COMSATS University Islamabad

Registrar Secretariat, Academic Unit (PS)

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No. CUI-Reg/Notif-4517 /21/3188 November 29, 2021

NOTIFICATION

Scheme of Studies of Master of Science in Artificial Intelligence

Academic Council in its 32nd meeting held on October 06, 2021 on the recommendations of 29th meeting of Board of Advance Studies and Research (BASAR), approved the Scheme of Studies of Master of Science in Artificial Intelligence effective from Spring 2022 at CUI System:

Nomenclature: Master of Science in Artificial Intelligence MS (AI)

1. Minimum Duration: 02 Years
2. Minimum No. of Semesters: 04

3. **Course Work:**		**(Min No. of Courses)**	**(Min No. of Credit Hours)**
a)	Core Courses (List Attached)	03	09
b)	Specialization Requirement Courses (List Attached)	02	06
c)	Research Methodology	01	01
d)	Elective Courses (List Attached)	03	09
e)	Thesis	--	06
Total No. of Courses in the Program:		**09**	--
Total Credit Hours of the Program:			**31**

Note:

1. The Department can offer an elective course from the list of elective courses of other "MS Program" being offered in the Department.
2. The Regulations relating to graduate Degree Programs approved by the Competent Authority and amended from time to time shall be applicable

Munibe Nasir

Muniba Nasir
Additional Registrar

Encl: (Total 22 pages, including this page)

Distribution:

1. All Campus Directors, CUI
2. All Deans of Faculties, CUI
3. Controller of Examinations, CUI
4. Chairperson, Department of Computer Science, CUI
5. Incharge QEC/CU Online, PS
6. All HoDs/Incharge of Academics/Examinations Sections, CUI Campuses
7. Internal Distribution, Registrar Office (Academic Unit), CUI

Cc:

1. PS to Rector CUI
2 PS to Registrar CUI

Core Courses

Course Code	Course Title	Credit Hours	Pre-requisite(s)
AIC530	Programming for Artificial Intelligence	3(2, 1)	-
AIC564	Advanced Artificial Intelligence	3(3, 0)	-
AIC572	Knowledge Representation and Reasoning	3(3, 0)	-

Specialization Requirement Courses
(Choose any 2)

Course Code	Course Title	Credit Hours	Pre-requisite(s)
AIC601	Statistical Learning Theory	3(3, 0)	-
AIC613	Advanced Machine Learning	3(3, 0)	-
AIC620	Cognitive Modelling	3(3, 0)	-
AIC628	Advanced Artificial Neural Networks	3(3, 0)	-

Pre-Requisite for Thesis

Course Code	Course Title	Credit Hours	Pre-requisite(s)
CSC607	Research Methodology	1(1, 0)	-

MS Thesis

Course Code	Course Title	Credit Hours	Pre-requisite(s)
AIC800	MS Thesis	6(0, 6)	-

Electives Courses

Course Code	Course Title	Credit Hours	Pre-requisite(s)
DS606	Deep Learning	3(3, 0)	-
DS607	Natural Language Processing	3(3, 0)	-
AIC651	Multi-Agent Systems	3(3, 0)	-
AIC653	Computer Vision and Video Analytics	3(3, 0)	-
AIC654	Advanced Pattern Recognition	3(3, 0)	-
AIC655	Reinforcement Learning	3(3, 0)	-
AIC657	Soft Computing Techniques	3(3, 0)	-
AIC662	Evolutionary Computing	3(3, 0)	-

AIC665	Ethical issues in Artificial Intelligence	3(3, 0)	-
AIC667	Robotic Planning and Perception	3(3, 0)	-
AIC668	Applications of Artificial Intelligence	3(3, 0)	-
AIC698	Advanced Topics in Artificial Intelligence - I*	3(3, 0)	-
AIC798	Special Topics in Artificial Intelligence – I*	3(3, 0)	-

* The contents for these courses would be subject to approval from the Head of Department.

