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| IQRA University (IU) | | |
| Faculty of Engineering Sciences and Technology (FEST) | | |
| Computer Science (CS) | | |
| Course Code | Course Name | Credit Hr |
| **AIC322** | **ARTIFICIAL NEURAL NETWORK** | **3+1** |

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| 1. Basic Information | | | |
| Instructor | DR. DUR E JABEEN | Designation | Associate Professor |
| Prerequisite(s) | None | Semester | Fall 2024 |
| Email | [Dr.jabeen@iqra.edu.pk](mailto:Dr.jabeen@iqra.edu.pk) | Phone | -- |
| Consulting Hours | 08:30 to 16:30 | Office Location | 1st floor |

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| 1. **Course Objective(s)** |
| This course will introduce Artificial Neural Networks and Deep Learning. ANN’s basic architecture and how they mimic the human brain using simple mathematical models. Many of the important concepts and techniques around brain computing and the major types of ANN will also be introduced. Emphasis is made on the mathematical models, understanding learning laws, selecting activation functions and how to train the networks to solve classification problems. Deep neural networks have achieved state of the art performance on several computer vision and speech recognition benchmarks. This course will further build on the fundamentals of Neural networks and artificial intelligence and will introduce advanced topics in neural networks, convolutional and recurrent network structures, deep unsupervised and reinforcement learning. |

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| 1. **Course Contents** |
| Introduction and history of neural networks, Basic architecture of neural networks, Perceptron and Adaline (Minimum Error Learning) for classification. Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Selected topics from: Gradient descent (Delta) rule, Hebbian, Neo-Hebbian and Differential Hebbian Learning, Drive Reinforcement Theory, Kohonen Self Organizing Maps, Associative memory, Bi-directional associative memory (BAM), Energy surfaces, The Boltzmann machines, Backpropagation Networks, Feedforward Networks; Theory of Generalization; Multi-layer perceptrons, error backpropagation; Deep convolutional networks, Computational complexity of feed forward and deep convolutional neural networks; Unsupervised deep learning including auto-encoders; Deep belief networks; Restricted Boltzman Machines; Deep Recurrent Neural Networks (BPTT, LSTM, etc.); GPU programming for deep learning CuDNN; Generative adversarial networks (GANs); Sparse coding and auto-encoders; Data augmentation, elastic distortions, data normalization; Mitigating overfitting with dropout, batch normalization, dropconnect; Novel architectures, ResNet, GoogleNet, etc. |

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| 1. **Course Learning Outcomes** | | | | | | |
| **CLOs** | **CLO Statement** | **BT Level** | **Mapping** | | | **% Weight** |
| **GAs** | **ACM KA** | **SGDs** |
| CLO1 | **Design** neural network architectures and deep learning models to address classification, optimization, and computational challenges effectively. | C6 | GA4 | #9  AR | 4 | 32% |
| CLO2 | **Apply** neural networks and deep learning algorithms to solve classification and complex real-world problems. | C3 | GA5 | 34% |
| CLO3 | **Analyze** results from deep learning to select appropriate solutions. | C4 | GA3 | 34% |
| ***Note: On successful completion of course, GA 1 (Academic Education) will automatically attain.*** | | | | | | |

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| 1. **Course Textbook / Reference Books and Supplementary Reading Material** | | | |
| **S No** | **Book Title** | **Author(s)** | **Edition/ publication year/publisher** |
| 1 | Neural Network Design | Martin T. Hagan, Howard, B. Demuth, Mark Hudson Beale and Orlando De Jesus | 2nd Edition, Publisher: Martin Hagan; (September 1, 2014), ISBN-10: 0971732116 |
| 2 | An Introduction to Neural Networks | James A Anderson | Publisher: A Bradford Book (March 16, 1995), ISBN-10: 0262011441 |
| 3 | Neural Networks and Learning Machines | S. Haykin, | 3rd Ed., Pearson Education, 2009, ISBN139780131293762 ISBN10 0131293761 |

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| 1. **CLO Outcome Based Assessment (OBA)** | | | | | | |
| **Assessment Tool** | | **CLO Mapped** | **CLO Marks** | **% Weight** | **Total Marks** | **Assessment Date** |
| **Quizzes**  **10** | Quiz #1 | CLO1 | 3 | 30% | 3 | 20/11/2024 |
| Quiz #2 | CLO2 | 3 | 30% | 3 | 11/12/2024 |
| Quiz #3 | CLO3 | 4 | 40% | 4 | 08/01/2025 |
| **Total Quizzes %** | | | **100%** | **10** |  |
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| **Assignments**  **15** | Assignment #1 | CLO1 | 7 | 46.67% | 7 | 06/11/2024 |
| Assignment #2 | CLO2 | 8 | 53.33% | 8 | 13/11/2024 |
|  | **Total assignment %** | | | **100%** | **15** |  |
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| **Midterm**  **25** | Midterm Q1 | CLO1 | 12 | 48% | 12 | 27/11/24 |
| Midterm Q2 | CLO2 | 13 | 52% | 13 | 27/11/24 |
|  | **Total Midterm %** | | | 100% | **25** |  |
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| **Project/CCP**  **10** | Project/CCP | CLO3 | **10** | **100%** | **10** | 06/12/2024 |
|  | **Total Project /CCP %** | | | **100%** |  |  |
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| **Final Exam**  **40** | Final Exam Q1 | CLO1 | 10 | 25% | 10 |  |
| Final Exam Q2 | CLO2 | 10 | 25% | 10 |  |
| Final Exam Q3 | CLO3 | 20 | 50% | 20 |  |
|  | **Total Final Exam %** | | | **100%** | **40** |  |
| **100** | **Total Marls** | | | | **100** |  |
| ***Note: Please make sure every CLO must be assessed at least 3 time.*** | | | | | | |

