Academic Year 2021/22

ASSIGNMENT/COURSEWORK PROFORMA

Module code:	**Assessment title:**	**Module tutors:**
ME3624	Introduction to AI Applications in Engineering	Dr QingPing Yang Dr Mingfeng Wang

Main objectives of the assessment:

- To gain an in-depth knowledge of basic theory, principles and techniques in modern artificial intelligence and robotics.
- To develop capabilities and skills in developing AI and robotic solutions for practical engineering problems.
- To understand and evaluate AI and robotic applications in engineering.

Brief Description of the assessment:

You will select from a list of project topics related to the applications of AI (including machine learning and robotics) as a group project (groups of 4-6 students). You will carry out the literature review about the state-of-the-art methods and performance, develop your own design (including algorithms and software programs), implement and test with experiments (and/or simulations) and evaluations.

Learning outcomes for the assessment (refer to the appropriate module learning outcomes)

Students will be able to demonstrate the following:

- To gain good understanding of basic concepts, principles and techniques of unsupervised learning, supervised learning and deep learning.
- To gain good understanding of basic principles of robotics, robot motion control and their applications.
- To critically analyse AI solutions based on unsupervised learning, supervised learning and deep learning.
- To develop AI solutions to practical problems in engineering using unsupervised learning, supervised learning, deep learning and robotics.
- To select and develop AI algorithms and programmes.
- To develop critical awareness of wider implications of AI.
- Practical use and evaluation of AI in engineering.
- Group work, technical presentation, report writing, time management.

Assessment criteria:

1. Group presentation (30%)
2. Group report (70%)

2.1 The technical quality of the work (40%)

2.2 Originality (20%)

2.3 Demonstration (20%)

2.4 Communication (20%)

The final mark of each students is calculated according to both the group mark and the individual contributions.

Assessment method by which a student can demonstrate the learning outcomes:

Literature review of the existing methods, techniques and performance. Design of algorithms and/or experiments. Implementation results and performance; including Matlab programs, demonstration, presentation and report.

Weighting:

20% of module marks

Format of the assessment/coursework: (Guidelines on the expected format and length of submission): **Note: full reports may <u>not</u> exceed 30 pages (including appendices)*

Format is a formal written report including diagrams/code, theory, experiments, results and discussion/ comments. Report to be written using Word in a 12 point font. Typical length of report is 3000 words, comprising Title Page; Introduction; Literature review; Design and Implementation; Results and Discussions, Conclusions and References. The report should identify the contributions of each group member.

Assessment date/<u>submission deadline</u>:

Please submit by *Wednesday 30th March 2022* via WISEflow

Indicative reading list:

- Alpaydin, Ethem. Introduction to Machine Learning. MIT Press, 2014. ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/brunelu/detail.action?docID=3339851.
- Burkov, Andriy. The Hundred-Page Machine Learning Book. Quebec City, Andriy Burkov, 2019. Draft: http://ema.cri-info.cm/wp-content/uploads/2019/07/2019BurkovTheHundred-pageMachineLearning.pdf
- Bishop, C.M., 2006. Pattern recognition and Machine learning. New York: Springer. ISBN: 9781493938438. Q327.B57 2006. https://www.microsoft.com/en-us/research/uploads/prod/2006/01/Bishop-Pattern-Recognition-and-Machine-Learning-2006.pdf
- Russell, Stuart, and Peter Norvig. Artificial Intelligence: a Modern Approach, EBook, Global Edition, Pearson Education, Limited, 2021. ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/brunelu/detail.action?docID=6563568
- Theobald, Oliver. Machine Learning for Absolute Beginners: A Plain English Introduction (Third Edition). Scatterplot Press, 2021. 2nd Edition: https://bmansoori.ir/book/Machine%20Learning%20For%20Absolute%20Beginners.pdf
- Craig, John J.. Introduction to Robotics: Mechanics and Control, Pearson Education UK, 2013. https://ebookcentral.proquest.com/lib/brunelu/detail.action?docID=5137593.
- Bartneck, Christoph, et al. Human-robot interaction: An introduction. Cambridge University Press, 2020. https://ir.canterbury.ac.nz/handle/10092/17049, https://learning.edx.org/course/course-v1:UCx+HRI01.1ucX+3T2021/home
- Spong, Mark W., et al. Robot modeling and control. John Wiley & Sons, 2020. Online source: https://www.vlebooks.com/Product/Index/2214347?page=0.
- Siciliano B., Khatib O., Torsten K., eds. Springer Handbook of Robotics (2nd Ed). Vol. 200. Berlin: springer, 2016. http://handbookofrobotics.org/.
  Murphy, Robin R. Introduction to AI robotics. MIT press, 2019. https://people.engr.tamu.edu/robin.r.murphy/IAIR2/IAIR2.html; http://index-of.es/z0ro-Repository-2/Cyber/02 - Electronic Engineering/An Introduction to AI Robotics - Robin Murphy.pdf.

