Cognitive Robotics ECS794P

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Q1 **a.**

- Help humans with certain tasks and environments by creating better robots
- Aim to understand and explain the human mind better

The first one aims to design robots that can adapt, learn, and interact with humans, improving their efficiency, Eg: robot support that assists specially-abled people. The second focuses on modelling cognition in robots to gain insights into the human mind Eg: a robot that learns motor capabilities for tasks, mirroring the developmental stages of a baby.

b. It describes how cognition& behaviour is realized through specific mechanisms.

c. Cognitivist: Symbolic computation and pre-existing structures enable cognition.

According to the cognitivist theory, perception involves the brain creating symbolic representations that are later used for thinking, planning, and carrying out actions. The goal of symbolic representation is to connect actual things or events with symbols.

Emergent: Ecological perception which concentrates on gathering only the information needed for autonomy and interaction. This sense is unique to the persistence of the system.

Q2

a.

(i.) $P(MO = slow \mid EM = sad) = P(MO = slow \mid EM = sad, EL = low) * P(EL = low) + P(MO = slow \mid EM = sad, EL = high) * P(EL = high)$

$P(EL = low) = P(EL = high) = 1/2$

$P(MO = slow \mid EM = sad) = (6/8 * 1/2) + (4/8 * 1/2)$

$= 3/4 + 2/4 = 5/8$

(ii) $P(EM = sad \mid MO = slow) = P(MO = slow \mid EM = sad) * P(EM = sad) / P(MO = slow)$

$P(EM = sad) = 1/3$

To find: $P(MO = slow)$:

$P(MO = slow) = P(MO = slow \mid EM = happy) * P(EM = happy) +$

$P(MO = slow \mid EM = sad) * P(EM = sad) +$

$P(MO = slow \mid EM = nervous) * P(EM = nervous)$

→ $P(MO = slow \mid EM = sad) = 5/8$ from part (i.)

→ $P(MO = slow \mid EM = happy) = (4/8 * 1/2) + (1/8 * 1/2) = \frac{2}{8}$

→ $P(MO = slow) = (3/8 * 1/3) + (5/8 * \frac{1}{3}) + (\frac{2}{8} * \frac{1}{3}) = 10/24$

Hence, $P(EM = sad \mid MO = slow) = (5/8 * \frac{1}{3}) / (10/24) = 5/10 = \frac{1}{2}$

(iii) For $P(EM = sad \mid MO = slow, EL = low)$

$$P(EM = sad \mid MO = slow, EL = low) = \frac{P(MO = slow \mid EM = sad, EL = low) * P(EM = sad)}{P(MO = slow, EL = low)}$$

→ $P(EM = sad) = 1/3$

For $P(MO = slow, EL = low)$:

$P(MO = sad \mid MO = slow, EL = low) = (6/8 * 1/3) / (13/24) = 6/13$

The results of (ii) & (iii) are different because the observation and events that have occured are different, hence the posterior probability the different.

b. Option B. (Environment will get the actions performed by the agent as a node and being a service performs the computation to give the reward)

c. The advantage of Locally Weighted Projection Regression over Locally Weighted Regression is its ability to handle high-dimensional data efficiently. LWPR uses partial least squares for dimensionality reduction, allowing it to adapt better to complex, high-dimensional spaces compared to LWR.

d. LWR is a discriminative model, as it focuses on finding the best separation boundary between data points rather than generating data from underlying distributions.

Q3

a. Nature defines the contribution of innate-knowledge (pre-defined rules) that govern the actions, reactions of the robot, while nurture defines the contribution of the environment where system directly interact with the environment to constructively develop a robust understanding of expected action-reaction. Example: assembly-line robots are nature-based, precisely performing pre-set sensorimotor-tasks, a self-driving car learn rules based on interactions with the environment. (referred from the lecture and slides)

b. Babies develop motor-skills from head to lower extremities. Head-control helps them explore, while motor-developments in the upper-body and legs allow them to focus on objects, surroundings to reach for objects. (referred from lecture)

c. Option B (Timestamp 58:49 of the guest lecture, Angelo says it's not much about what you can do perceptually or motorically but how you cognitively reorganize the structure of your dictionary at that stage, this development is much later in time than motor development)

d. Option E (Chomsky as a cognitivist says that we have predefined structures in our brain that we build on top of. Saying about learning most of the structure through talking and interaction is unlikely to be said by him) (referred from the lecture and slides)

Q4

a.

(i) Bayesian-inference

(ii)

- Camera-image;
- Prior color-expectations;
- Human-opinion;
- Apple's colour-possibilities
- Confidence-level

(iii) Controlled setting with various lighting-conditions, apples of various colours, and human subjects.

(iv) Robot using camera-captured image, saved pixel intensities, prior expectations to estimate the color before human feedback. Prediction is compared to the truth to analyze the effect of human-input and lighting.

b. Using ecological perception, a robot can determine the liquid content of a container by identifying its shape, weight, and substance. Improving estimates, active perception entails interaction, such as probing or tilting the container. This way the liquid level within the container can be estimated without the aid of computer vision.

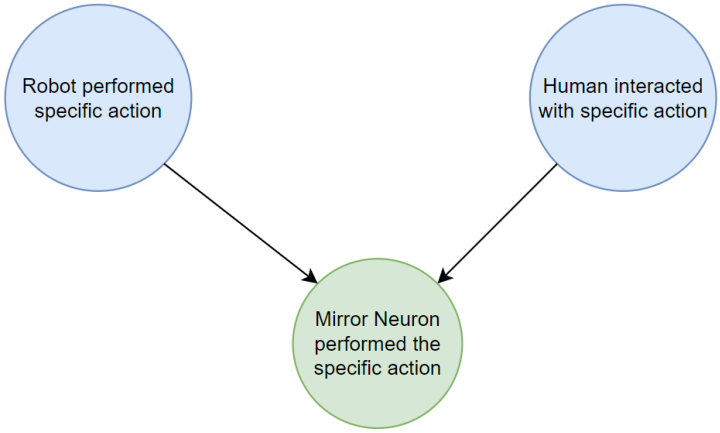
c.

(i.)

- **Robots action**: Robot performed the specific action that the mirror neuron relates to.
- **Human action**: Human performed the same action

- **Mirror Neuron firing**: Mirror neuron will fire or not

(ii.)



Robot performed the specific action	Human interacted with specific action	Mirror Neuron performed the specific action	Prob of Mirror Neuron Output
T	T	T	0.9
T	T	F	0.1
T	F	T	0.7
T	F	F	0.3
F	T	T	0.6
F	T	F	0.4
F	F	T	0.1
F	F	F	0.9