modern-day Artificial Intelligence and Machine Learning applications. Students will be introduced to

- The latest algorithms and architectures of deep learning to the student with practical viewpoint
- The necessary background to fully understand the ongoing research and gain required implementation knowledge

Prerequisites:

- Introductory course in Linear Algebra
- Introductory course in Calculus
- Introductory course in Probability
- Introductory course in Machine Learning Fundamentals

Contents:

1. **Feed-forward Deep Networks**
   Review of Machine Learning Basics, Overview of Deep Networks, Bias and Variance, the curse of dimensionality, Vanilla MLP, Flow Graphs and Back propagation, Universal Approximation Theorem, Feature representation

2. **Convolutional Networks**
   Concept of Convolution, Convolution Operation, Pooling, Stride, Convolution Modules, Efficient Convolution Algorithms, Random or Unsupervised features, Applications in Computer Vision

3. **Recurrent and Recursive Nets**
   Unfolding Flow graphs and parameter sharing, Recurrent Neural Networks, Bidirectional RNNs, Deep Recurrent Architecture, Recursive Neural Networks, Auto-Regressive Networks, Recurrent Vs. Recursive Neural Nets

4. **Regularization of Deep Models**
   Regularization from Bayesian Perspective, Parameter Norm Penalty, Regularization as Constrained Optimization, Under-Constrained Problems, Classical Regularization as Noise Robustness, Dropout, Multi-Task training, Adversarial Training

5. **Optimization for Training Deep Models**

Optimization for Model Training, Challenges in Optimization, Basic Algorithms, Adaptive learning rates, Second order methods, Natural gradient methods, Global Optimization

6. **Practical Implementations**
   Image Classification, Types of Image Classifiers, Building a deep neural architecture, Building feature set, Preparing Data for training, Adding Dropout, Understanding Alex Net and Google LeNet, Using existing architectures in applications, Using inbuilt Tensor Flow functionality to build a Convolutional Neural Network

References:

1. Deep Learning, Ian Goodfellow, Yoshua Bengio and Aaron Courville
2. Artificial Intelligence for Humans: Deep Learning and Neural Networks, Book 3, Jeff Heaton
3. Deep Learning with Tensor Flow, Giancarlo Zaccone

Accomplishments of the student after completing the course:

After completion of this course, students will be able to know the ongoing trends in Deep Learning, understand the architecture of various deep networks from the viewpoint of implementation, learn to design and develop various types of deep networks, to understand how to implement and control behaviour of deep networks

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M. Sc. (Artificial Intelligence and Machine Learning)

Course Name: Reinforcement Learning

Course Code: MSCAI 212(1)

Objectives:

Explore a computational approach to learn from the environment. Introduce key concepts and application of Reinforcement learning keeping in my both theoretical background and practical applications.

Prerequisites:

1. Introductory course in Linear Algebra
2. Introductory course in Algorithms

Contents:

1. **Introduction**
   Problem formulation and motivating examples, Elements of Reinforcement Learning, History of Reinforcement learning, Probability, Eigen Value, Eigen Vector, Steady State

2. **Evaluative Feedback**
   n-Armed Bandit Problem, Action Value Methods, Evaluation vs. Instruction, Incremental Implementation, Tracking non-stationary problems

3. **Problem Definition**
   Agent-Environment Interface, Goals and rewards, Returns and Utility, The Markov Property, Value functions, Optimal value functions, Optimality and approximation

4. **Dynamic Programming**
   Policy Evaluation, Policy improvement, Policy Iteration, Value Iteration, Asynchronous Dynamic Programming

5. **Monte Carlo Methods**
   Monte Carlo Policy Evaluation, Estimation of Action Values, Monte Carlo Control, Incremental Implementations

6. **Temporal Difference Learning**
   Classical Conditioning, TD Prediction, Optimality of TD(0), TD(Lambda), Q-Learning, Actor-Critic Method

7. **Function Approximator**
   Grandmother Cell Theory, Function Approximators, Perceptron-Linear Function

approximator, Neural Network-Non- Linear Function Approximator, Brief of Genetic Algorithm

Accomplishment of the student after completing the course:

After completion of this course, students will be able to learn a type of machine learning that enables an agent/robot to learn in an interactive environment by trial and error using feedback from its own actions and experiences. Students will also learn psychology or way of learning of animals.

