Savitribai Phule Pune University Fourth Year of Artificial Intelligence and Data Science (2020 Course) 417529: Computational Intelligence		
Teaching Scheme: **TH: 03 Hours/Week**	**Credit** **03**	**Examination Scheme:** **In-Sem (Paper): 30 Marks** **End-Sem (Paper): 70 Marks**

Prerequisites Courses: Artificial Neural Network (317531), Artificial Intelligence (310253)

Companion Course: Computer Laboratory III (417533)

Course Objectives:

- To provide students with a comprehensive understanding of the fundamental concepts, theories, and techniques in the field of computational intelligence
- To understand, explain, and apply the fuzzy set and fuzzy logic in real life applications
- To familiarize with various evolutionary algorithms and optimization techniques inspired by natural evolution processes
- To understand the principles, techniques, and applications of genetic algorithms
- To apply computational intelligence techniques to solve complex NLP problems
- To introduce the concepts inspired by the human immune system and their application in problem-solving and optimization

Course Outcomes:

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

CO1: Understand Computational Intelligence techniques to solve real-life problems

CO2: Apply fuzzy logic techniques to solve real life problems

CO3: Design and implement evolutionary algorithms to solve optimization problem

CO4: Analyze and evaluate the performance of genetic algorithms in terms of convergence and computational efficiency

CO5: Interpret and analyze the results obtained from computational intelligence models in NLP, providing meaningful insights and recommendations

CO6: Design and Develop Artificial Immune System to solve complex problems

Course Contents		
Unit I	**Introduction To Computational Intelligence**	**06 Hours**
Introduction to Computational Intelligence, Paradigms of Computational Intelligence, Difference between Artificial Intelligence and Computational Intelligence, Approaches to Computational Intelligence, Synergies of Computational Intelligence Techniques, Applications of Computational Intelligence, Grand Challenges of Computational Intelligence		
#Exemplar/Case Studies	Study of Intelligent Waste Classification System using Computational Intelligence	
*Mapping of Course Outcomes for Unit I	CO1	
Unit II	**Fuzzy Logic**	**06 Hours**
Introduction to Fuzzy Set- Introduction, definition, membership Function, Fuzzy operator, Fuzzy Set Characteristics, Fuzziness and Probability. **Fuzzy Logic and Reasoning**–Fuzzy Logic: Linguistics Variables and Hedges, Fuzzy Rules. Fuzzy Inferencing: neuro inferencing Fuzzification, Defuzzification **Fuzzy logic Controllers**: Fuzzy logic Controllers, Fuzzy logic Controller Types		

#Exemplar/Case Studies	Study of Object Detection Robot Using Fuzzy Logic Controller
*Mapping of Course Outcomes for Unit II	CO2

Unit III	Evolutionary Computing		06 Hours

Introduction, Evolutionary Computing, Terminologies of Evolutionary Computing, Genetic Operators, Evolutionary Algorithms: - Genetic Algorithm, Evolution Strategies, Evolutionary Programming, Genetic Programming, Performance Measures of EA, Evolutionary Computation versus Classical Optimization.
Advanced Topics: Constraint Handling, Multi-objective Optimization, Dynamic Environments
Swarm Intelligence: Ant Colony Optimization

#Exemplar/Case Studies	Study of Engineering application of Artificial humming bird algorithm
*Mapping of Course Outcomes for Unit III	CO3

Unit IV	Genetic Algorithm		07 Hours

Introduction to Basic Terminologies in Genetic Algorithm: Individuals, Population, Search space, Genes, Fitness function, Chromosome, Trait, Allele, Genotype and Phenotype.
GA Requirements and representation- Binary Representations, Floating-Point Representations
Operators in Genetic Algorithm: Initialization, Selection, Crossover (Recombination), Mutation; fitness score, Stopping Condition, reproduction for GA Flow, Constraints in Genetic Algorithms.
Genetic Algorithm Variants: Canonical Genetic Algorithm (Holland Classifier System), Messy Genetic Algorithms, Applications, and benefits of Genetic Algorithms**.**

