M.TECH. ARTIFICIAL INTELLIGENCE

DEPARTMENT OF COMPUTER SCIENCE

M.Tech in Artificial Intelligence programme has been designed for students with sufficient background in computer science and engineering to develop into adept professionals. M.Tech in CSE is a graduate degree that builds skill and knowledge in advanced and current topics of computer science. The degree is suitable for students with a bachelor’s degree in a computing related field as well as students who want to demonstrate computer science expertise in addition to a degree in another field. The curriculum has been designed to prepare students for highly prolific careers in industry. Some of the job profiles include: Application analyst, Data Scientist, Data analyst, Database administrator, Information systems manager, IT consultant, Multimedia analyst.

It is a reality that that computer technology has revolutionized the modern world. Technologies that we now use for granted - Internet, mobile phones, medical technology, would not be possible without the major developments made in the field of computing. This M.Tech programme gives a specialized focus on areas of technology, aiming to develop skills and career prospects. The master's degree program offers an integrated course of study covering the theory, implementation and design of information, computing, communication and embedded systems. This programme has specialized courses in the streams of Data Science, Computer Vision, IoT and High Performance Computing with significant focus on research. As a part of the programme during the period of study, students have the opportunity to intern at leading companies and R&D labs for a period of 6 months to one year. There are opportunities for the students to take up a semester or one-year study at International Universities like Virje University, Netherlands, UC Davis, UNM for an exchange programme or to pursue a dual degree programme.

Graduates of this programme are well represented in Oracle, IBM, HP, Cerner, Intuit, and other major MNCs as well as in research in premier academic institutions in India and abroad. The graduates are competent to take up R&D positions in Industry, academia and research laboratories.

Programme Objectives:

- Hone the skill of computer science professionals in areas of research and innovation
- Develop experts with high professional competence in recent and futuristic technologies
- Create man power with technical competency in computer science to design and develop solutions for the societal problems
## CURRICULUM

### First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Type</th>
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<th>Cr</th>
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<tr>
<td>19AI601</td>
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<td>Advanced Data structures and Algorithms</td>
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<td>FC</td>
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<td>19AI602</td>
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<td></td>
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<td>Soft Core I</td>
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<td>Amrita Values Program*</td>
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**Total Credits** 23

*Non-credit course

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**Total Credits** 21

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**Total Credits** 10

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**Total Credits** 12

**Total Credits − 66**
# Foundation Courses

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# SOFT CORE

Students have to select any four soft core subjects from the list given below:

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<td>19AI612</td>
<td>Statistical Learning Theory</td>
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<td>Machine Learning</td>
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<td>Probabilistic Graphical Models</td>
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<td>Computational Statistics and Inference Theory</td>
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## Electives

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<td>Introduction to Game Theory</td>
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### Elective (Live-in-Labs)

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Students can do Live-in-Labs course in lieu of an elective from II Semester or III Semester.
Unit I:

Unit II:
Applications of Divide-and-Conquer, Greedy and Dynamic programming techniques - Knapsack, Median finding, Scheduling algorithms, Party planning, bitonic TSP. String matching algorithms: Z Algorithm, KMP algorithm, Rabin-Karp, Aho-Corasick, 2D queries, efficient algorithms for longest palindrome, longest common substring/subsequence.

Unit III:

Text Books/References:

Fractal 1- Linear Algebra for Computer Science (Fractal: 2 Credits)
Text Books/References:

Fractal 2- Probability and Statistics for Computer Science (Fractal: 2 Credits)

Text Books/References:
1. David Forsyth, “Probability and Statistics for Computer Science”, Springer international publishing, 2018

19AI602 FOUNDATIONS OF ARTIFICIAL INTELLIGENCE 3-0-1-4

Unit1:
Unit II:


UnitIII:


Text Books/References:


19AI611 FOUNDATIONS OF DATA SCIENCE 3-0-1-4

Unit I
Introduction – High Dimensional Spaces - Best-Fit Subspaces and Singular Value Decomposition (SVD) - Random walks and Markov Chains.

Unit II
Concentration of measure, VC dimension, Machine Learning and Algorithms for Massive Data Problems: Johnson-Linden Strauss lemma and Streaming algorithms, sketching methods, community detection, and regression, Clustering.

Unit-III
Case study on Data scrapping and Data Wrangling tools.
Text Books/References

3. Ani Adhikari and John DeNero, “Computational and Inferential Thinking - The Foundations of Data Science”, eBook from UC Berkeley

19AI612 STATISTICAL LEARNING THEORY 3-0-1-4

Unit I:
Overview of Supervised Learning, Linear methods for Regression, Linear methods for Classification, Basis Expansions and Regularization, Kernel smoothing.