Note: More courses may be added to the above list of electives after the approval of BOS

Tentative Semester Plan:

Semester	Course Title	Credits
1st Semester	Advanced Artificial Intelligence	3(3, 0)
	Programming for Artificial Intelligence	3(2, 1)
	Elective-I	3(3, 0)
	Research Methodology	1(1, 0)
2nd Semester	Knowledge Representation and Reasoning	3(3, 0)
	Specialization-Elective-I	3(3, 0)
	Specialization Elective-II	3(3, 0)
3rd Semester	Elective II	3(3, 0)
	MS-Thesis-I	3(3, 0)
4th Semester	Elective III	3(3, 0)
	MS-Thesis-II	3(3, 0)

Core Courses

Course Code: AIC530 **Pre-Requisite:** None

Course Title: Programming for Artificial Intelligence

Credit Hours: 3(2, 1)

Course Objectives:

- To describe the Paradigms of AI Programming;
- To explain the fundamental constructs of AI programming language;
- To provide an implementation of the AI concepts presented in terms of intelligent agents: Search, Knowledge representation, inference, logic, and learning;
- To Learn the essential AI programming tools (Python, NumPy, PyTorch), the math (calculus and linear algebra), and the key techniques of neural networks (gradient descent and backpropagation).

Course Contents:

Topics include: Paradigms of AI Programming, IDE for the Language (e.g. Jupyter Notebook Or Ipython), Variables, Expressions, Operands and Operators, Loops, Control Structures, Debugging, Error Messages, Functions, Strings, Lists, Object-Oriented Constructs and Basic Graphics in the Language; logic programming; Analyzing and Plotting Numerical Data (e.g., Numpy, Matplotlib, Anaconda and Pandas for Python) and give examples of each library using simple use cases and small case studies.

Recommended Books:

1. Artificial Intelligence with Python: Your complete guide to building intelligent apps using Python 3.x, Artasanchez, A. & Joshi, P., Packt Publishing, 2020.
2. Introduction to Logic Programming (Synthesis Lectures on Artificial Intelligence and Machine Learning), Genesereth, M., et al., Morgan & Claypool, 2020.

Course Code: AIC564 **Pre-Requisite:** None

Course Title: Advanced Artificial Intelligence

Credit Hours: 3(3, 0)

Course Objectives:

- To become familiar with basic principles of AI towards problem solving, inference, perception, knowledge representation, and learning;
- To be familiar with techniques for computer-based representation and manipulation of complex information, knowledge, and uncertainty;
- To gain awareness of several advanced AI applications and topics such as intelligent agents, planning and scheduling, machine learning, etc;
- To explore the current scope, potential, limitations, and implications of intelligent systems.

Course Contents:

Topic includes: AI methodology and Fundamentals; Intelligent Agents; Solving Problems by Searching; Constraint Satisfaction Problems: Constraint Satisfaction Problems, Backtracking Search for CSPs, Local Search for Constraint Satisfaction Problems. Adversarial Search; Planning: The Planning Problem, Planning with State-Space Search, Partial-Order Planning, Planning Graphs, Planning with Propositional Logic, Analysis of Planning Approaches. Time, Schedules, and Resources, Hierarchical Task Network Planning, Planning and Acting in Nondeterministic Domains, Continuous Planning, Multi Agent Planning. Handling uncertainty: Non-Monotonic Reasoning, Probabilistic reasoning, and use of certainty factors; Learning from Observations; Current research topics in Artificial Intelligence.

Recommended Books:

1. Artificial Intelligence. A Modern Approach, Russell, S., Norvig, P., Prentice Hall, Inc., 2020.
2. Advanced Artificial Intelligence, Shi, Z., World Scientific Publishing Company, 2019

Course Code: AIC572 **Pre-Requisite:** None

Course Title: Knowledge Representation and Reasoning

Credit Hours: 3(3, 0)

Course Objectives:

- To describe the principles of logic-based Knowledge Representation;
- To represent the knowledge of a domain formally; To design, implement and apply a knowledge-based system;
- To understand the limitations and complexity of reasoning algorithms;
- To understand the fundamental trade-off between representation power and computational properties of a logic-based representation language.

