Module Introduction

CSIP5403 – Research Methods and AI Applications

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Overview

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Who am I?

Nathanael L. Baisa

- ▶ Lecturer in Artificial Intelligence.

- ▶ Enthusiastic about: AI for solving real-world computer vision problems.

- ▶ FYP, postgraduate & PhD supervisor.

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Course Structure

▶ **Lectures:** (1hr X 3) lectures time per week (mostly).

▶ **Labs:** (2hr X 2) x 3 practical labs per week (mostly).

    ➢ We use **Python** for practical labs.

    ➢ "Code-a-long" style to begin with.

    ➢ Prior to your first lab **download Python** (latest version).

        ➢ https://www.python.org/downloads/

    ➢ We can also use **Jupyter Notebook** on Google Colab (this will be explained in the lab).

▶ **Online Seminar:** ~2hrs on the last week of the module delivery (assessment week).

▶ Lecture materials will be uploaded at least **24hrs** before lecture.

▶ Listen, take notes, and participate in online discussions for the best results!

Learning Outcomes

▶ LO1: Critically appraise a given research method and justify its application to appropriate research problems. (Weekly Participation Exercises (WE), Coursework 1).

▶ LO2: Write a research proposal which demonstrates an understanding of the research process and its application to a given research problem (WE, Coursework 1).

▶ LO3: Critically review relevant literature to formulate a plan for their own practical/experimental work. (Coursework 2) → Applied AI.

▶ LO4: Identify and critically discuss professional, legal, managerial and ethical problems associated with the development and execution of a research project, to synthesise a solution to the problem and evaluate the solution. (WE, Coursework 1).

▶ LO5: Apply AI techniques to given practical problems, present results, and to recognise the multi-disciplinary nature of AI and its potential application areas. (WE, Coursework 2) → Applied AI.

Sessions

- ▶ Knowledge Representation (KR): KR Structures, Expert System, etc.

- ▶ Machine Learning: Supervised, Unsupervised and Reinforcement Learning

- ▶ Deep Learning: CNNs, RNNs, Transformers, etc.

- ▶ Computer Vision: 2D and 3D

- ▶ Generative AI and Its Applications

- ▶ Other Topics with focus on AI Applications

Assessment

▶ Assessment is done by **coursework** – a mini-project to be done in small groups (**maximum 3 members**). The deliverables of the mini-project are as follows:

  ➢ **Report** (70% of the overall module mark of **Applied AI** part) divided into:

    ➢ 10% for group part and

    ➢ 60% for individual part

  ➢ **Presentation** (30% of the overall module mark of **Applied AI** part) divided into:

    ➢ 10% for group part and

    ➢ 20% for individual presentation

▶ **Applied AI** part takes **50%** of the overall combined module mark.

▶ **Be aware of plagiarism and other academic offences.**

▶ **There is a page limit you MUST adhere to.**

Assessment

▶ Coursework will be released in **week 33** on **Monday 13th May 2024**.

▶ Report and Presentation slides:

➢ Submission deadline: **4th June 2024 (at 12 noon)**.

➢ Feedback: **25th June 2024**

Assessment

- **Unauthorised late submission of assessments:** [University regulations](University%20regulations).

  - **"**If an assessment is submitted later than the deadline without an approved extension or deferral the mark received will be capped.

  - If an assessment is submitted up to 24 hours past the deadline for submission, the mark for the work will be capped at the pass mark of 40 percent for undergraduate modules or 50 percent for postgraduate modules.

  - If an assessment is submitted more than 24 hours late the work will receive a mark of zero percent. The above applies to a student's first attempt at the assessment.

  - If work submitted as a reassessment of a previously failed assessment task is submitted later than the deadline the work will immediately be given a mark of zero percent.**"**

Tasks to be Undertaken:
AI Mini-Project

▶ The mini-project aims to take you through the steps of modelling and implementing AI algorithms / solutions to deliver an application or to solve a practical problem.

▶ You will work in a group of 2- 3 students.

▶ You may use this mini-project as a proof of concept (PoC) for final MSc project but several problems and topics will also be provided for those who may not have thought of a topic yet.

