GUJARAT TECHNOLOGICAL UNIVERSITY

BIO MEDICAL ENGINEERING (31)
ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS
SUBJECT CODE: 2733105
SEMESTER: III

Type of course: Major Elective

Prerequisite: Basic simulation and modelling skills and its application using software tools

Rationale: The purpose of this course is to cover a broad range of topics relevant to computer assisted techniques for biomedical decision making and intended to give a broad overview of the complex area of decision support systems and their uses in medicine and biology. It contains sufficient theoretical material to provide a deep understanding of the techniques involved. For learner in the field, the course is important for initiating in-depth studies on specific topics, hopefully producing new and interesting theoretical and practical developments.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	PA (V)		PA (M)		
						ESE	OEP	PA	RP	
3	2#	2	5	70	30	20	10	10	10	150

Content:

Sr. No.	Topics	Teaching Hrs.	% Module Weightage
1	**NEURAL NETWORKS** **Foundations of Neural Networks:** Objectives of Neural Networks, Biological Foundations of Neural Networks, Early Neural Models, Precursor to Current Models: Pattern Classification, Resurgence of the Neural Network Approach, Basic Concepts. **Classes of Neural Networks**: Basic Network Properties, Classification Models, Association Models, Optimization Models, Self-Organization Models, Radial Basis Functions (RBFs). **Classification Networks and Learning**: Network Structure, Feature Selection, Types of Learning, Interpretation of Output. **Supervised Learning**: Decision Surfaces, Two-Category Separation, Linearly Separable Sets, Nonlinearly Separable Sets, Multiple Category Classification Problems, Relationship to Neural Network Models, Comparison of Methods, Applications. **Unsupervised Learning**: Background, Clustering, Kohonen Networks and Competitive Learning, Hebbian Learning, Adaptive Resonance Theory (ART), Applications. **Design Issues**: Input Data Types, Structure of Networks, Implications of Network Structures, Choice of Learning Algorithm. **Comparative Analysis**: Input Data Considerations, Supervised Learning Algorithms, Unsupervised Learning, Network Structures, Interpretation of Results.	**12**	**20**

	Validation and Evaluation: Data Checking, Validation of Learning Algorithm, Evaluation of Performance.		
2	**ARTIFICIAL INTELLIGENCE** **Foundations of Computer-Assisted Decision Making**: Motivation for Computer-Assisted Decision Making, Databases and Medical Records, Mathematical Modeling and Simulation, Pattern Recognition, Bayesian Analysis, Decision Theory, Symbolic Reasoning Techniques. **Knowledge Representation**: Production Rules, Frames, Databases, Predicate Calculus and Semantic Nets, Temporal Data Representations. **Knowledge Acquisition**: Expert Input, Learned Knowledge, Meta-Knowledge, Knowledge Base Maintenance. **Reasoning Methodologies**: Problem Representations, Blind Searching, Ordered Search, AND/OR Trees, Searching Game Trees, Searching Graphs, Rule Base Searching, Higher-Level Reasoning Methodologies, Examples in Biomedical Expert Systems. **Validation and Evaluation**: Algorithmic Evaluation, Knowledge Base Evaluation, System Evaluation.	**12**	**20**
3	ALTERNATIVE APPROACHES **Genetic Algorithms**: Foundations, Representation Schemes, Evaluation Functions, Genetic Operators, Evolution Strategies, Biomedical Examples. **Probabilistic Systems**: Bayesian Approaches, Parameter Estimation, Discriminant Analysis, Statistical Pattern Classification, Unsupervised Learning, Regression Analysis, Biomedical Applications. **Fuzzy Systems**: Fuzzy Information, Fuzzy Neural Networks, Fuzzy Approaches for Supervised Learning Networks, Fuzzy Generalizations of Unsupervised Learning Methods, Reasoning with Uncertain Information, Pre-Processing and Post-Processing Using Fuzzy Techniques, Applications in Biomedical Engineering. **Hybrid Systems**: Hybrid Systems Approaches, Components of Hybrid Systems, Use of Complex Data Structures, Design Methodologies.	**15**	**25**
4	**HYBRID EXPERT SYSTEM** **Knowledge-Based Component**: Crisp Implementation, Partial Substantiation of Antecedents, Weighted Antecedents and Partial Substantiation of Rules, Handling of Temporal Data **Neural Network Component**: Learning Algorithm, Special Data Types. **Analysis of Time Series Data**: Chaos Theory, Continuous versus Discrete Chaotic Modeling, Difference Equations and Graphs, Central Tendency Measure. **Combined System**: Weighting of Antecedents, Determination of Thresholds, Neural Network with Symbolic Layer. **Application: Diagnosis of Heart Disease**: Categories of Heart Disease, Knowledge-Based Information, Data-Based Information, Chaotic Data, Sample System.	**6**	**20**