Course Contents:

Representing knowledge using logic; The Language of First Order Logic: Syntax, Semantics, Explicit and Implicit belief; Expressing Knowledge: Knowledge Engineering, Vocabulary, Basic and Complex Facts, Terminological Facts, Entailments; Resolution: The propositional case, Handling Variables and Quantifiers, Computational Intractability; Reasoning with Horn Clauses: SLD resolution, Computing SLD Resolution; Procedural Control of Reasoning; Rules in Production Systems; Object Oriented Representation; Structured Descriptions; Ontology languages for the Semantic Web; Non-monotonic logics.

Recommended Books:

1. Knowledge representation and reasoning, Blokdyk, G., 5STARCooks, 2018.
2. Knowledge Representation, Reasoning, and the Design of Intelligent Agents: The Answer-Set Programming Approach, Gelfond, M., Kahl, Y., Cambridge University Press, 2014.
3. Knowledge Representation and Reasoning, Brachman, R., Levesque, H., The Morgan Kaufmann Series in Artificial Intelligence, 2004.

Specialization Requirement Courses

Course Code: AIC601 **Pre-Requisite:** None

Course Title: Statistical Learning Theory

Credit Hours: 3(3, 0)

Course Objectives:

- To apply statistical methods and techniques to formulate real life artificial intelligence problems;
- To create skill set spanning hypothesis tests, regression and analysis of variance, maximum likelihood for a scalar parameter;
- To familiarize with the basic methods used to analyze modern datasets;
- To develop skills that help in interpreting and communicating the results of statistical analysis.

Course Contents:

This is an introduction to the statistical and mathematical methods behind scientific techniques developed for extracting information from large data sets encountered in industrial applications. Topics includes: Statistical Inference estimation, Hypothesis Testing: Chi Square distribution and statistical Inference, t-distribution and statistical inference, F distribution and statistical distribution; Analysis of variance, Statistical inference in regression and correlation; Logistic regression; Analysis of covariance; experimental design; Nonparametric test; Bayesian regularization; Normal equations and gradient descent. The Penrose axioms, Pseudo-inverse. QR factorization and Householder reflections. Clustering via K-means, Decision boundaries and discriminants; Vector norms and unit balls, FTLA and SVD, Matrix norms, the Eckart/Young/Mirsky theorem. Dimension reduction via PCA.

Recommended Books:

1. An Introduction to Statistical Learning, Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Springer, 2017.
2. Matrix Computations, Golub, G. H., Van Loan, C. F., . Johns Hopkins University Press, 2013

Course Code: AIC613 **Pre-Requisite:** None

Course Title: Advanced Machine Learning

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss machine learning concepts and their applications;
- To describe variety of machine learning algorithms along with their strengths and weaknesses;
- To apply machine learning algorithms to solve problems of moderate complexity.

Course Contents:

Introduction to machine learning; concept learning: General-to-specific ordering of hypotheses, Version spaces Algorithm, Candidate elimination algorithm; Supervised Learning: decision trees, Naive Bayes, Artificial Neural Networks, Support Vector Machines, Overfitting, noisy data, and pruning, Measuring Classifier Accuracy; Linear and Logistic regression; Unsupervised Learning: Hierarchical Aglomerative Clustering. k-means partitional clustering; Self-Organizing Maps (SOM) k-Nearest-neighbor algorithm; Semi-supervised learning with EM using labeled and unlabled data; Reinforcement Learning: Hidden Markov models, Monte Carlo inference Exploration vs. Exploitation Trade-off, Markov Decision Processes; Ensemble Learning: Using committees of multiple hypotheses. Bagging, boosting.

Recommended Books:

1. Machine Learning, Tom, M., McGraw Hill, 1997.
2. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press,2012

Course Code: AIC620 **Pre-Requisite:** None

Course Title: Cognitive Modelling

Credit Hours: 3(3, 0)

Course Objectives:

- To scientifically explain the basic cognitive processes of perception, thinking, problem solving, decision making, and moving in the environment and how these processes interact;
- To describe the basic methods used to develop and test computational models of cognition;
- To provides a presentation of psychological, mathematical, statistical, and computational methods used in different areas of cognitive modeling;
- To understand detailed examples of these methods in a variety of modeling areas that include recognition, categorization, decision making, and learning.

