TDT4137 - Cognitive Architectures

Assignment 4

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Topic 1-A: ACT-R

1.1

The ACT-R architecture is split into modules, and the modules are coordinated with the central production system, which can be identified as the *basal ganglia* in the human brain. The central production system is not sensitive to all the activity or information in each of these modules, but only to the limited amount of information stored in their buffers. This can be linked to the brain structure, because us humans are not aware of everything in our visual field, but only the the object we are attending to. We are also not aware of all our memory stored in the long term-memory, only the parts that are currently retrieved.

1.2

ACT-R integrates both symbolic and sub-symbolic representations, in its framework. The production system is symbolic. Here rules or productions operate on symbolic buffers. However there are sub-symbolic processes which operate and control the symbolic processes. Such processes can be calculating production utility or production choice, and are set of parallel processes that can be represented by mathematical equations.

1.3

Both ACT-R and SOAR have many similarities, they both share features such as declarative memory where knowledge is stored a symbols, and rule based inference on these symbolic representations. They also have both symbolic and sub-symbolic processes.

ACT-R however splits its knowledge representation into a declarative module where facts are stored as chunks, and a procedural module to store procedural knowledge such as knowledge about how to to something. ACT-R production rules are also often more explicit and human-readable, which makes them accessible for cognitive modeling and psychological theory testing. However Soar production rules, can be more complex due to the unified representation of knowledge, making them sometimes less intuitive for human interpretation.

1.4

ACT-R can learn in many different ways, in its different systems. Firstly it can learn in its procedural memory, or production system. By experiencing actions, it can learn from its successes and failures, by tuning the utility of its productions. It can also learn in its declarative memory, by learning facts and encodes them into its declarative memory.

1.5

ACT-R is not only a cognitive architecture, but also a theory. It models human cognition it terms of the brain and the bodies motor functions. It describes the different parts of the brain in terms of modules and buffers, where each part is coordinated by a central production system. It also tries to explain why humans behave like we do in various cognitive tasks. Lastly the framework lets us understand various cognitive processes.

1.6

ACT-R retrieves information from its declarative module, in a *chunk*. ACT-R calculates the activation of each chunk, which reflects its usefulness in the pas and its relevance to the current context. This activation is dependent on the mapping from elements in its attention to the chunk, and the goal. It also depends on a base activation of the chunk. The activation of the chunk will then influence the probability of the chunk being retrieved and the time to retrieve it. This makes the model have real predictions about performance. This processes is subsymbolic.

Topic 1-B ICARUS

1.7

Conceptual inference in ICARUS is data driven, or bottom-up, and similar to Soar's elaboration phase. It is the mechanism which matches the conceptual structures in its long-term memory to its percepts and beliefs. In each cycle, ICARUS retrieves the attributes of the perceived objects, and puts them into the perceptual buffer. It then matches them to conceptual definitions in the long-term memory. This will result in that all implied elements are added to its belief state.

1.8

In the ICARUS architecture the *goals* represent the agents objective, and it focuses on only one goal at a time. To achieve its goals, the agents executes *skills* from its long-term memory and bringing the agent closer to its goals. In each cycle, the agent chooses the goal which has the highest priority.

1.9

In ICARUS conceptual knowledge can be found in its long- and short-term memory. These are facts which can be used for categorization and inference. Skill knowledge on the other hand can be found in the both the long- and short-term skill memory, but also in the goal memory. Skill knowledge is knowledge about which actions the agent can perform, and how it affects different goals.

1.10

Concepts are organized in a hierarchical manner, where more complex terms, are explained using simpler structures. In this hierarchy we can find concepts, conceptual clauses and precepts at the bottom. This is useful because, we can then start with our percepts and move up in the hierarchy to match percepts to concepts.

1.11

When selecting a skill in ICARUS if firstly starts with a conceptual inference, to match its percepts to concepts. It then retrieves all skills which are relevant. Relevant means that their head unify with the goal, and that they can be applied. The skills conditions also has to match the current beliefs. If the chosen skill is not a primitive skill, it will then in the next cycle and find a subgoal. It will continue this recursively until its finds a primitive skill and sends all actions associated with that skill to the motor buffers.

1.12

When ICARUS encounters an unsatisfied goal or sub-goal, where its lacks the skill to accomplish the goal, the problem solver creates new intentions and sub-goals. It will recursively search for a applicable primitive skill which it can execute, or backtrack when it reaches a dead end. Whenever the architecture achieves a goal using problem solving, it will construct a new skill which encodes the step. This means that whenever ICARUS solves a problem, it constructs skills which can solve the problem for future use.

Topic 1-C Belief Desire Intention (BDI)

1.13

A desire is the objectives of the agent, almost like a goal. Except than in BDI the term *goals* are only used for non-conflicting desires. Intentions on the other hand are the actions an agent is committed to perform, in order to achieve its desires

1.14

A goal in the context of AI, is something the agent tries to achieve, and if it cant achieve it, it tries to learn methods to achieve the goals. Desires in BDI however are something that an agent *would wish* to achieve. It will not be able to achieve all its desires, but tries to commit to some of them in the form of intentions.

1.15

BDI is not a cognitive architecture, but a conceptual framework. Cognitive architectures such as ACT-R and ICARUS a comprehensive and provides explanations of how various cognitive processes work. They focus on created human like cognition. BDI on the other hand tries to model coherent model behavior, and simplifies cognition into beliefs, desires and intentions.

1.16

Practical reasons is reasoning directed towards actions, it tries to find out what to do. Another form of reasoning in theoretical reasoning, were the reasoning is directed towards beliefs. An example of such reasoning is inference in knowledge.

1.17

The BDI architecture tries to avoid reconsidering to reduce decision times. It does not reconsider intentions, but can reconsider plans after each iteration, if the plan is no longer sound given its beliefs. I can reconsider intentions, but there are some criteria; when it has completely executed a plan, believes it has achieved its current intentions or when it believes that the current intentions are no longer possible.

1.18

There are several costs when it comes to reconsidering. Firstly we are not sure if the other options are worth exploring, so this would lead to unnecessary decision times. Also in a fast changing environment, we cant always consider all the options, but choose the intention which is most likely the best. Also if we frequently reconsider our intentions, we loose commitment to the intention. This can lead to unreliability and fail to achieve goals which are close.

Topic 1-D Subsumption

1.19

The first key idea behind the subsumption architecture is situatedness/embodiment. It comes from the fact that real intelligence is found in the world. They wanted a cognitive architecture which was grounded in physical reality instead of relying on abstract representations using symbols.

The second key idea comes from intelligence and emergence. It states that intelligent behavior results from and agents interaction with its environment.

1.20

The Subsumption Architecture uses the real worlds as it models, and maps from its sensory states directly to actions. A subsumption architecture is built up from layers, where the lowest layers have the highest priorities, and are the most important. Bottom layers are primitive behaviors can be obstacle detection or wandering. Layers can be added on top of each other to create more complex behavior.

1.21

The subsumption architecture moves away from the physical symbol systems hypothesis, which is a system that can manipulate symbolic representation to create a general problem solving agent. The subsumption architecture has no internal representation of the world, it simply reacts to its surroundings and uses the world as it state. I does not either rely on the Heuristic Search Hypothesis because it does not have to search though a problem space.