▶ Your own ideas for this project should be checked before you begin your work on this assignment. Please send an email with **a paragraph** for each idea describing your proposed assignment work.

▶ Ideas need to be specific, measurable, achievable, relevant to applications of AI, and time-related (**SMART**), so the work of each individual in the team is also clearly defined and measurable.

Tasks to be Undertaken:
AI Mini-Project

▶ You will carry out **investigative work** into your chosen area, where you explore the multi-facets of the area and possible solutions.

▶ This should include the following activities:

  ➢ A **critical review** of related literature, this is to be included in your report. Part of this may be done as a group activity followed by more specific literature review in the topic of investigation or solution each individual in the group is attempting.

  ➢ Each individual will either undertake:

    1) A **practical implementation** to illustrate some feature of an application area, e.g. if you are developing solutions in the areas of Robotics or Expert Systems;   OR

    2) An **appropriate experimental work** to support an investigation on existing data/research, e.g. if you are applying existing AI algorithms to a new application area.

▶ **Collaboration** between onsite and distance learning students is particularly encouraged. This will enhance your skills in remote working and reinforce the necessity to agreeing standards for collaborative work, e.g. what tools to be used: typesetting system, prototyping tools, and what style to be applied: referencing formats, presentation style, etc.

Tasks to be Undertaken:
Project Report

▶ The final **report** will form **70%** of the total mark of the module (Applied AI part).

▶ The report will consist of two main sections:

   1) Individually written parts on the individual tasks.

   2) Team written part on project management showing team work, professionalism, consideration of ethics and collaborative research.

▶ An additional option is to deliver a research (conference or journal) paper: Ideally the solution developed within this project will have a new contribution that could be published as a conference paper. Support and feedback on this option will be provided but it will not form part of the marks. Those who are considering PhD or a career in industrial R&D are encouraged to utilize this option.

Tasks to be Undertaken:
Presentation

- The **Presentation** will form **30%** of the total mark of the modulee (Applied AI part) and have to be done by the entire team.

- This is a **30 – 40 minutes** presentation (including 5 - 10 minutes of demo (if relevant) and 5 – 10 minutes for questions) in the classroom face-to-face or on MS Teams.

- For distance learning students who cannot present their work within the normal hours of the lecture/lab sessions on MS Teams, an alternative time that fits with their work schedules will be arranged.

- Presentations would usually be in PowerPoint or PDF formats (or a suitable alternative). **Presentations** should clearly introduce (this could be slightly different for different topics):

  - The presenter(s) and the topic of research,

  - Problem definition,

  - Summary of existing literature and tools,

  - Proposed solution(s): methodology, experimental design, data collection, and experimental results,

  - Critical review and any additional work proposed or conducted,

  - Conclusions and references.

Deliverables to be submitted for assessment

▶ 1) A group presentation (worth 30% of overall mark).

▶ 2) A project report with group and individual parts (worth 70% of overall mark) that includes:

  ➢ A critical review of the associated literature.

  ➢ A description of the planned research, methodology and evaluation methods.

  ➢ A description of the activities undertaken (e.g. any implementation and/or design of experiments).

  ➢ The findings of the work.

  ➢ Conclusions and further work.

Deliverables to be submitted for assessment

▶ The **report and all the code and data** must be submitted electronically using the link on LearningZone and the report also submitted using Turnitin. The length of the report should be **18-24 pages** (double column) in **IEEE conferences template** format including references. You should use a standard template for your report. The IEEE conferences format is the recommended template. The templates are in MS word or Latex and can be acquired from IEEE Author Centre: https://ieeeauthorcenter.ieee.org Or from: https://journals.ieeeauthorcenter.ieee.org/create-your-ieee-journal-article/authoring-tools-and-templates/tools-for-ieee-authors/ieee-article-templates/

▶ If you wish to use an alternative template, please email me in advance to confirm agreement.

Topics

▶ **AI** is a multi-disciplinary field and its methods are often inspired by other disciplines and equally its applications can often be found in various fields, e.g.:

➢ Cognition: Neuroscience and Psychology e.g. Memory, Attention, Emotions (Cognitive and Neuro-Cognitive Systems).