Unit II:

Unit III:
Support Vector Machines and Flexibilities, Prototype methods and Nearest Neighbors, Unsupervised Learning, Undirected graphical Models, High dimensional Problems.

Text Books/References:


19AI613 MACHINE LEARNING 3-0-1-4

Unit I:

Unit II:
Computational Learning theory- Sample complexity, \( \varepsilon \)- exhausted version space, PAC Learning, agnostic learner, VC dimensions, Sample complexity - Mistake bounds.
Gaussian models: Multivariate Gaussian distributions, Maximum Likelihood Estimate, Inferring parameters, Linear and Quadratic Discriminant Analysis, Mixture models, EM algorithm for clustering and learning with latent variables.

**Unit III:**

**Text Books/References:**


**19AI614 PROBABILISTIC GRAPHICAL MODELS 3-0-1-4**

**Unit I:**

**Unit II:**

**Unit III:**

Text Books/References:

19AI615OPTIMIZATION TECHNIQUES3-0-1-4

Unit I:

Unit II:
Constrained minimization, Interior point methods Convex optimization in finite dimension – Dimension-free convex optimization, Convex Optimization and Randomness.

Unit III:

Text Books/References:

19AI616COMPUTATIONAL STATISTICS AND INFERENCE THEORY3-0-1-4
Unit I:


Unit II:

Data Mining- data mining Algorithms-Instance and Features, Types of Features (data), Concept Learning and Concept Description, Output of data mining Knowledge Representation; Decision Trees- Classification and Regression trees constructing.

Unit-III:


Text Books/References:

Unit I:

Unit II:

Unit III:

Text Books/References:

19AI618 COMPUTATIONAL INTELLIGENCE 3-0-1-4


Fuzzy systems: Fuzzy sets – properties - membership functions - fuzzy operations, Applications, Implementation, Hybrid systems.


Applications: case studies may include image processing, digital systems, control, forecasting and time-series predictions.

Text Books/References:

19AI619  DEEP LEARNING  3-0-1- 4

Unit I:
Neural Networks basics – Linear Separable Problems and Perceptron – Multi layer neural networks and Back Propagation, Practical aspects of Deep Learning: Train/ Dev / Test sets, Bias/variance, Overfitting and regularization, Linear models and optimization, Vanishing/exploding gradients, Gradient checking, Hyper Parameter Tuning

Unit II:
Deep Neural Network Architectures – Convolutional neural networks, Recurrent neural networks - LSTM

Unit III:

Text Books/References:


19AI620  REINFORCEMENT LEARNING  (3 0 1  4)
Unit I:

Unit II:
Monte Carlo Methods – Temporal-Difference Learning – n-step Bootstrapping - Planning and Learning with Tabular Methods

Unit III:

The course must include RL case studies/project to different fields including robotics, video game, and health care.

Text Books/References:


19AI621  COMPUTER VISION 3-0-1-4

Unit I:

Unit II:

Unit III:
2D and 3D feature-based alignment, Poseestimation, Geometric intrinsic calibration, -Camera Models and Calibration: Camera Projection Models – orthographic, affine, perspective, projective models. Projective Geometry, transformation of 2-d and 3-d, Internal Parameters,

**Text books/References:**

2. Introduction to Computer Vision and its Application, Richard Szelinski, 2010

**19AI622                 NEGOTIATED STUDIES                         2-0-0-2**

This course is intended to be a self-study course. Each student can select an area of self-study in consultation with the Faculty. Collect and study basic and recent research articles (project reports, review articles, published articles in journals and book chapters) on the topic. It can also involve semester long case study or mini projects involving programming, implementation, testing performance analysis etc. in different application specific contexts. Students will be required to make two in-class presentation and prepare a review article, possibly of publishable quality. The seminars and article will be evaluated for grading purpose. The evaluation will be done by a panel of (at least) two Faculty members.

**19RM600                 RESEARCH METHODOLOGY                           2-0-0-2**

**Unit I:** Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in research.

**Unit II:** Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

**Unit III:** Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection,
Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

**Unit IV:** Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

**Unit V:** Intellectual property rights (IPR) - Patents-Copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science

**Textbooks/References:**

**19AI701  MACHINE LEARNING FOR BIG DATA 3-0-0-3**

**Unit I:**

**Unit II:**

**Unit III:**
Large Scale Machine Learning: Neural Networks - The Support Vector Machines model and use of Kernels to produce separable data and non-linear classification boundaries.
Overview - Deep learning; Tools for Data Ingestion; analytics and visualization.

Text Books/References:


19A1702 APPLICATIONS OF MACHINE LEARNING 3-0-0-3

UNIT I


UNIT II
Mining Social network graphs – Clustering of Social Network Graphs, Partitioning of Graphs, and Finding Overlapping Communities.


