TDT4137 - Cognitive Architectures

Assignment 2

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1-A: Building blocks of Cognitive Architectures

1.1

Cognitive architectures are programs that could reason about problems across different domains, develop insights, adapt to new situations Cognitive architectures are programs which try to model the human mind. These programs should be able to reason about problems across different domains, develop insights and adapt to new situations.

1.2

Symbolic representations, represent knowledge using explicit symbols. These explicit symbols can be combined for inference or syntactical parsing.

However sub-symbolic representations are associated with computing using non-binary values, such as numeric data, pixels and probabilities. Instead of explicit symbols and rules, information is encoded in the form of numerical values or distributed patterns.

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Symbols are used to represent knowledge, and has a rule-based system to manipulate this knowledge. It uses inference for problem solving by using this rule bases reasoning.

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One main difference between cognitivistic and emergent approaches are its perception. In cognitivist systems perception provides a connection between the external world and its symbolic representation. In emergent systems perception perception is the extraction of spatio-temporal from sensory data.

1-B: Hybrid architectures

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Firstly we can use the emergent systems perception and actions to explore and construct knowledge about the world. We can then represent its knowledge using symbols and the logical rule bases system to reason this knowledge. Secondly instead of a designer programming all the necessary knowledge, a hybrid system can represent knowledge as observed correspondences between sensed perceptions, agent actions, and sensed outcomes. As both cognitive and emergent systems have their strengths and weaknesses, they are combined into hybrid systems which can draw out both systems strengths, without the disadvantages.

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For autonomous robots, hybrid architecture can be beneficial. Symbolic reasoning can be used for its high-level task planning and reasoning. Sub-symbolic approaches such as computer vision can be used for its low-level perception, such as computer vision and controlling.

Another example is natural language understanding for virtual assistants such as Siri. Symbolic approaches are used for understanding and parsing user queries. These symbolic representations can be used in machine learning models for retrieving and understanding the queries, which is a sub-symbolic task.

1-C: Perception and sensing

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Vision was viewed as the dominating sensory modality for humans. This lead to cognitive architecture research being very centered around vision. However new research suggests that humans does not have a domination sensory modality.

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David Marr stages of vision are early, intermediate and late. The early stage is data-driven and extracts simple elements, such as color, luminance, shape and motion. The intermediate stage groups elements into regions which are used in the late stage. In the late stage the regions are used for object recognition and assigning them meaning using available knowledge.

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We generalize Marr's three stages, the first step (early) it extracts information and data from a given problem. The second step (intermediate) processes the extracted data into the foundation of our knowledge. Then the third step (late) uses the processed information and uses reasoning for giving the knowledge meaning. We can draw parallels to how emergent systems work. The first stage is similar to the perception of emergent systems, it collects information from sensory data. The second stage can be seen as computer vision or object detection with are both sub-symbolic tasks. Lastly the third step can be seen as a neural network classifying and giving meaning to objects.

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There are 6 stages of image understanding. The first stage detects and groups intensity-location-time values, which will result in edges, regions and flow vectors. The second stage groups the edges and regions, and creates surfaces, volumes, boundaries and depth information. The third stage identifies objects and the objects motions. The fourth stage builds object-centered representations for entities. The fifth stage assigns labels to objects bases on the task. Lastly the sixth stage uses inference of spatiotemporal among entities.

1-D: Attention

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The three classes of information reduction mechanisms are selection, restriction and suppression. Selection is a choose one from many mechanism, where we select a gaze and viewpoint. The world model consists of objects and events to focus on, and lastly we select time/region/features/events of interest. Restriction is a choose some from many mechanism. It prunes the search space by preparing the visual system for inputs based on task demands, domain knowledge, external stimuli, restricting attention to objects relevant for the task, and limiting the field of view. Suppression is a suppress some from many mechanism. It consists of feature/spatial surround inhibition, which is the temporary suppression of the features around the object its attending to. It also suppresses task-irrelevant stimuli and does negative priming. Lastly it has a bias against returning attention to previous attended location or stimuli

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Data-driven or bottom up attention identifies regions which are distinct from its surroundings. Task-driven or topdown attention are hard-coded or learned heuristics which searches the space for a given task. An example is searching for blue objects. A topdown approach would use use and look for blue objects. A bottom-up approach would try to identify areas which are different in color from its surroundings.

1-E: Action selection

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The two major approaches to action selection are planning and dynamic. Planning involves determining a sequence of steps to reach a goal. This type of action selection is most prevalent in symbolic architectures. Dynamic action selection selects the best action based on the the information given at the time. Dynamic action selection or reactive actions is most prevalent in sub-symbolic architectures.

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When someone is action rationally they select the most optimal decision given its known knowledge.

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Purely reactive systems are rare and used under certain conditions, for example avoidance of collisions, or to react to unexpected input such as fast moving objects or loud sounds. So an agent can be successful without planning, but under certain conditions, such as a simple reactive environment,

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Yes, it could be rational. In artificial intelligence there is always a balance of exploitation (using the good action) and exploration (knowledge gathering). In many cases, even though the agent already knows of a good action, it could find an even better action. However if the agent uses too much time on the information gathering, it could be un-rational, as the action could loose its optimality.

1-F: Memory

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The multi-store concept of memory is a theoretical framework. It describes memory as a unit consisting of multiples stores, each with its own functions. These stores can be sensory memory, working memory, short term or long term memory.

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The distinguishing of short-term and long-term memory comes from the field of cognitive psychology. The foundation of this research came from George A. Miller who experimented on the capacity of long-term memory.

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In symbolic architectures, knowledge is represented by explicit symbols and rules, such as strings or real world characters. Symbols can also be interpreted by humans. On the other hand non-symbolic architectures use non-binary values for representing knowledge. Such representations can be distributions, pixels or numeric data.

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As opposed to symbolic systems where symbols are used to store knowledge, emergent systems often use distributed representations for its knowledge. This can be connected weights as in neural networks or feedback loops. Lastly emergent systems are self-organizing where they adapt reorganize knowledge though local rules and interactions.

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Yes, neural networks do have memory. As neural networks are associated with non-symbolic architectures it stores its memory as distributed connected weights. The weights gets trained and stored as in a feedback loop, it also organizes activation's among the network.