➢ Linguistics and Social Sciences e.g. Linguistic Data Analysis, Language Acquisition (Computational Linguistics), Interaction Models.

➢ Philosophy e.g. Philosophy of Mind, Epistemology (Knowledge Representation and Reasoning).

➢ Computing Science e.g. Software Architecture, Probabilistic Reasoning, Evolutionary Computing, Data Mining.

➢ Game and Media Technology e.g. Multimedia Retrieval, Computer Animation, Path Planning, Games and Agents.

➢ Business Informatics e.g. Business Intelligence, Analytics.

➢ Engineering e.g. Control, Autonomous Systems, Robotics, Sensor Networks, Internet of Things.

Examples of Possible Projects

▶ Here are some ideas and examples for the mini-project. You are not restricted to choose from these topics and if you have an idea of your own that is usually preferable.

➢ Applications of AI in image recognition

➢ Adaptive Differential Evolution Applied to Point Matching 2D GIS Data.

➢ Fast Handwritten Digit Recognition using machine (deep) Learning.

➢ Object detection and tracking.

➢ Data mining and text mining:

➢ Semantic Analysis for Document Similarity and Search Queries.

➢ Applications of AI in video games:

➢ Learning from User Experience in Games.

➢ Mathematical modelling of problems from work or our daily lives:

➢ Optimization of a Stagger Chart for Aviation Fleet Planning.

Examples of Possible Projects

▶ Applications of games technologies such as KINECT e.g. in assisted living, computer vision.

▶ Search algorithms in optimization problems.

▶ Machine learning and Analytics, e.g. Clustering algorithms.

▶ Chatbots and Turing Test (e.g. The Loebner Prize).

▶ Practical applications of AI algorithms for data mining, e.g.

  ➢ Credit scoring.

  ➢ Forecasting, e.g. weather forecasting.

  ➢ Stock market prediction and investor planning.

  ➢ Security.

Examples of Possible Projects

▶ Philosophy of AI – e.g. consciousness, ethics, etc.

▶ Applications of AI in finance or business.

▶ Computational Creativity, e.g. AI and music (or AI and the arts).

▶ Applications in bio-informatics, e.g. Protein Folding, image-based cancer detection.

▶ Security applications, e.g. behaviour-based malware detection, biometrics, etc.

▶ Social media and web analytics.

▶ Behaviour analysis, e.g. online or in-shop consumers

Suggested Reading List

- R.J. Brachman and H. J. Levesque, 'Knowledge Representation & Reasoning', Elsevier, 2004. (available online).

- S. Russell and P. Norvig, 'Artificial Intelligence: A Modern Approach, 4 Edition', Pearson Series, 2021.

- C. Bishop, 'Pattern Recognition And Machine Learning', Springer, 2006.

- K. Murphy, 'Machine Learning: A Probabilistic Perspective', MIT Press, 2012. [https://probml.github.io/pml-book/]

- R. Sutton and A. Barto, 'Reinforcement Learning: An Introduction, 2nd Edition', MIT press, 2018. Awesome RL: https://github.com/aikorea/awesome-rl

- I. Goodfellow, Y. Bengio, A. Courville, 'Deep Learning', MIT Press, 2016.

- R. Szeliski, 'Computer Vision: Algorithms and Applications', Springer, 2021. [https://szeliski.org/Book/]

What is Artificial Intelligence (AI)?

A quick overview

What is AI?

- Systems that think and act **like humans?**
  - "...activities such as decision-making, problem solving, learning..." (Bellman, 1978)

- Systems that think and act **rationally?**
  - "The study of computations that make it possible to perceive, reason, and act" (Winston, 1992)

