MODULE DESCRIPTION FORM

نموذج وصف المادة الدراسية

| **Module Information**  **معلومات المادة الدراسية** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Module Title** | Artificial Neural Networks | | | | **Module Delivery** | | |
| **Module Type** | Core | | | | * **☒ Theory** * **☐ Lecture** * **☒ Lab** * **☐ Tutorial** * **☐ Practical** * **☐ Seminar** | | |
| **Module Code** | BID412 | | | |
| **ECTS Credits** | 5.00 | | | |
| **SWL (hr/sem)** | 125 | | | |
| **Module Level** | | UGx11 4 | **Semester of Delivery** | | | | 7 |
| **Administering Department** | | BID | **College** | BMIC | | | |
| **Module Leader** | Ahmed Oday Ezzat | | **e-mail** | Ahmed.oday@uoitc.edu.iq | | | |
| **Module Leader’s Acad. Title** | | Asst.Lect | **Module Leader’s Qualification** | | | | Master |
| **Module Tutor** |  | | **e-mail** |  | | | |
| **Peer Reviewer Name** | | omar A.M | **e-mail** | omara.m@uoitc.edu.iq | | | |
| **Scientific Committee Approval Date** | | 18/6/2023 | **Version Number** | | |  | |

| **Relation with other Modules**  **العلاقة مع المواد الدراسية الأخرى** | | | |
| --- | --- | --- | --- |
| **Prerequisite module** | Artificial Intelligence / BMI311 | **Semester** | 6 |
| **Co-requisites module** | None | **Semester** |  |

| **Module Aims, Learning Outcomes and Indicative Contents**  **أهداف المادة الدراسية ونتائج التعلم والمحتويات الإرشادية** | |
| --- | --- |
| **Module Objectives**  **أهداف المادة الدراسية** | Upon successfully completing the course, the student will be able to:  • Understand generic machine learning terminology  • Understand motivation and functioning of the most common types of deep neural networks  • Understand the choices and limitations of a model for a given setting  • Apply deep learning techniques to practical problems  • Critically evaluate model performance and interpret results  • Write reports in which results are assessed and summarized in relation to aims, methods and available data |
| **Module Learning Outcomes**  **مخرجات التعلم للمادة الدراسية** | Learning outcomes for a module on Artificial Neural Networks may vary depending on the specific course or educational institution. However, here are some common learning outcomes that can be expected from such a module:   1. Understanding Neural Networks: Students should be able to explain the basic concepts and principles of artificial neural networks, including the structure of a neuron, activation functions, and the feedforward and backpropagation algorithms. 2. Network Architectures: Students should be familiar with various network architectures, such as feedforward neural networks, convolutional neural networks (CNNs), recurrent neural networks (RNNs), and deep neural networks (DNNs). They should understand the purpose and characteristics of each architecture. 3. Training Neural Networks: Students should be able to train neural networks using various optimization algorithms, such as gradient descent and its variants (e.g., stochastic gradient descent, mini-batch gradient descent), and understand the impact of hyperparameters on training. 4. Backpropagation: Students should understand the backpropagation algorithm and its role in updating the weights and biases of neural networks during training. They should be able to perform backpropagation manually for simple network architectures. 5. Activation Functions: Students should know about different types of activation functions, such as sigmoid, ReLU, and tanh, and understand their properties, advantages, and limitations. They should be able to select appropriate activation functions for different network layers. 6. Overfitting and Regularization: Students should be aware of the problem of overfitting in neural networks and understand techniques to mitigate it, such as regularization methods (e.g., L1 and L2 regularization), dropout, and early stopping. 7. Convolutional Neural Networks: Students should have a good understanding of CNNs, including convolutional layers, pooling layers, and how they are used for tasks like image classification and object detection. 8. Recurrent Neural Networks: Students should be familiar with RNNs and their ability to process sequential data. They should understand concepts like recurrent layers, long short-term memory (LSTM), and applications of RNNs in natural language processing and time series analysis. 9. Transfer Learning: Students should be aware of the concept of transfer learning and its practical applications in leveraging pre-trained neural network models for new tasks. 10. Evaluation and Performance Metrics: Students should know how to evaluate the performance of neural network models using metrics such as accuracy, precision, recall, and F1 score. They should understand the concepts of validation and test sets and be able to interpret evaluation results. 11. Practical Implementation: Students should gain hands-on experience in implementing neural networks using a programming language and a deep learning framework (e.g., TensorFlow, PyTorch). They should be able to build, train, and evaluate neural network models for various tasks. 12. Ethical and Social Implications: Students should be aware of the ethical considerations and potential biases associated with the use of neural networks. They should understand the societal impact of artificial intelligence and be able to discuss ethical issues related to data privacy, fairness, and accountability.   These learning outcomes provide a broad overview of what students can expect to achieve after completing a module on Artificial Neural Networks. The specific details and depth of coverage may vary depending on the level and focus of the course. |
| **Indicative Contents**  **المحتويات الإرشادية** | The indicative contents of a module on Artificial Neural Networks may vary depending on the level and scope of the course. However, here are some typical topics that might be covered:  1. Introduction to Artificial Neural Networks  - Historical overview and basic concepts  - Biological inspiration and neuron model  2. Perceptron and Feedforward Neural Networks  - Perceptron learning algorithm  - Multilayer perceptron (MLP) architecture  - Activation functions and their properties  - Forward propagation and output calculation  3. Backpropagation Algorithm  - Derivation of backpropagation equations  - Weight and bias updates  - Gradient descent optimization  - Training convergence and stopping criteria  4. Deep Neural Networks (DNNs)  - Introduction to deep learning  - Deep architectures and layer types  - Vanishing and exploding gradients  - Initialization strategies  5. Convolutional Neural Networks (CNNs)  - Convolutional layers and filters  - Pooling layers and downsampling  - Convolutional arithmetic and receptive fields  - Architectures for image classification and object detection  6. Recurrent Neural Networks (RNNs)  - Recurrent layers and memory cells  - Long Short-Term Memory (LSTM) networks  - Training and prediction in sequential data  - Applications in natural language processing and time series analysis  7. Training Techniques and Optimization  - Stochastic Gradient Descent (SGD) and its variants  - Learning rate schedules and adaptive optimization methods  - Regularization techniques (e.g., L1 and L2 regularization, dropout)  - Batch normalization and weight decay  8. Transfer Learning and Pre-trained Models  - Transfer learning concepts and applications  - Fine-tuning and feature extraction  - Pre-trained models and model zoos  - Domain adaptation and generalization  9. Evaluation and Performance Metrics  - Training, validation, and test sets  - Classification accuracy, precision, recall, and F1 score  - Confusion matrix and ROC curves  - Cross-validation and model selection  10. Practical Implementation and Deep Learning Frameworks  - Introduction to deep learning frameworks (e.g., TensorFlow, PyTorch)  - Building and training neural network models using a framework  - Hyperparameter tuning and model optimization  - Debugging and troubleshooting common issues  11. Advanced Topics in Neural Networks  - Generative Adversarial Networks (GANs)  - Reinforcement Learning with neural networks  - Autoencoders and dimensionality reduction  - Attention mechanisms and Transformer networks  12. Ethical and Social Implications  - Bias and fairness in neural networks  - Privacy and security concerns  - Explainability and interpretability  - Responsible AI practices and guidelines  These indicative contents provide a general overview of the topics that may be covered in a module on Artificial Neural Networks. The actual content and depth of coverage can vary depending on the specific course and its objectives. |

