



Test Canvas: COMP34212 Exam 2021/22

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Description

2 hours**THE UNIVERSITY OF MANCHESTER**

Cognitive Robotics

Thursday 9th June 2022**09:45 - 11:45**

- Please answer ALL of the questions.
- ALL answers must be submitted via Blackboard.
- Students are NOT allowed to bring in their notes.
- Electronic Calculators are NOT allowed.
- Rough paper will be provided.

Instructions

Total Questions 8

Total Points 70


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☐ **1. Essay: Cognitive robotics concepts: (a) Give a definition of Cognitive Ro...**Points: 20 **Question**

(a) Give a definition of Cognitive Robotics, describe two of its principles, and contrast how this approach differs from other robotics approaches [5 Marks]

(b) Explain the difference between Developmental Robotics and Evolutionary Robotics, or alternatively between Developmental Robotics and Swarm Robotics [5 marks]

(c) List Marr's three levels of Abstraction, and explain how a these three levels are mapped to a robot language learning model (e.g. use the example of the Modi experiment from the first lecture, or any other robot language model) [10 marks]

Answer

(a) Give a definition of Cognitive Robotics, describe two of its principles, and contrast how this approach differs from other robotics approaches [5 Marks]

The student can start from the definition of cognitive robotics: e.g. Cognitive robotics is the field that combines insights and methods from AI, as well as cognitive and biological sciences, to robotics. [1/5]

They will then focus on the principles of Embodied cognition theories (Wilson, Pfeifer, Barsalou), AI and knowledge-based systems (Levesque & Reiter), –Behavior-Based Robotics (Brooks), Synthetic methodologies. [2/5]

The difference from the classical robotics/control is focus on learning, and from AI Robotics, for the bio-inspired approach in the choice of AI methods.

Good to mention sub-fields such as developmental/evolutionary/swarm/soft robotics [2/5]

(b) Explain the difference between Developmental Robotics and Evolutionary Robotics, or alternatively between Developmental Robotics and Swarm Robotics [5 marks]

Developmental focuses on ontogenetic development, from babies to adult robots/agents, working on individuals. Evolutionary has emphasis on genetic algorithms and population-based approaches. Swarm focuses on distributed control in swarm-like colonies of agents. [3/5 depending on level of details in the comparison]

Also discuss developmental focus on higher order cognition, and evolutionary focus on sensorimotor/navigation skills. [2/5]

(c) List Marr's three levels of Abstraction, explain how these three levels are mapped to a robot language learning model (e.g. to the Modi experiment from the first lecture, or any other robot language model) [10 marks]

5 marks for:

Marr's Levels of Abstraction (Marr 1982): Levels of analysis and understanding of a system; Hierarchical and sequential levels

1. Computational / theory: What is the phenomenon to study/simulate?

2. Representation / algorithmic: how can it be represented e.g. input/output

3. Implementation: How is this implemented

5 marks for:

The point Marr was making is that you should decouple the different levels of abstraction and begin your analysis at the highest level, avoiding consideration of implementation issues until the computational or theoretical model is complete. It can then subsequently drive the decisions that need to be taken at the lower level when realizing the physical system.

Example of modi language analyses:

1. Computational / theory: We want to model the acquisition of the first words exploiting embodiment

2. Representation / algorithmic: Robots will be given speech and visual input stimuli, and there will lead to internal semantic representations, which will guide behaviour (naming object or acting on objects)

3. Implementation: A CNN with LSTM will be used to implement the robot's cognitive architecture; the robot platform iCub will be used because of its embodiment and speech handling routines

☐ **2. Essay: Deep Neural Networks: (a) Discuss the difference between de...**Points: **20** **Question**

- (a) Discuss the difference between deep neural networks and classical neural networks, naming some example for each of the two types of networks [5 marks]
- (b) Explain in which period deep neural networks started to become important and discuss which model caused such a development [5 marks]
- (c) Explain how the convolution and the pooling mechanisms work in a CNN Convolutional Neural Network [5 marks]
- (d) What is a softmax function in a neural network, and how does it work? [5 marks]

Answer

(a) Discuss the key differences between deep neural networks and classical neural networks, naming some example for each of the two types of networks [5]

DNNs, such as CNNs, use a higher number of hidden layers. These are typically organised in convolution/pooling/dense layers. Alternatively, LSTM considers the depth of the memory timespan. Classical networks, such as MLP, use just one or few hidden layers. Hidden layers are typically dense/fully connected. Or simple RNN only cope with small time steps. [3/5]

The student can additionally discuss other differences related to the use of large datasets for DNNs and higher computational requirements. [2/5]

(b) Explain in which period deep neural networks started to become important and discuss which model caused such a development [5]

The student can say 2011-2012 or early 2010s, and this development is linked to the Alexnet model/publication. [2/5]

They should mention the 2012 Imagenet competition/dataset. [2/5]

It is OK to mention the 1998 Le-Net as an important moment, if the student explains that this was the first CNN implementation, which was optimised by Alexnet and other later models in 2012 onwards. [1/5]