Course Contents:

Topics include: Introduction to computational theories of human cognition and behavior. Fundamental issues include perception, knowledge representation, memory, decision-making, learning, and motor control. Readings and assignments will explore a variety of formal/theoretic approaches: neural, probabilistic, and symbolic/architectural. A focus of the course will be how to evaluate and compare models against each other and empirical data.

Recommended Books:

1. Cognitive Modeling, J. Busemeyer and A. Diederich, Sage Publications, 2015.
2. Computational Modeling in Cognition: Principles and Practice, Farrel& S. Stephan Lewandowsky, Sage Publications, Inc, 2010.

Course Code: AIC628 **Pre-Requisite:** None

Course Title: Advanced Artificial Neural Networks

Credit Hours: 3(3, 0)

Course Objectives:

- To describe the underlying principles making neural networks generic computing frameworks;
- To build computational skills for training neural networks, understanding and working with learning algorithms;
- To understand the choices and limitations of a model for a given setting;
- To understand motivation and functioning of the most common types of deep neural networks;
- To apply deep learning techniques to practical problems.

Course Contents:

Topics include: Fundamentals of learning in Artificial Neural Networks (ANN); Stochastic Gradient Descent, Adam, Dropout, Initialization; Different types of ANNs: Convolutional networks, RNNs, LSTM, GANs; Adversarial Approaches to ANN; Advanced Topics: Optimization, Hyper-Parameter, Advanced Optimization; simple examples and motivation for deep networks; Use of tensorflow.

Recommended Books:

1. Motivation, Effort, and the Neural Network Model (Neural Network Model: Applications and Implications), Theodore Wasserman and Lori Wasserman ,Springer 2020
2. Efficient Processing of Deep Neural Networks, Sze, V., Chen, Y., Yang, T., Emer, J. S.,, Morgan & Claypool Publishers , 2020.
3. Deep Learning, Goodfellow, I., Bengio, Y., Courville, A., MIT Press 2016

Electives Courses

Course Code: DS606 **Pre-Requisite:** None

Course Title: Deep Leaning

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss major deep learning algorithms, the problem settings, and their applications to solve real world problems;
- To familiarize graduate students with the current state-of-the-art in machine perception of images and sound using Deep Learning architectures;
- To Analyze and contrast broad classes of deep learning models (multilayer perceptrons vs ConvNets vs RNNs);
- To derive and implement Backprogation-based parameter learning and modern optimization techniques in deep learning models; Summarize and review state-of-art approaches in deep learning.

Course Contents:

In this course topics include Theoretical Advantages of Deep Architectures; Architectures for Deep Neural Networks; Convolutional Neural Networks; Properties of CNN representations: Invertibility, Stability, Invariance; Deep Unsupervised Learning: Auto-Encoders (Standard, Denoising, Contractive), Variational Auto-Encoders, Adversarial Generative Networks, Maximum Entropy Distributions, Optimization Methods for Deep Neural Networks, Non-convex optimization for deep networks, Deep Reinforcement Learning; Deep Belief Networks, Recent Applications of Deep Learning (case studies).

Recommended Books:

1. Deep Learning: A practitioner Approach, Adam Gibson, Josh Patterson, O'Reilly Media, 2017.
2. Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, MIT Press, 2016.
3. Learning Deep Architectures for AI: Foundations and Trends(r) in Machine Learning, Yoshua Bengio, Now Publishers Inc, 2009.

Course Code: DS607 **Pre-Requisite:** None

Course Title: Natural Language Processing

Credit Hours: 3(3, 0)

Course Objectives:

- To present the main models, formalisms and algorithms necessary for the development of applications in the field of natural language information processing.