| **Learning and Teaching Strategies**  **استراتيجيات التعلم والتعليم** | |
| --- | --- |
| **Strategies** | Network Architecture Design: Carefully design the structure of the neural network, including the number of layers, neurons per layer, and connectivity pattern, to suit the problem at hand. Activation Function Selection: Choose appropriate activation functions for different layers to introduce non-linearity and control the flow of signals within the network. Weight Initialization: Initialize the weights of the neural network properly to avoid issues like vanishing or exploding gradients during training. Regularization Techniques: Apply regularization methods like L1 and L2 regularization, dropout, and batch normalization to prevent overfitting and improve generalization. Optimization Algorithms: Select suitable optimization algorithms (e.g., stochastic gradient descent, Adam) to train the network efficiently and improve convergence. |

| **Student Workload (SWL)**  **الحمل الدراسي للطالب محسوب لـ ١٥ اسبوعا** | | | |
| --- | --- | --- | --- |
| **Structured SWL (h/sem)**  **الحمل الدراسي المنتظم للطالب خلال الفصل** | 64 | **Structured SWL (h/w)**  **الحمل الدراسي المنتظم للطالب أسبوعيا** | 4 |
| **Unstructured SWL (h/sem)**  **الحمل الدراسي غير المنتظم للطالب خلال الفصل** | 61 | **Unstructured SWL (h/w)**  **الحمل الدراسي غير المنتظم للطالب أسبوعيا** | 4 |
| **Total SWL (h/sem)**  **الحمل الدراسي الكلي للطالب خلال الفصل** | **125** | | |