5	**FUTURE PERSPECTIVES** **Effects of Hardware Advances:** Faster Computing Speeds, Increased Memory, Parallel Machines, Miniaturization, Organic Semiconductors. **Effects of Increase in Knowledge:** Information Explosion, Human Genome Project, Contents, Proliferation of Databases, Communication of Information. **The Future of Software:** Hybrid Systems, Parallel Systems, Non textual Data, Neural Network Models, Artificial Intelligence Approaches.	**6**	**15**

Reference Books:

1. Donna L. Hudson, Maurice E. Cohen, Neural Networks and Artificial Intelligence for Biomedical Engineering, IEEE Press, New York, 2000.
2. Elaine Rich and Kevin Knight, Artificial Intelligence, Tata McGraw Hill.
3. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hal of India.
4. Nils J. Nilsson: Principles of Artificial Intelligence, Narosa Publication house.
5. Stuart Rusell, Peter Norving, Artificial Intelligence: A Modern Approach, 2nd Edition, Pearson Education.
6. Winston, Patrick, Henry, Artificial Intelligence, Pearson Education.
7. Gopal Krishna, Janakiraman, Artificial Intelligence.

Course Outcome:

Upon successful completion of this subject students should be able to:

1. Develop the skills to gain a basic understanding of neural network theory and artificial Intelligence theory.
2. Explore the functional components of neural network classifiers and the functional components of artificial intelligence classifiers.
3. Develop and implement a basic trainable neural network or an artificial Intelligence system for a typical biomedical application.
4. Describe, apply, and implement uninformed and informed search techniques to solve problems.
5. Independently investigate an AI technique and describe, apply, and implement that technique.

List of Experiments: An experimental study should be used in conjunction with a theoretical approach, such as the use of ANN and AI in Biomedical applications like Modeling and diagnosing the cardiovascular system, Pattern recognizing of pathology images, ultrasound and magnetic resonance medical images textures analysis using computer simulation or the use of artificial neural networks within the scope of this course.

Design based Problems (DP)/Open Ended Problem: Student has to search and select (i) research paper from reputed conference or journal, or (ii) mini project, related to medical diagnostic application and has to implement the same using any tool/platform under the guidance of course instructor. Some of the suggested areas are;

1. Epidemiological Data inference (e.g. tracking epidemics, finding patterns of exposure/symptoms),
2. Experts Systems for advising health-care professionals,
3. Brain-Computer Interface and Neuroprosthetics (lots of interesting adaptive signal processing issues here),
4. Biomedical Image Analysis (Segmentation, Tracking).

5. Health-care robotics (Assisted surgery, haptic rehabilitation systems, laboratory automation systems),
6. Protein Folding,
7. Directed Evolution (in vitro genetic algorithms),
8. Sequence Analysis (gene finding, multiple dataset integration) etc.

Major Equipment: advanced modelling and simulation software with advanced computational facilities.

List of Open Source Software/learning website: Students may visit the online research and publication and ongoing project information from following research centers from the respective websites.

1. Hybrid Systems Resources, http://www.cogsci.rpi.edu/~rsun/hybrid-resource.html
2. Advanced methods in artificial intelligence, with biomedical applications, http://pages.cs.wisc.edu/~dpage/cs731/
3. The Joshua Lederberg Papers, Computers, Artificial Intelligence, and Expert Systems in Biomedical Research, http://profiles.nlm.nih.gov/ps/retrieve/Narrative/BB/p-nid/31

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.