Other information

Use your student ids for anonymity (i.e. no student names on the assignment itself).

Group Project Topics

Project 1: Automated fabric defect detection

Acoustic panels are increasingly used to improve the sound quality of buildings. However, the current production of acoustic panels is largely manual. One of the important needs in the automation of acoustic panel manufacturing is to automatically detect defects/faults of the fabrics used for covering acoustic panels. This project aims to develop an automated fabric fault detection system using the state-of-the-art AI solution, as a part of the KTP project funded by the UK Government. You will be working closely with other researchers and engineers during this project.

Project 2: Hand gesture recognition

Hand gesture recognition is receiving increasing attention in research since it has wide potential applications in human-computer interactions and collaborative robotics. This project aims to develop a demonstrator for accurate and robust online recognition of static and temporal hand gestures. The project tasks include critical literature review of the field, identification of suitable hand gesture datasets, development and validation of the deep learning models, and experimental test and evaluation.

Project 3: Handwriting recognition

Handwriting recognition has many potential applications and can also be used to test and benchmark different deep learning algorithms. The project aims to develop a demonstrator for accurate recognition of handwritten texts (numbers, words, sentences and paragraphs). This project tasks include critical literature review, identification of suitable hand gesture datasets, development and validation of the AI models using CNN and RNN. The system should ideally have a text to speech interface. It will be tested and evaluated with experiments.

Project 4: AI applications in Covid-19 pandemic management

The ongoing Covid-19 pandemic has remained a global challenge and has so far caused more than 351 million cases and 5.59 million deaths, making it one of the deadliest in human history. AI can play an important role in the management of current and future pandemics. This project aims to demonstrate the successful application of AI in the management of Covid-19, e.g. for the prediction of the pandemic, diagnosis and prognosis of Covid-19. A critical review of the literature and the relevant datasets generated during the pandemic will be carried out to identify suitable AI applications. An AI demonstrator based on the chose data set(s) will developed and validated, with possible bias and interpretation issues of the AI models adequately considered.

Project 5: Object recognition and pick-and-place with a robot arm

Many pick-and-place robotic applications require a lengthy workflow: from computer vision and deep learning for object detection, motion planning and control, to simulation and deployment. This project aims to design a vision-driven pick-and-place application for a robot manipulator in MATLAB® and Simulink® environment, with given virtual working scenario.

Project 6: Ball balancing using a robot arm

The goal of the project is to design a controller that can balance a ping-pong ball on a flat surface attached to the end effector of the manipulator. In this project, you will need through how to use Reinforcement Learning Toolbox™ to create and train agents that can perform the ball balancing task while being robust to variabilities in the environment. At the end of the project, you will demonstrate how to create environments, represent agents through neural networks, and train the networks to satisfactory performance.

Project 7: Motion planning for a robotic arm

Motion planning plays a vital role in the field of robotics. Most of the recent motion planning algorithms are based on random sampling algorithms. More effective algorithms such as optimization-based, Probabilistic Movement Primitives (ProMPs)-based, and physics-based methods are feasible directions to explore to improve the effectiveness. In this project, given by randomly 5 trajectory points, you will demonstrate how to plan a fast route passing all these 5 points with consideration of physical limits of the robotic arm.

Project 8: Obstacle avoidance for a robotic arm

Obstacle avoidance is a very classic problem in robotics files. In this project, given the obstacles' location, size and shape, you will modulate a linear dynamical system for generating the robot trajectories that avoid the obstacles when moving towards a target. meanwhile, the generation of the robot trajectories from dynamical system can enable a rapid reconfiguration of the trajectories after perturbations.

Note:

1. Each project will allow a maximum of two groups.
2. You may also propose your own group project topic, but it needs to be agreed with at least one of the module tutors as the supervisor.