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| 1. **Weekly Plan** | | | | |
| **Week** | **Lecture No** | **Topic Covered** | **CLO** | **Assessment Tool** |
| 1 | 1 | Biological motivation and The Human Brain. | **CLO/1/2/3** | **Quiz1** |
| 2 | Historical remarks on artificial neural networks. |  |  |
| 3 | Applications of artificial neural networks. A taxonomy of artificial neural network models and learning algorithms. |  |  |
| 2 | 4 | General artificial neuron model or Models of a Neuron, |  | **Mid 1** |
| 5 | Discrete valued perceptron model, threshold logic and their limitations. |  |  |
| 6 | Hebb's rule. Connection weight matrix as an outer product of memory patterns. |  |  |
| 3 | 7 | Types of learning: Error-Correction Learning and Memory-Based Learning |  |  |
| 7 | Hebbian Learning, Differential Hebbian Learning |  | **A 1** |
| 9 | Step-by-Step Working of an Artificial Neural Network, Mathematical Models of Hebbian Modifications |  |  |
| 4 | 10 | Hamming, Hopfield networks and learning rules |  |  |
| 11 | Boltzmann Learning and Boltzmann Machine |  |  |
| 12 | Gradient descent: Learning with and without a Teacher |  |  |
| 5 | 13 | Unsupervised Learning, Unsupervised deep learning including auto-encoders |  | **Mid 1** |
| 14 | Typical Problem Areas / Learning Tasks: Pattern Association and Function Approximation |  |  |
| 15 | Reinforcement Learning/Neurodynamic Programming |  |  |
| 6 | 16 | Supervised learning. |  |  |
| 17 | Perceptron learning algorithm. |  |  |
| 18 | Learning Tasks: Memory, and Correlation Matrix Memory and Adaptation |  | **CCP** |
| **7** | 19 | Feedforward Networks, Backpropagation Networks and learning |  |  |
|  | 20 | Recurrent Networks and Training Data or Training Sample, Adaptive linear element. Supervised learning as output error minimization problem. |  |  |
|  | 21 | **Project/ CCP assignment** |  |  |
| **8** | **Midterm Exam** | | | |
| 9 | 22 | Knowledge Representation |  |  |
| 23 | Knowledge Representation types and applications |  | **Quiz2** |
| 24 | Design of a Neural Network for Character Recognition and Rules for Knowledge Representation |  |  |
| 10 | 25 | Gradient descent algorithm for minimization. Least mean square rule. |  |  |
| 26 | Adaptive Filtering Problem, Linear Least-Squares Filter |  |  |
| 27 | Wiener Filter: limiting form of the Linear Least-Squares Filter for an Ergodic Environment |  | **Quiz3** |
| 11 | 28 | Least-Mean-Square Algorithm |  |  |
| 29 | Signal-Flow Graph Representation of the LMS Algorithm |  |  |
| 30 | Learning Curves, Perceptron, Perceptron Convergence Theorem |  |  |
| 12 | 31 | Feature Detection , Relation to Fisher's Linear Discriminant |  |  |
| 32 | Convolutional Networks |  |  |
| 33 | Matrix Multiplication, Structural Constraints |  |  |
| 13 | 34 | Deep Recurrent Neural Networks |  |  |
| 35 | LSTM |  |  |
| 36 | GRU |  |  |
| 14 | 37 | GPU programming for deep learning CuDNN |  |  |
| 38 | Generative adversarial networks (GANs) |  |  |
| 49 | Sparse coding and auto-encoders |  |  |
| 15 | 40 | Data augmentation, elastic distortions, data normalization, Mitigating overfitting with dropout, batch normalization, dropconnect; |  |  |
| 41 | Novel architectures, ResNet, GoogleNet |  |  |
| 42 | **Assessment CCP / Project** |  |  |
| **16** | **Final Exam** | | | |

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| 1. **IU Assessment / grading Policy** | **Instructor grading for course \*** |
| Quizzes 10-15%  Assignments 10-15%  Projects/Presentation/CCP 0-10%  Mid Semester Examination/ 20-30%  End Semester Examination 40-50% | 10  15  10  25  40 |