Reference Books:

1. Reinforcement Learning: An Introduction, Richard S. Sutton & Andrew G. Barto

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Course Name: Recommendation Systems

Course Code: MSCAI 212(2)

Objectives:

Students will be introduced to

- Study the concept of recommender systems and machine learning algorithms used for prediction
- Get knowledge of various algorithms to build recommendations based on contextual parameters

Additionally, this study will cover other related issues, such as evaluation methods, and implication of Recommender system on society.

Prerequisites:

- Basic concepts of mathematics such as vector, matrix and algebra; computer algorithms, programming language

Contents:

1. **An Introduction to Recommender Systems**
   Goals of Recommender Systems, Basic Models of Recommender Systems, Domain-Specific Challenges in Recommender Systems, introduction to Advanced Topics and Applications

2. **Neighborhood-Based and Model-Based Collaborative Filtering**
   Key Properties of Ratings Matrices, Predicting Ratings with Neighborhood-Based Methods, Clustering and Neighborhood-Based Methods, Dimensionality Reduction and Neighborhood Methods, A regression Modeling View of Neighborhood Methods, Graph Models for Neighborhood-Based Methods. Decision and Regression Trees, Rule-Based Collaborative Filtering, Naive Bayes Collaborative Filtering, Using an Arbitrary Classification Model as a Black-Box, Latent Factor Models

3. **Content based and Knowledge based Recommender Systems**
   Basic Components of Content-Based Systems, Preprocessing and Feature Extraction, Learning User Profiles and Filtering, Using Content-Based Models for Collaborative Filtering, Knowledge representation and reasoning, constraint-based Recommender system, case-based Recommender system

4. **Hybrid and Social and Trust-Centric Recommender Systems**

Hybridization design: Weighted, Switching, Cascade Meta-level, Feature Augmentation, and Mixed; Multidimensional Models for Social Context, Network-Centric and Trust-Centric Method, User Interaction in Social Recommenders

5. **Context aware Recommender system**
   Pre-filtering and Post-filtering methods, Contextual Modelling, Time and location sensitive Recommender system: - Temporal Collaborative Filtering and Location-Aware Recommender Systems

6. **Evaluation of Recommendation systems**
   Evaluation Paradigms, General Goals of Evaluation Design, Design Issues in Offline Recommender Evaluation, Accuracy Metrics in Offline Evaluation

References:

1. Recommender Systems: The Textbook 1st ed. 2016 Edition, Charu C. Aggarwal
2. Recommender system-An Introduction, Jannach, D., Zanker, M., Felfernig, A., & Friedrich, G.
3. Recommender Systems Handbook, Francesco Ricci, LiorRokach, Bracha Shapira, Paul B. Kanto

Accomplishments of the student after completing the course:

After the completion of the course students will be able to understand the importance of building an efficient Recommender system, also learn different methods and models of building recommender system, acquire knowledge of different parameters on which the recommender systems are based on, and will be able to build an effective recommender system.

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Course Name: MOOCs

Course Code: MSCAI 212(3)

Objectives :

To learn from experts in the field across the nation and across the world by means of Massive Open Online Courses.

Contents :

- Student can take any 4 credit certificate course from any recognized platforms such as SWAYAM, NPTEL, Coursera, Edx.
- Student will be required to submit the certificate obtained to the Department of computer Science, Gujarat University for the grant of credits.
- Course taken up by the student should be relevant the degree.
- Students will be required to take prior permission from Head of the Department / Course Coordinator to ascertain whether the course student intend to take up, can be considered for grant of credits.

Course Name: Natural Language Processing

Course Code: MSCAI 213(1)

Objectives:

- To study the key concepts pertaining to Linguistics and NLP that are used to describe and analyze natural language
- To gain insights into statistical and semantic approaches to NLP
- To apply basic principles of machine learning to natural language data
- Appreciate the use standard software packages for machine learning in the domain of NLP
- To understand how data structures and algorithms are used in NLP

Prerequisites:

Introduction to AI & Machine Learning, Probability & Statistics, Linear Algebra

Contents:

1. **Introduction to natural language processing**
   Structural features of texts in natural language; ambiguity on all levels of language; the main challenges of natural language processing; basic approaches to problem solving: manually written rules and machine learning

2. **Basic text processing and edit distance**
   Preprocessing: tokenization and segmentation; normalization of words: stemming, lemmatization, Bag of Words, TF-IDF, morphological analyzers; regular expressions; edit distance.

3. **Language models**
   N-grams; perplexity; the use of language models: input prediction, error correction, speech recognition, text generation.