#Exemplar/Case Studies	Use Genetic Algorithm to design a solution to the Traveling Salesman Problem. **Solution**:1. Use Permutation Encoding 2. DefineObjective Function. 3. Apply Selection Method 4. Crossover 5. Mutation 6. Repeat Until stopping criteria is met. 7.Stop
*Mapping of Course Outcomes for Unit IV	CO4

Unit V	Computational Intelligence and NLP		06 Hours

Introduction, Word embedding Techniques-Bag of Words, TF-IDF,Word2Vec, Glove, Neural word embedding, Neural Machine Translation, Seq2Seq and Neural Machine Translation, translation Metrics (BLEU Score & BERT Score) , Traditional Versus Neural Metrics for Machine Translation Evaluation, Neural Style Transfer, Pertained NLP BERT Model and its application

#Exemplar/Case Studies	1) Study of Patient Triage using ChatGPT which can be utilized by physicians for expedited diagnoses. 2) Study of Question Answering System with BERT
*Mapping of Course Outcomes for Unit V	CO5

Unit VI	Artificial Immune Systems		06 Hours

Natural Immune System, Artificial Immune Models, Artificial Immune System Algorithm, Classical View Models, Clonal Selection Theory Model, Network Theory Model, Danger Theory Model, Dendritic cell Model, Applications of AIS models

#Exemplar/Case Studies	Study of an artificial immune system with bootstrap sampling for the diagnosis of recurrent endometrial cancers

*Mapping of Course Outcomes for Unit VI	CO6

Learning Resources

Text Books:

1. Computational Intelligence an introduction, (second edition) Andreis P. Engelbrecht, Wiley publication
2. Computational Intelligence, Synergies of Fuzzy logic, Neural Networks and Evolutionary computing, Nazmul Siddique, Hojjat Adeli, Wiley publication
3. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis & Applications, S. Rajasekaran, G. A. Vijayalakshami, PHI, 2007

Reference Books:

1. Seyedali Mirjalili, ―Evolutionary Algorithms and Neural Networks Theory and Applications, Studies in Computational Intelligence‖, Vol 780, Springer, 2019, ISBN 978-3-319-93024-4Press, 1998
2. Computational Intelligence in Medical Decision Making and Diagnosis Techniques and Applications, Edited By Sitendra Tamrakar, Shruti Bhargava Choubey, Abhishek Choubey, CRC Press ,2023
3. An Introduction to Genetic Algorithms, Melanie Mitchell, MIT Press, 2000.
4. Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation, James M. Keller, Derong Liu, David B. Fogel, John Wiley & Sons, 13-Jul-2016
5. Getting Started with Google BERT, Build and train state-of-the-art natural language processing models using BERT, Sudharsan Ravichandiran, Packt Publishing, 2021, ISBN 9781838826239.
6. An Introduction to Genetic Algorithms, Mitchell Melanie, The MIT Press Cambridge, Massachusetts, Fifth printing, 1999 First MIT Press paperback edition, 1998
7. Nature-Inspired Metaheuristic Algorithms, Xin-She Yang, Second Edition, University of Cambridge, United KingdomLuniver Press

MOOC Courses:

1. https://nptel.ac.in/courses/108104157
2. https://youtu.be/xwUKQcT1bKc
3. https://onlinecourses.nptel.ac.in/noc21_me43/preview
4. https://nptel.ac.in/courses/112105235
5. https://nptel.ac.in/courses/106105173
6. https://nptel.ac.in/courses/106106211

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	-	-	-	-	-	-	-	-
CO2	3	2	2	2	1	-	-	-	-	-	-	-
CO3	2	2	3	2	-	-	-	-	-	-	-	-
CO4	2	3	3	2	-	-	-	-	-	-	-	-
CO5	2	2	2	2	1	1	-	-	-	1	-	1
CO6	2	2	3	2	1	1	-	-	-	-	-	1