Course Contents:

Course Orientation and Overview; Introduction to background knowledge; Various Applications of Natural Language Processing (NLP); Zipf'law; Linguistic Essentials; Corpus-Based Work; Collocations; N-grams Models over Sparse Data; Word Sense Disambiguation; Hidden Markov Model (Word Guessing and HMM. Decoding and Training); Maximum Entropy; Part-of-Speech Tagging; Fundamentals of Natural Language Parsing; Grammar and Parsing; Statistical approaches; Text Alignment and Machine Translation; Information Retrieval and Information Extraction; Deep Learning for NLP; Modern Trends in NLP and Speech Recognition; Term Project Presentations.

Recommended Books:

1. Speech and Language Processig, D. Jurafsky and J. Martin, Prentice Hall, 2008.
2. Natural Language Processing and Information Retrieval, Tanveer Siddiqui, U. S. Tiwary, Oxford University Press, 2008.
3. Natural Language Processing with Python, Steven Bird, O'Reilly,2009.

Course Code: AIC651 **Pre-Requisite:** None

Course Title: Multi-Agent Systems

Credit Hours: 3(3, 0)

Course Objectives:

- To describe the Models of agency, architectures and languages;
- To understand the Agent communication and interaction protocols;
- To build multi-agent systems and select the right MAS framework for solving a real-world problem based on concepts such as distribution of tasks, communication, cooperation and coordination of actions.

Course Contents:

Agents: agent definitions and classification, multi-agent systems(MAS); Models of agency, architectures and languages; Agent communication and interaction protocols; Distributed problem solving and planning; Coordination mechanisms and strategies; Negotiation and coalition formation; Learning in MAS; Agent languages, Agent-oriented programming; Organizational theories Agent platforms; Agent-oriented software engineering, Industrial applications of MAS; MAS in e- commerce and virtual markets, Adaptive information agents and information retrieval.

Recommended Books:

1. Multi-Agent Oriented Programming: Programming Multi-Agent Systems Using JaCaMo, Olivier Boissier, Rafael H. Bordini, Jomi Hubner, Alessandro Ricci, MIT Press, 2020.
2. Multi Agent Systems Strategies and Applications, Ricardo Lopez-Ruiz, Intech Open, 2019
3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton, Brown - Computers – 2008

Course Code: AIC653 **Pre-Requisite:** None

Course Title: Computer Vision and Video Analytics

Credit Hours: 3(3, 0)

Course Objectives:

- To demonstrate fundamental computer vision techniques;
- To implement ideas on publicly available or self-generated datasets for particular CV tasks.

Course Contents:

This course covers different aspects of computer vision and is focused on providing enough grounding in both theoretical and practical aspects of what computer vision is. The theoretical foundations required for a professional in CV include mathematical, statistical, image processing, and machine learning aspects of it, and then building on them to build a complete computer vision system. Students will be required to implement their ideas on publicly available or self-generated datasets for particular CV tasks. The topics include: Linear Algebra; Pixels and Filters; Edge Detection; RANSAC; Feature Detectors: Harris; Difference of Gaussian; SIFT; Panorama Stitching; Segmentation; Clustering; Feature Tracking; Linear Classifiers and Classification; PCA and Eigen faces; Deep Learning.

Recommended Books:

1. Deep Learning, Goodfellow, I., Bengio, Y., Courville, A., The MIT Press, 2016
2. Computer Vision: Models, Learning, and Inference. Prince, S. J. D., Cambridge University Press, 2012.
3. Computer Vision: A Modern Approach. Forsyth and Ponce, Pearson, 2012.
4. Computer Vision: Algorithms and Applications. Richard Szeliski, Springer, 2011.

Course Code: AIC654 **Pre-Requisite:** None

Course Title: Advanced Pattern Recognition

Credit Hours: 3(3, 0)

Course Objectives:

- To discuss concepts and applications of pattern recognition;
- To explain the probability theory used in pattern recognition;
- To discuss the classification and feature selection techniques;
- To demonstrate the dimensionality reduction techniques;
- To discuss the clustering techniques for pattern recognition.