- What **common themes** are there to these ideas?
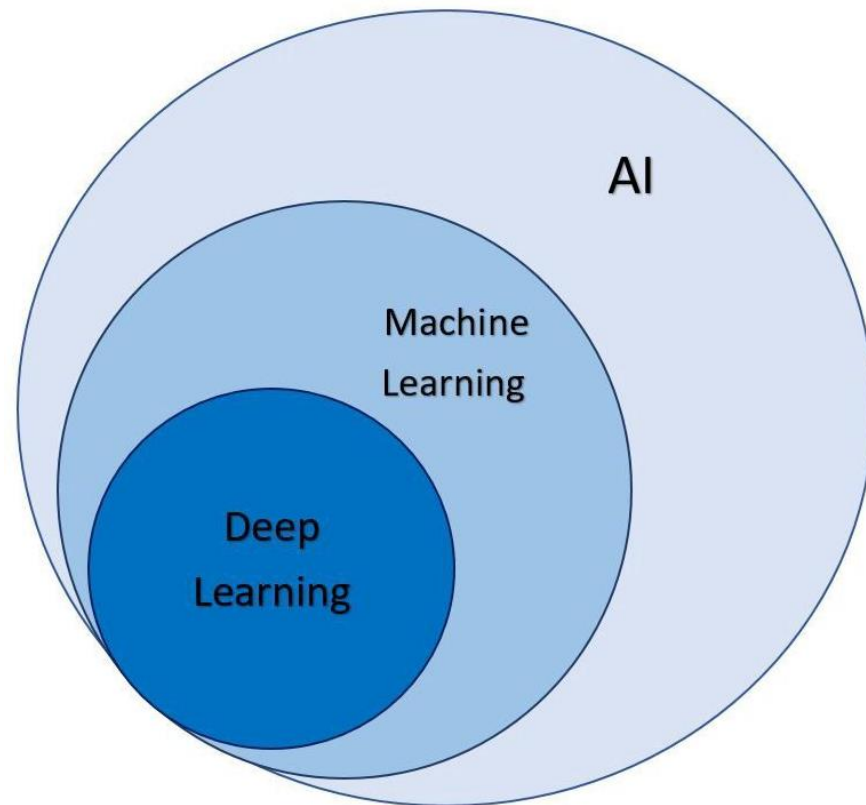
What is AI?

▶ "Intelligent behaviour involves perception, reasoning, learning, communicating, and action in a complex environment" (Nilsson, 1998)

▶ Oxford University Press (OUP) defines AI as "the theory and development of computer (intelligent) systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."

What is AI?

▶ The six disciplines that compose most of AI:

➢ Knowledge representation

➢ Automated reasoning

➢ Machine learning

➢ Natural language processing

➢ Computer vision

➢ Robotics

What is AI?

▶ Computational Intelligence (CI) is a branch of AI.

▶ "The three main pillars of CI have been neural networks, fuzzy systems, and evolutionary computation" (IEEE Computational Intelligence Society).

➢ **Neural networks:** inspired by how information is sent around the brain.

➢ **Fuzzy systems** (systems based on fuzzy logic)**:** inspired by human reasoning.

➢ **Evolutionary computation:** mimics processes from evolution, e.g. genetic algorithm (GA).

▶ Hence, fuzzy systems and evolutionary computation are also part of AI.

What is AI?

- ‘Hard’ computing vs ‘Soft’ computing:

  - **‘Hard’ computing** uses traditional mathematical methods, such as algorithms and mathematical models, to solve problems. These algorithms find provably correct and optimal solutions to problems.

    - Logic and facts.

    - Optimised for certainty and precision.

  - **Soft computing** is a set of algorithms, including neural networks, fuzzy logic, and evolutionary algorithms. These algorithms are tolerant of imprecision, uncertainty, partial truth and approximation.

    - **CI** is a form of soft computing.

Some Applications of a AI

- **Life style** e.g. face recognition, spam filtering, recommendation system, Autonomous vehicles, etc.

- **E-commerce** e.g. fraud prevention, personalized shopping, AI-powered assistants, etc.

- **Robotics** e.g. rescue operation, agriculture, cleaning offices, customer service, food preparation, entertainment, military, exploration (space, underwater), etc.

- **Healthcare** e.g. detect diseases, identify cancer cells, etc.

- **Gaming** e.g. AI can be used to create smart, human-like non-player characters (NPCs) to interact with the players, etc.

- **Data security** e.g. identifies unknown threats, threat prevention, responding to threats, etc.

- **Automotive industry** e.g. manufacturing, inspections, quality control, etc.

- Etc.

Some Applications of a AI

▶ Please list any application of a AI you can think of?

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