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**Department of Computer & Information Sciences**

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| **ASSESSMENT BRIEF - Product** | |
| **Module Title:** | **Artificial Intelligence and Robotics** |
| **Module Code:** | KF6007 |
| **Academic Year / Semester:** | 2023-24 / Semester 2 |
| **Module Tutor / Email (all queries):** | Alan Godfrey  alan.godfrey@northumbria.ac.uk |
| **% Weighting (to overall module):** | 60% |
| **Assessment Title:** | An Intelligent Interactive System |
| **Date of Handout to Students:** | Week 1, week beginning 29th January 2024 |
| **Mechanism for Handout:** | Module Blackboard Site |
| **Deadline for Attempt Submission by Students:** | Wednesday 15th May 2024 12:00 (noon) GMT |
| **Mechanism for Submission:** | Document upload to Module Blackboard Site |
| **Submission Format / Word Count** | Files upload to Module Blackboard Site  (Word count not applicable for product) |
| **Date by which Work, Feedback and Marks will be returned:** | 31st May 2024 |
| **Mechanism for return of Feedback and Marks:** | The mark and individual written feedback sheet will be uploaded to the Module Site on Blackboard. |

**LEARNING OUTCOMES**

The learning outcomes (LOs) for this module are:

**LO1**. Demonstrate knowledge and understanding of artificial intelligence techniques and robotics applications and identify state-of-the-art developments in the field.  
**LO2**. Appraise machine learning and robotics applications and intelligent processes using appropriate methods.  
**LO3**. Design and implement advanced artificial intelligence, robotics, and machine learning applications.  
**LO4**. Evaluate the effectiveness of implemented artificial intelligence applications, including using student developed methodologies where appropriate.   
**LO5**. Practise research skills in the construction of project reports and presentation of the products.

**This assessment addresses leaning outcomes:** LO1, LO2, LO3, LO4, and LO5

**Total assignment brief:**

The module will be assessed by a product (60%) and a report (40%).

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| Part 1 | Product | 60 marks |
| Part 2 | Report | 40 marks |
| Total |  | 100 marks |

**Additional Instructions to students:**

This is an individual assignment and must be your own unaided work.

**Referencing Style:**

Either Harvard or British Standard as long as the reference style is consistent.

**Expected size of the submission:**

2000-word report + appropriate software

**Academic Integrity Statement:** You must adhere to the university regulations on academic conduct. Formal inquiry proceedings will be instigated if there is any suspicion of plagiarism or any other form of misconduct in your work. Refer to the University’s Assessment Regulations for Northumbria Awards if you are unclear as to the meaning of these terms. The latest copy is available on the University website.

**Failure to submit:** Note that failure to submit work or submission of work after the required deadline without an authorised late approval will result in a record of incomplete (IC) for the assessment component. Referral in that component will then be required even when the module is passed overall.

# 1. General description

You are required to develop an interactive intelligent system in an application domain of your choice. You have learned several approaches for decision making that can be used in robotics, computer vision, games, and general Artificial Intelligence (AI) applications. For this assessment, you will be required to practise your skills in AI, robotics, and affective computing by producing a product that will include the following:

**1.1 An interactive user interface:**

* You are required to develop an interactive user interface. You may use any GUI development environment as the basic platform for your work e.g., PyQt5, TKinter or gaming engines such as Unity or Slick2D. If you have problems developing a sophisticated GUI, then a text or console-based user interface is also acceptable as long as you justify the development decisions made and it follows good UI design principles.

**1.2 A core AI component**

* To provide at least one AI agent that it is capable of learning from an environment and making decisions.
* To develop an autonomous agent behaviour that augments the decision making of other agents or a human user (e.g., in e-learning or healthcare applications), or in the case of a gaming an agent that opposes a human player effectively.

**1.3 Suggested extra AI features that may enhance your development:**

* Employ two machine learning approaches for decision-making. The chosen approaches should be able to effectively cooperate with each other to make decisions.
* Implement a complex rule-based inference or other probability-based decision-making component for robotics, affective computing, vision, bioinformatics, or game applications.
* Provide an advanced speech or gesture-based interaction.

**1.4 Approaches/examples to choose from for your implementation:**

* Rule-based Inference using expert systems,
* Fuzzy logic,
* Reinforcement Learning,
* Decision tree learning,
* Naive Bayes classifier,
* Neural networks (ANN’s, CNN’s).

From the list you should choose at least one machine learning method combined with an AI decision making method. Note: If you develop a basic rule-based expert system with a basic decision-making AI component, this will be considered a basic product and you should expect a passing mark (Please see the marking criteria in section 3).

**2. Assessment allocation**

Product (60%): The software product should be bug free and demonstrated in a suitable University lab. Video demos are also required to be included in your submission to illustrate your system’s best AI-related performances. You may implement the product using a programming language of your choice.

**Please note any code from the Internet should be referenced, so that your own contribution is clear.**

**3. Marking criteria**

**3.1 The product (60%)**

**0 – 39**

* The overall product is non-functional or has basic functionality (especially pertaining to the decision-making agent).
* The work does not implement an AI method or shows very limited functionalities on decision making. Or the implemented AI function is seriously misunderstood.
* The overall product does not compile or has significant flaws and/or run-time errors.

**40 – 49**

* A basic and limited user interface has been developed.
* The system has limited functionalities on decision making and is developed based on one machine learning approach only.
* There is an attempt at the development of an autonomous agent behaviour, or a very basic version (or a very simple behaviour tree) has been implemented.
* A very basic decision-making component is included.
* The overall product is stable and able to perform to a certain degree although there are some flaws.