Course Contents:

Topics include: Pattern recognition: basic concepts; Probability theory: conditional probability theory, bayes decision theory;Linear classifiers: the perceptron algorithm, least-squares methods; Nonlinear classifiers: multilayer perceptron's, back propagation algorithm, decision trees, combinations of classifiers, boosting; Feature selection: data preprocessing, ROC curves, class separtability measures, feature subset selection, bayesian information criterion; Dimensionality reduction: basis vectors, singular value decomposition, independent component analysis, kernel PCA, wavelets; Additional features and template matching: texture, shape and size characterization, fractals, features for audio, Context dependent classification; Clustering: sequential algorithms, hierarchical algorithms, functional optimization-based clustering, graph clustering, learning clustering, clustering high dimensional Data, Cluster validity measures.

Recommended Books:

1. Essentials of Pattern Recognition: An Accessible Approach, Jianxin Wu, Cambridge University Press, 2020.
2. Pattern Recognition, Theodoridis, S. & K. Koutroumbas, CA: Academic Press, 2009.
3. Pattern Recognition and Machine Learning, Bishop, C. M., Springer, 2007.
4. Pattern Classification, Duda, R.O., Hart, P.E., &Stork, D.G., Wiley-Interscience, 2001.

Course Code: AIC655 **Pre-Requisite:** None

Course Title: Reinforcement Learning

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the basics of deep learning and reinforcement learning paradigms;
- To understand Architectures and optimization methods for deep neural network training;
- To understand How to implement deep learning methods within Tensor Flow and apply them to data;
- To understand the theoretical foundations and algorithms of reinforcement learning;
- To understand How to apply reinforcement learning algorithms to environments with complex dynamics.

Course Contents:

Topics covered includes: Markov decision processes, planning by dynamic programming, model-free prediction and control, value function approximation, policy gradient methods, integration of learning and planning, and the exploration/exploitation dilemma.

Recommended Books:

1. Reinforcement Learning with TensorFlow: A beginner's guide to designing self-learning systems with TensorFlow and OpenAI Gym, Sayon Dutta, Packt Publishing, 2018.
2. Algorithms for Reinforcement Learning, Csaba Szepesvari, Morgan and Claypool Publishers, 2010.

Course Code: AIC657 **Pre-Requisite:** None

Course Title: Soft Computing Techniques

Credit Hours: 3(3, 0)

Course Objectives:

- To familiarize with soft computing concepts;
- To describe the basics of Soft computing and its application areas particularly to intelligent systems;
- To introduce the ideas of Fuzzy Logic, Genetic algorithm, genetic programming;
- To identify problems where artificial intelligence techniques are applicable;
- To apply selected basic AI techniques, judge applicability of more advanced techniques;
- To participate in the design of systems that act intelligently and learn from experience.

Course Contents:

Topics covered includes: Soft Computing Constituents and Conventional Artificial Intelligence, Neuro-Fuzzy and Soft Computing Characteristics, Fuzzy Sets: Introduction, Basic Definitions and Terminology, Set Theoretic Operations, MF Formulation and Parameterization; Fuzzy Rules & Fuzzy Reasoning: Extension Principle and Fuzzy Relations, Fuzzy If-Then Rules, Fuzzy Reasoning; Fuzzy Inference Systems: Mamdani Fuzzy Models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Models, Other Considerations; Genetic Algorithms, Genetic Programming, Simulated Annealing, Random Search, Downhill Simplex Search; Adaptive Neuro-Fuzzy Inference Systems (ANFIS): ANFIS Architecture, Hybrid Learning Algorithm;.

Recommended Books:

1. Principle of Soft Computing, S.N. Sivanandan & S.N. Deepa, Wiley India Edition,2017.
2. Neuro-Fuzzy and Soft Computing, J.-S.R.Jang, C.-T.Sun & E. Mizutani, PHI,2015.
3. Neural Networks Fuzzy Logic & Genetic Algorithms; Synthesis & Applications, S.Rajasekaran & G.A. VijayaLaxmi Pai, Prentice Hall, India, 2006.

Course Code: AIC662 **Pre-Requisite:** None

Course Title: Evolutionary Computing

Credit Hours: 3(3, 0)

Course Objectives:

- To explain evolutionary computation techniques and methodologies set in the context of modern heuristic methods;
- To apply various evolutionary computation methods and algorithms for different classes of problems;
- To develop evolutionary algorithms for real-world applications.