| **Module Evaluation**  **تقييم المادة الدراسية** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **As** | | **Time/Number** | **Weight (Marks)** | **Week Due** | **Relevant Learning Outcome** |
| **Formative assessment** | **Quizzes** | 2 | 10% (10) | 5 and 10 | LO #1, #2 and #10, #11 |
| **Assignments** | 2 | 10% (10) | 2 and 12 | LO #3, #4 and #6, #7 |
| **Projects / Lab.** | 1 | 10% (10) | Continuous | All |
| **Report** | 1 | 10% (10) | 13 | LO #5, #8 and #10 |
| **Summative assessment** | **Midterm Exam** | 2hr | 10% (10) | 7 | LO #1 - #7 |
| **Final Exam** | 3hr | 50% (50) | 16 | All |
| **Total assessment** | | | 100% (100 Marks) |  |  |

| **Delivery Plan (Weekly Syllabus)**  **المنهاج الاسبوعي النظري** | |
| --- | --- |
| **Week** | **Material Covered** |
| **Week 1** | Intro to machine learning and neural networks: supervised learning, linear models for regression, basic neural network structure, simple examples and motivation for deep networks. |
| **Week 2** | Perceptron and Feedforward Neural Networks |
| **Week 3** | Backpropagation Algorithm |
| **Week 4** | Weight initialization strategies |
| **Week 5** | Artificial neural network (ANN) |
| **Week 6** | Recurrent Neural Networks (RNNs) |
| **Week 7** | Optimization Algorithms |
| **Week 8** | Learning rate schedules and adaptive optimization methods |
| **Week 9** | Regularization techniques (L1 and L2 regularization, dropout) |
| **Week 10** | Training Techniques and Best Practices |
| **Week 11** | Data preprocessing and normalization |
| **Week 12** | Hyperparameter tuning and model selection |
| **Week 13** | Model evaluation and performance metrics |
| **Week 14** | Advanced Architectures and Techniques |
| **Week 15** | Final Exam |

| **Delivery Plan (Weekly Lab. Syllabus)**  **المنهاج الاسبوعي للمختبر** | |
| --- | --- |
| **Week** | **Material Covered** |
| **Week 1-2** | intro to tensorflow, simple ML examples. (2 sessions) Maybe include exercises for a small assignment to be handed |
| **Week 3-4** | neural networks. Exercises on NNs, solving a problem with NNs on tensorflow |
| **Week 5-6** |  |
| **Week 7-8** | Mid - First Exam and optimization methods |
| **Week 9-10** | Model evaluation and performance metrics |
| **Week 11-12** | Advanced Architectures and Techniques |
| **Week 13-14** | Hyperparameter tuning and model selection |
| **Week 15** | Second Exam |

| **Learning and Teaching Resources**  **مصادر التعلم والتدريس** | | |
| --- | --- | --- |
|  | **Text** | **Available in the Library?** |
| **Required Texts** | LeCun, Y., Bengio, Y., Hinton, G. (2015). Deep Learning. Nature, 521, 436-444. | No |
| **Recommended Texts** | Byrnes, P. G., and DiazDelaO, F. A. (2017). Reliability Based Bayesian Inference for Probabilistic Classification: An Overview of Sampling Schemes. In International Conference on Innovative Techniques and Applications of Artificial Intelligence | No |

| **Grading Scheme**  **مخطط الدرجات** | | | | |
| --- | --- | --- | --- | --- |
| **Group** | **Grade** | **التقدير** | **Marks %** | **Definition** |
| **Success Group**  **(50 - 100)** | **A -** Excellent | **امتياز** | 90 - 100 | Outstanding Performance |
| **B -** Very Good | **جيد جدا** | 80 - 89 | Above average with some errors |
| **C -** Good | **جيد** | 70 - 79 | Sound work with notable errors |
| **D -** Satisfactory | **متوسط** | 60 - 69 | Fair but with major shortcomings |
| **E -** Sufficient | **مقبول** | 50 - 59 | Work meets minimum criteria |
| **Fail Group**  **(0 – 49)** | **FX –** Fail | **راسب (قيد المعالجة)** | (45-49) | More work required but credit awarded |
| **F –** Fail | **راسب** | (0-44) | Considerable amount of work required |
|  |  |  |  |  |
| **Note:** Marks Decimal places above or below 0.5 will be rounded to the higher or lower full mark (for example a mark of 54.5 will be rounded to 55, whereas a mark of 54.4 will be rounded to 54. The University has a policy NOT to condone "near-pass fails" so the only adjustment to marks awarded by the original marker(s) will be the automatic rounding outlined above. | | | | |