Example products that may fall into this marking category are:

* A simple rule-based system with less than 20 rules.
* A simple fuzzy logic-based system with 1-3 fuzzy variable functions, with the implementation close to the sample code provided in the tutorial sessions.

**50 – 59**

* A reasonable user interface has been developed.
* The system has achieved reasonable functionalities on decision making, which has been developed based on one machine learning approach only.
* A reasonable autonomous agent behaviour component has been implemented.
* The overall product is stable and able to perform reasonably well although there are minor deficiencies or runtime errors.

Example products that may fall into this marking category are as follows.

* A reasonable implementation of a Naïve Bayes classifier (NBC), with successful deployment in a new domain (e.g., medical diagnosis).
* A complex rule-based reasoning system with a substantial number (e.g., 20+) of rules and forward and backward chaining to deal with complex decision-making.

**60 – 69**

* A reasonable to good user interface has been developed.
* The product provides good decision-making functionalities. Either it is developed based on one machine learning approach only and there is also an attempt to use more than one machine learning approach for development but there are obvious flaws in the second approach chosen. Or two simple AI approaches with basic complexity for decision making are implemented.
* A reasonable to good autonomous agent behaviour has been implemented.
* There are also attempts for the development of advanced AI features such as complex path finding, emotion detection, speech or gesture-based interaction, robotics applications, object recognition, team AI etc, but with limited success.
* The overall product is stable and able to perform reasonably well without runtime errors.

Example sample works that may fall in this marking category are as follows.

* Reasonable implementations of NBC and fuzzy logic, with some efforts in further development for the successful deployment in a new domain.
* The employment of NBC for two different decision-making tasks e.g., two implementations of NBC dedicated to two different decision-making tasks e.g., one for the diagnosis of a particular type of disease and the other for the identification of the severe level of that disease. Or two NBC methods with one for topic detection and the other for sentiment classification for online news.
* A Decision Tree Learning (DTL) algorithm classification system with substantial new coding development for the successful deployment in a new domain.
* A Reinforcement Learning agent that successfully learns to complete a goal.

**70 – 79**

* A very good user interface has been developed.
* The system has employed more than one machine learning approach with the development of significant decision-making functionalities.
* A well-behaved autonomous agent has been implemented.
* There are also attempts for the development of advanced AI features such as complex path finding, emotion detection, speech or gesture-based interaction, robotics, object recognition etc, with limited or reasonable success.
* The overall product is stable and able to perform very well without runtime errors.

Example sample works that may fall in this marking category are as follows.

* Two NN models are implemented for two classification tasks which show distinctive characteristics in nature. Each NN model is well implemented with a substantial number of training data (e.g., 150+). The NN implementation has been enriched with a substantial amount of self-developed code either for the NN mechanisms or for the related project context development (e.g., the extraction of training data from live systems). For instance, an environmental monitoring system with landslide and flooding predictions where two sets of distinctive environmental factors/features are considered and extracted for these two independent prediction tasks. Or a health monitoring system with heart disease detection and cancerous skin lesion classification where ECG signals and lesion images are extracted for these two distinctive classification tasks.
* A system incorporating a NN model, a NBC and a fuzzy logic function is implemented. Each function is well developed and enriched with a large amount of new coding development. The system can achieve an impressive accuracy rate. (This category is easily going into high end of 60s if the overall developments are still close to the lab samples provided.)
* A system incorporating a classification model (e.g., NN) with one of the following techniques i.e., a clustering method (e.g., K-means clustering), a regression model (e.g., linear regression), and a dimension reduction technique (e.g., Principal Component Analysis or Independent component analysis). Each component is well implemented with novel approaches. The system achieves reasonable or comparable accuracy rates in comparison with those of state-of-the-art related studies.
* A new or off-the-shelf complex deep learning model is implemented. It is either trained from scratch or deployed with a transfer learning process. The model employs existing data sets for evaluation and achieves reasonable accuracy rates. Please note with respect to transfer learning, the deep learning model has to be re-trained with a distinctive new task, different from those mentioned in existing popular online tutorial examples. Otherwise, marks will be deducted accordingly.
* The development and training of a Deep Reinforcement learning agent that performs a specific task in a stochastic environment. This could be parking a self-driving car or teaching an agent to evade capture from another agent.

**80+**

* An exceptional user interface has been developed.
* The system has employed more than one machine learning approaches with good or significant complexity for the development of advanced functionalities with respect to decision making.
* A well-behaved autonomous agent has been implemented.
* There are also attempts for the development of other advanced AI features such as complex path finding, emotion detection, speech or gesture-based interaction, robotics, object recognition, etc, with reasonable or great success.
* The overall product is stable and able to perform significantly well without runtime errors.

Example sample works that may fall in this marking category are as follows.

* Multiple NN models are implemented. Each NN model is well implemented with a substantial number of training data (e.g., 150+). The NN implementation has been enriched with a substantial amount of self-developed code either for the NN mechanisms or for the related project context development (e.g., the extraction of training data from live systems). As an example, multiple NN models are built and trained using different training samples. Then they are subsequently used to build an ensemble classification model to deal with a challenging multi-class classification problem to enhance performance.
* A system incorporating a complex newly proposed or off-the-shelf deep learning model with one or multiple shallow NN models. Each component is well implemented with novel approaches. The deep learning model is either trained from scratch or deployed with a transfer learning process. The overall system can be tested with both existing data sets and live deployment. The system achieves competitive accuracy rates in comparison with those of state-of-the-art related studies. Please note with respect to transfer learning, the deep learning model has to be re-trained with a distinctive new task, different from those mentioned in existing online tutorial examples. Otherwise, the marks will be deducted accordingly.
* This could be parking a self-driving car in a stochastic environment or teaching a team of agents to evade capture from another team of agents.