Course Contents:

Topics covered includes: History of evolutionary computation; evolution strategies, evolution programming, genetic programming, classifier systems; constraint handling; multi-objective cases; dynamic environments; parallel implementations; coevolutionary systems; parameter control; hybrid approaches; commercial applications.

Recommended Books:

1. Introduction to Evolutionary Computing, "A. E. Eiben, J. E. Smith, Springer, 2003.

Course Code: AIC665 **Pre-Requisite:** None

Course Title: Ethical issues in Artificial Intelligence

Credit Hours: 3(3, 0)

Course Objectives:

- To understand the fundamental principles of Professional practices;
- To understand the importance of ethics; To understand the special ethical considerations for AI.

Course Contents:

The course includes the following topics:

Introduction: Artificial Intelligence and Ethics; What are Ethics: Normative Ethical Theories, Ethics and Empirical Evidence, why do we need Ethics? Moral Relativism, Moral Justification and AI, A Distributed Morality? Moral Agents, Moral Motivation, AI, Code of Ethics and the Law; Does AI raise any distinctive questions? Codes of Professional Ethics: The varieties of Ethical Codes; Professional Codes of Ethics; The Context of Codes of Ethics; How AI Challenges Professional Ethics? Developing Codes of Ethics Amidst Fast Technological Change; Pitfalls in Considering the Ethics of AI;

Recommended Books:

1. Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way, Dignum, V., Springer, 2019.
2. Artificial Intelligence: Evolution, Ethics and Public Policy, Sarangi, S., Sharma, P., Routledge India, 2018.
3. Towards a Code of Ethics for Artificial Intelligence (Artificial Intelligence: Foundations, Theory, and Algorithms), Boddington, P., Springer, 2017.

Course Code: AIC667 **Pre-Requisite:** None

Course Title: Robotic Planning and Perception

Credit Hours: 3(3, 0)

Course Objectives:

- To describe how robots perceive the world and their own movements so that they accomplish navigation and manipulation tasks;
- To understand how grasping objects is facilitated by the computation of 3D posing of objects and navigation can be accomplished by visual odometry and landmark-based localization;
- To learn approaches for motion planning including graph-based methods, randomized planners and artificial potential fields;
- To learn how to program a robot to perform a variety of movements such as flying and grasping objects.

Course Contents:

Robot Autonomy, Robot Perception; Object Detection, 3D Data Processing, physical simulations for robot learning, Representation Learning: Priors, Motions; Multimodal Perception; Recursive State Estimation; Pose Estimation; PyTorch deep learning framework; Active Perception; Robot Decision Making; Model-free Reinforcement Learning; Imitation as Supervised Learning; Inverse Reinforcement Learning; Adversarial Imitation Learning; Graph-based Plan Methods, Configuration Space, Sampling-based Planning Methods; Artificial Potential Field Methods. Robots in the Real World

Recommended Books:

1. Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques Francis X. Govers, Packt Publishing, 30-Aug-2018
2. Modern Robotics, Kevin M. Lynch, Frank C. Park, Cambridge University Press, 2017.
3. Path Planning for Vehicles Operating in Uncertain 2D Environments, Viacheslav Pshikhopov, Elsevier Science, 2017.

Course Code: AIC668 **Pre-Requisite:** None

Course Title: Applications of Artificial Intelligence

Credit Hours: 3(3, 0)

Course Objectives:

- To identify problems where artificial intelligence techniques are applicable;
- To apply selected basic AI techniques, judge applicability of more advanced techniques;
- To participate in the design of systems that act intelligently and learn from experience.

Course Contents:

The contents of this course will vary, but in general focus on applications of AI domain including: Planning and scheduling; Applications from Computer Vision such as Medical diagnosis; Natural Language Understanding; Natural Language Interaction; Robotic Sensing and Manipulation; Mobile Robots;: Cognitive Collaboration;

Recommended Books:

Instructor will decide the book