4. **Tagging problems and hidden Markov models**
   PoS tagging; named entity recognition as a tagging problem; hidden Markov models, their advantages and disadvantages; the Viterbi algorithm.

5. **Text classification and sentiment analysis**
   Classification problems; naive Bayes classifier; text classification; sentiment analysis.

6. **Parsing**
   Constituency and dependency trees; context-free grammar; probabilistic approach to parsing; lexicalized PCFGs; CKY algorithm.

7. **Computational semantics**
   Word senses and meanings; WordNet; semantic similarity measures: thesaurus-based and distributional methods.

8. **Vector space models of semantics**
   Word2vec and doc2vec, Word embeddings, Character to Sentence Embeddings

9. **Text summarization**
   Extractive and abstractive summarization; multiple-document summarization; query-based summarization; supervised and unsupervised learning; evaluation of summarization systems; ROUGE.

10. **NLP with Sequence Models**
   Recurrent Neural Networks: LSTM; GRU, Neural Networks for sentiment analysis, Deep N-Grams

11. **Practical**
   Working with Text:
   Tokenization, Token Normalization, Stemming: Porter Stemmer, Lemmatization: Wordnet lemmatizer, Bag of words (BoW), TF -IDF
   Text Classification Model: Sentiment analysis

   Parts-of-Speech Tagging:
   Creating POS-tagged corpora, Selecting a machine learning algorithm, Statistical modeling involving the n-gram approach, Developing a chunker using pos-tagged corpora

   Parsing:
   Treebank construction, Extracting Context Free Grammar (CFG) rules from Treebank, Creating a probabilistic CFG, CYK chart parsing algorithm, Early chart parsing algorithm

   Semantic Analysis:
   Named Entity Recognition (NER) using Hidden Markov Model, NER using POS tagging, Disambiguating senses using Wordnet

References:

1. J. Perkins, Python 3 Text Processing with NLTK 3 Cookbook. Packt Publishing Ltd, 2014.
2. C. D. Manning, P. Raghavan, H. Schütze, and others, Introduction to information retrieval, vol. 1. Cambridge university press Cambridge, 2008.
3. Steven Bird, Ewan Klein, and Edward Loper, Natural language processing with Python: analyzing text with the natural language toolkit. O'Reilly Media, Inc., 2009.
4. J. Pustejovsky and A. Stubbs, Natural language annotation for machine learning. O'Reilly Media, Inc., 2012.

5. U. S. Tiwary and T. Siddiqui, Natural language processing and information retrieval. Oxford University Press, Inc., 2008.
6. D. Chopra, N. Joshi, and I. Mathur, Mastering Natural Language Processing with Python. Packt Publishing Ltd, 2016.

Accomplishments of the student after completing the course:

After completion of this course, students will be able to develop formal models to express natural language phenomenon, to utilize mathematical expressions and notations to describe algorithms for language processing, to implement NLP systems in a clean and structured manner, to design and Implement tools for NLP and to appreciate the use of Machine Learning techniques in the domain of NLP.

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Course Name: IoT (Internet of Things)

Course Code: MSCAI 213

Objectives:

The aim of this course is to:

- Understand general concepts of Internet of Things (IoT)
- Recognize various devices, sensors and applications
- Apply design concept to IoT solutions
- Analyze various M2M and IoT architectures
- Evaluate design issues in IoT applications
- Create IoT solutions using sensors, actuators and Devices

Pre-requisites:

Wireless networking concepts, Network Security

Contents:

1. Introduction to IoT

Sensing, Actuation, Networking basics, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, IoT Definition, Characteristics. IoT Functional Blocks, Physical design of IoT, Logical design of IoT, Communication Protocols, IoT enabling technologies, Sensor Networks, Machine-to-Machine Communications

2. IoT & M2M

Difference between IoT and M2M, IoT architecture, Software define Network, SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing

3. IoT Architecture

Introduction, State of the art, Architecture Reference Model- Introduction, Reference Model and architecture, IoT reference Model, IoT Reference Architecture- Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views

3. Interoperability in IoT

Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry, Implementation of IoT with Raspberry Pi

4 IOT Applications

. Case studies: Lighting as a service, Intelligent Traffic systems, Smart Parking, Smart water management, IoT for smart cities, IoT in Indian Scenario: IoT and Aadhaar IoT for health services. IoT for financial inclusion IoT for rural empowerment