UNIT III

Sparse models, State space models, Markov Decision Process, Markov random Fields, Review of Inference for graphical models, Latent Linear and Variable models for discrete data, random algorithms in Computational Linear algebra.

Text Books/References:

3. Selected Journal papers to be given as case study from each module.
Unit I:


Unit II:


Unit III:

Spectral Learning: Spectral methods, spectral clustering, co-training, spectral learning of Hidden Markov Models (HMMs), tensor factorization, latent variable PCFGs, multivariate latent tree structures.

Text Books/References:


Unit-I:


Unit-II:

Prediction and Classification Methods - Multiple Linear Regression - Explanatory vs. Predictive Modeling - Estimating the Regression Equation and Prediction - The k-NN Classifier

Unit III:

Text Books/References

2. Daniel T. Larose and Chantal D. Larose, “Data Mining and Predictive Analytics” (Wiley Series on Methods and Applications in Data Mining), Wiley, 2015

19AI705 AI IN NATURAL LANGUAGE PROCESSING 3-0-0-3

Unit I:

Unit II:

Unit III:

**Text Books/References:**


**19A1706 INTRODUCTION TO ROBOTICS 3 0 0 3**

**Unit I:**

**Unit II:**
Introduction to mobile robots: wheeled robots, legged robots and drones – Environment perception – Path planning – Probabilistic based localization and mapping

**Unit III:**
Introduction to robotic vision – Object detection – Pose estimation – Introduction to Robot Operating System

**Textbooks / References:**

5. Roland Siegwart and IllahNourbakhsh, “Introduction to Autonomous Mobile Robots” MIT Press, 2004

19AI707       INTRODUCTION TO GAME THEORY         3-0-0-3

Unit I:

Unit II:

Unit III:

Text books/References:

19AI708       COMPUTATIONAL LINEAR ALGEBRA 3-0-0-3

Unit I:
Matrices and Gaussian Elimination – Introduction, Geometry of Linear Equations, Gaussian Elimination, Matrix multiplication, Inverses and Transposes, Special matrices and applications. Vector spaces and Linear equations– Vector spaces and subspaces, linear independence, basis and dimension, the four fundamental subspaces.

Unit II:
Orthogonality -Perpendicular vectors and orthogonal subspaces, inner products and projections onto lines, projections and least square applications, orthogonal basis, orthogonal spaces, orthogonal matrices, GramSchmidt orthogonalization, FFT.
Unit III:
Eigenvalues and Eigenvectors – Introduction, diagonal form of a matrix, difference equations and the powers of $A^k$, Positive Definite Matrices - Minima, Maxima and saddlepoints, tests for positive definiteness, semi-definite and indefinite matrices, Singular Value Decomposition, iterative methods for $Ax = b$, Applications in sparse signal and image processing. Concept of Streaming algorithms, Sketching methods with examples.

Text books/References:

4. https://doi.org/10.1073/pnas.0803205106
several system design, Confidence interval for the difference between expected responses of two systems.

Textbooks/References:


19A1710 ADVANCED ALGORITHMS AND ANALYSIS 3-0-0-3

Unit I:

Unit II:

Unit III:

Textbooks/References:


19AI711 INFORMATION RETRIEVAL 3-0-0-3

Unit I:
Introduction to IR: Space Retrieval Models - Ranked Retrieval - Text Similarity Metrics - Tokenizing- Stemming-Evaluations on benchmark text collections - Components of an information retrieval system.

Unit II:

Unit III:

Text books/References:

19AI712 WEB INTELLIGENCE & BIG DATA 3-0-0-3

Unit I:
Unit II:

Unit III:

Text books/References:

19AI713 DATA VISUALIZATION 3-0-0-3

Unit I:

Unit II:

Unit III:
Manipulate view: Change view over time – Select elements – Changing viewpoint – Reducing attributes. Facet into multiple views: Juxtapose and Coordinate views – Partition into views – Static and Dynamic layers – Reduce items and attributes: Filter – Aggregate. Focus and context:
Text books/References:


19AI714 NETWORKS AND SPECTRAL GRAPH THEORY 3-0-0-3

Unit I:
Graphs and Networks- Review of basic graph theory, Mathematics of networks- Networks and their representation, Graph spectra, Graph Laplacian, Structure of complex networks, Clustering, Community structures, Social networks - the web graph, the internet graph, citation graphs. Measures and metrics- Degree centrality, Eigenvector centrality, Katz centrality, PageRank, Hubs and authorities, Closeness centrality, Betweenness centrality, Transitivity, Reciprocity, Similarity, assortative mixing.

Unit II:

Unit III:
Models of network Formation- Preferential attachment, Model of Barabasi and Albert, Vertex copying models, Network optimization models; Epidemics on networks- Models of the spread of disease, SI model, SIR model, SIS model, SIRS model; Network Search-Web search, Searching distributed databases.