(c) Explain how the convolution and the pooling mechanisms work in a CNN Convolutional Neural Network [5 Marks]


Examples of concepts on Convolution: Sequential implementation of feature map; Slide over the window to compute the dot product; constitute filters with shared weights

Examples of pooling concepts: To reduce spatial resolution of feature maps; Locally invariant: Reduces the sensitivity of the output to shifts and distortions; Max pooling

(d) What is a softmax function in a neural network, and how does it work? [5]

The softmax activation function is used in output layers for categorical classification tasks. [2/5]

It concerns the whole layer, not a single independent output unit, to have a total layer activation of 1. This facilitates the activation of a single categorical unit over time. [3/5]

☐ **3. Essay: Cognitive robotics experiment design: Explain the design of a novel cogniti...**Points: **20** **Question**

Explain the design of a novel cognitive robotics experiments using a machine learning model. This experiment can be on any behavioural or cognitive robot skill that you choose. You can take inspiration from existing examples from the literature, but do not just repeat the description of an existing model and experiment. Discuss the following parts of the experimental design, justifying your choices:

- (a) The cognitive hypothesis/mechanism which will inspire the design of the robot's cognitive skill and machine learning method [5 marks]
- (b) The robot's task and the input and output dataset that the robot's model will use [5 marks]
- (c) The architecture of the machine learning model and how this is linked to the input/output, and the type of robot to use [5 marks]
- (d) The procedure to train and test the robot [5 marks]

Answer

(a) The cognitive hypothesis/mechanism which will inspire the design of the robot's cognitive skill and machine learning method [5]

The student should mention some psychology example that the robot will try to replicate. Any skill is allowed, from motor/navigation, to language to social skills, to abstract knowledge. E.g. an experiment inspired by the modi experiment for language learning, and the hypothesis that the child/robot exploits embodiment to learn new words. Justify this e.g. for the importance of embodiment in linguistics task.

(b) The robot's task and the input and output dataset that the robot's model will use [5]

E.g. the robot is first presented a set of objects initially visually, and only after with a word associated to it. The dataset consists of N objects.

The input consists of images of the objects, and of the speech of the words

The output consists of the name of the object being learned.

Data might need to be collected offline, or alternatively propose and justify the online data collection and training.

(c) The architecture of the machine learning model and how this is linked to the input/output, and the type of robot to use [5]

The student could use a standard multimodal CNN with image and sound input, and a softmax output layer for the words. Best to suggest resolution of the image, and some indication of convolution/pooling layers.

Or use an LSTM for words in a sentence (or a BERT-like transformer)

One would expect to use a humanoid, e.g. Pepper robot. But a mobile robot can be used if the language task is about navigation.

(d) The procedure to train and test the robot [5]

Train: Provide (i) image only inputs, (ii) then image+sound input; Output

test: use different dataset, or run a live experiment.

Also discuss the fact that the training could be extended on online data collection during the robot's interaction with the environment.

☐ 4. Multiple Choice: Navigation:: Which of these is the function of Gri...

Points: 2

Question	Which of these is the function of Grid Cells in cognitive SLAM?
Answer	<p>A. The function of grid cells is to represent the LIDAR of the animal's location</p> <p>.....</p> <p>B. The function of grid cells is to represent the specific place of the animal's location</p> <p>.....</p> <p>✓ C. The function of grid cells is to represent the specific map of the animal's location</p> <p>.....</p> <p>D. The function of grid cells is to represent the kinematics of the animal's location</p>
Correct Feedback	Grid cells represent the specific map of the animal's location
Incorrect Feedback	Grid cells represent the specific map of the animal's location

☐ 5. Multiple Choice: Manipulation: A robot uses the Cartesian coordinate...

Points: 2


Question	A robot uses the Cartesian coordinates of the target object position to calculates the values of its joint to reach the object. The mechanism to do this is called:
Answer	<p>✓ A. Inverse kinematics</p> <p>.....</p> <p>B. Forward kinematics</p> <p>.....</p>

C. Inverse dynamics

D. Forward dynamics


☐ 6. Multiple Choice: Uncanny Valley: The Geminoid robot:

Points: 2

Question	The Geminoid robot:
Answer	<p>A. Has no effect on the Uncanny Valley</p> <p>B. Has minimal effect on the Uncanny Valley</p> <p> C. Has strong effect on the Uncanny Valley</p> <p>D. Flattens the Uncanny Valley</p>

☐ 7. Multiple Choice: Ethics: In machine and robot ethics, the Deon...

Points: 2

Question	In machine and robot ethics, the Deontological approach:
Answer	<p> A. states that there are moral laws which are universally applicable</p>

B.

states that there are moral laws based on the greatest possible good for the greatest number of people

C. states that there are moral laws develop over time and can change

D. states that there are moral laws which are only valid for humans

☐ 8. Multiple Choice: Android: An Android robot is characterised by ...

Points: 2

Question

An Android robot is characterised by the fact that:

Answer

A. It uses the Android operating system

B. It uses the ROS operating system

☒ C. It is indistinguishable from humans

D. It is indistinguishable from humanoids

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