5 Challenges

. Challenges in IoT implementation: Big Data Management, Connectivity challenges, Mission critical applications, security and privacy issues

References:

1. Internet of Things (A Hands-on-Approach) ,1st Edition, Vijay Madisetti and Arshdeep Bahga, VPT, 2014
2. Rethinking the Internet of Things: A Scalable Approach to Connecting everything, 1st Edition, Francis daCosta, Apress Publications, 2013
3. Getting Started with the Internet of Things, Cuno Pfister, O‟Reilly Media, 2011, ISBN: 978-1-4493-357-1

Accomplishments of the student after completing the Course:

After completion of this course, students will be able to apply IoT concepts and IoT Standards, understand Components and relevance of IoT System for the future, build IoT Applications, apply IoT in smart city environment in Indian scenario, analyze challenges in IoT implementation

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Course Name: SQL For Data Science

Course Code: 213(3)

Objectives:

Students will be introduced to

- Different parts of SQL as they are needed for the tasks usually carried out during data analysis.
- Learn the Data cleaning, Wrangling and analytics of Relational Databases in theory and practical

Prerequisites:

- Vector algebra
- Matrices

Contents:

1. **The Data Life Cycle**
   Stages and Operations in the Data Life Cycle, Types of Datasets: Structured Data, Semi-structured Data, Unstructured Data, Types of Domains: Nominal/Categorical Data, Ordinal Data, Numerical Data Metadata

2. **Relational Data**
   Database Tables: Data Types, Inserting Data, Keys, Organizing Data into Tables, Database Schemas: Heterogeneous Data, Multi-valued Attributes, Complex Data, Other Types of Data: XML and JSON Data, Graph Data, Text,
   Getting Data In and Out of the Database: Importing and Loading Data, Updating Data, Exporting Data

3. **Data Cleaning and Pre-processing**
   The Basic SQL Query: Joins, Functions, Grouping, Order, Complex Queries, Exploratory Data Analysis (EDA): Univariate Analysis, Multivariate Analysis, Distribution Fitting, Data Cleaning: Attribute Transformation, Missing Data, Outlier

Detection, Duplicate Detection and Removal, Data Pre-processing: Restructuring Data, Metadata and Implementing Workflows: Metadata

4. **Introduction to Data Analysis**
   What is Data Analysis, Supervised Approaches: Classification: Naive Bayes, Logistic Regression, Unsupervised Approaches, Distances and Clustering, The KNN Algorithm, Association Rules, Dealing with JSON/XML, Text Analysis, Graph Analytics: Recursive Queries, Collaborative Filtering

5. **More SQL**
   More on Joins, Complex Subqueries, Windows and Window Aggregates, Set Operations, Expressing Domain Knowledge

6. **Databases and Other Tools**
   SQL and R: DBI, dbplyr, sqldf, Packages: Advanced Data Analysis, SQL and Python, Python and Databases: DB-API, Libraries and Further Analysis

References:

1. SQL for Data Science, Antonio Badia, Springer
2. SQL for Data Analytics, Upom Malik, Matt Goldwasser, Benjamin Johnston, Packt Publishing
3. Practical Statistics for Data Scientists, by Peter Bruce, Andrew Bruce, O'Reilly Publications
4. Introducing Data Science: Big Data, Machine Learning and More, Davy Cielen, Arno D.B. Meysman, Mohamed Ali, Dreamtech Press
5. Hands-on Data Analysis with Numpy and Pandas, Curtis Miller, Packt Publishing

Accomplishments of the student after completing the course:

After completion of this course, students will be able to:

- Understand Data life cycle and database terminologies
- Implement SQL concepts for data analysis
- Implement Data Cleaning, Wrangling and Analytics with Relational databases.
- Get understanding of other Database tools and implement SQL concepts with python

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NEW SCHEME FOR M. Sc. (Artificial Intelligence and Machine Learning) COURSE

SEMESTER - IV (M.Sc. (AI & ML)) Applicable from January 2021 onwards

SR. NO.	UBJECT NO.	NAME OF THE SUBJECT	TEACHING SCHEME			EXAMINATION SCHEME						
			THEORY TUTO HR	PRACT. HR.	ESSIONAL M.HR.	THEORY M.	HR	PRACT. M	H		T.W.	TOTAL MARKS
1	**MSCAI 221**	Major Project	-	8	30	250	-	-	-	400	-	300	950
	TOTAL		-	8	30	250	-	-	-	400	-	300	950