Text books/References:

4. Alain Barrat, Marc Barthelemy and Alessandro Vespignani, “Dynamical processes on

19AI715 PARALLEL & DISTRIBUTED DATA MANAGEMENT  3-0-0-3

Unit I:
Introduction: Parallel and Distributed architectures, models, complexity measures, Communication aspects, A Taxonomy of Distributed Systems - Models of computation: shared memory and message passing systems, synchronous and asynchronous systems, Global state and snapshot algorithms.

Unit II:

Unit III:
Query Processing and Optimization – Parallel/Distributed Sorting, Parallel/Distributed Join, Parallel/Distributed Aggregates, Network Partitions, Replication, Publish/Subscribe Systems-CASE study on Apache Kafka Distributed Publish/Subscribe messaging Hadoop and Map Reduce – Data storage and analysis, Design and concepts of HDFS, YARN, Map Reduce workflows and Features, Setting up a Hadoop cluster.

Text books/References:
2. Dimitri P. Bertsekas and John N. Tsitsiklis, “Parallel and distributed computation : Numerical methods”,
6. Parallel database systems: The future of high performance database systems

19AI716 CLOUD & BIG DATA ANALYTICS (3 0 0 3)

Unit I:
Data analysis versus Hypothesis Testing, Design of Data processing for Analytics, Elastic Analysis Concepts.

**Unit II:**

Management of Big data in cloud Computing, Big Data platforms – exposure to Hadoop ecosystem, Spark, Scala, Spark Streaming, Hive and Kafka Architecture

**Unit III:**

Real-world Case studies – Web Analytics, Web-scrapping, Google Analytics, Social medial Analytics, Issues in integrating Big data with Clouds- security concerns and measures to handle them.

**Text books/References:**


**19A1717 MEDICAL SIGNAL PROCESSING 3-0-0-3**

**Unit I:**

Signals and systems: Review, Medical Imaging Modalities and the need for different modalities (MRI, CT, OCT for Retinal Images, PET, X-Ray, Ultra Sound, Microscopy, Flow Cytometry, Imaging Flow Cytometry, etc.


**Unit II:**


ECG data acquisition, ECG lead system, ECG signal characteristics (parameters and their estimation), Analog filters, ECG amplifier, and QRS detector, Power spectrum of the ECG, Band
pass filtering techniques, Differentiation techniques, Template matching techniques, A QRS detection algorithm

**Unit III:**

Classification and Clustering– Examples of image classification for diagnostic/assistive technologies –Deep learning based classifiers. 3D volume reconstruction – Reconstruction techniques for CT, MRI-. Reconstruction of cell structure from focus stack of images - CT and MRI volume reconstruction – Wavelet based Volume Rendering, Applications of EEG

**Text book/References:**


**19A1718 IOT PROTOCOLS AND ARCHITECTURE 3-0-0 3**

**Unit I:**


**Unit II:**

Application Protocols for IoT: UPnP, CoAP, MQTT, XMPP. SCADA, Web Socket; IP-based protocols: 6LoWPAN, RPL; Authentication Protocols; IEEE 802.15.4

**Unit III:**

Case study: Cloud-Based Smart-Facilities Management, Healthcare, Environment Monitoring System
Text books/References:


19AI719 PARALLEL AND DISTRIBUTED COMPUTING 3-0-0-3

Unit I:
Introduction-Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD examples.

Unit II:
Multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools.

Text Books/References:


19AI720MODERN COMPUTER ARCHITECTURE 3-0-0-3

Unit I

Unit II:

**Unit III**
Simultaneous Multi-Threading (SMT), Chip Multi-Processors (CMP), General Purpose Graphics Processing Units (GPGPU). VLSI Scaling issues, data speculation, dynamic compilation, communication architectures, near data processing, and other advanced topics.

**Text Books/References:**


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19AI721 GPU ARCHITECTURE AND PROGRAMMING 3-0-0-3
(Prerequisite – Modern Computer Architecture)

**Unit I:**
Introduction to Parallel Programming – Types of Parallelism - Introduction to OpenCL - OpenCL Device Architectures - Basic OpenCL – examples - Understanding OpenCL - Concurrency and Execution Model - Dissecting a CPU/GPU - OpenCL Implementation – OpenCL.

**Unit II:**
CUDA programming – CUDA C – Setting up CUDA, Grids, Blocks - Thread Cooperation – Memory types – CUDA streams.

**Unit III:**
Case study: Convolution, Video Processing, Histogram and Mixed Particle Simulation - OpenCL Extensions - OpenCL Profiling and Debugging – WebCL, Applications of GPU Architecture like Gaming, Computer Vision, etc.

**Text Books/References:**