

# Building blocks of Cognitive Architectures

## Symbolic vs sub-symbolic representations

### **Task 1.1**

We separate methods in symbolic methods and sub-symbolic methods in artificial intelligence because they differ in a fundamental way. Symbolic methods are based on feeding computers symbols that relate to each other in some way. These symbols can be arranged in different ways. In sub-symbolic methods the computer will be provided with sub-symbolic representations, such as numerical patterns. The computer will learn from these patterns, and function similar to how a neuron does. It is customary to use the term sub-symbolic instead of non-symbolic because both representations are based on different definitions of symbols.

### **Task 1.2**

The main difference between cognitivist and emergent approaches is their use of symbolic representations. Cognitivism asserts that the symbolic knowledge it represents about the world is a faithful counterpart of the world itself. Emergent approaches make no such claim, they simply allow that internal state reflects some regularity or lawfulness in the world which it does not know but which it can adapt to and exploit through its dynamically determined behavior.

### **Task 1.3**

If a system shows intelligent behavior through emergent approaches that means that the system is acting based on internal patterns of actions and reactions that the system itself has developed over time.

## Hybrid Architectures

### **Task 1.4**

Hybrid architectures exploit symbolic knowledge to represent the agents world and a logical rule based system to reason with this knowledge to pursue tasks and achieve goals. Hybrid representations may combine any number of elements from both cognitivism and emergent representations.

### **Task 1.5**

The symbolic architecture is combined with self-contained modules performing sub-symbolic computation.

## Perception and sensing

### **Task 1.6**

Any system of relevance will have an impact on the world outside of the regarded system. Cognitive architecture research is often centered around vision because it has been the dominating sensory modality, due to the sheer amount of available experimental evidence. It is relatively simple to build physiological or physical experiments regarding vision and the eye in general.

### **Task 1.7**

David Marr proposed a three-staged description of vision. The three stages are:

- An early primal sketch of the scene, a data driven approach that involves parallel processing of the visual scene and extracts simple elements such as color and shape
- An intermediate 2.5D sketch which groups the elements into regions
- A late stage 3D representation of vision subsequently recognizing objects and assigning a meaning to them, given the available knowledge.

His work and theories were very influential for computational neuroscience.

### **Task 1.8**

Audition is a common modality in the cognitive architectures. Currently, most effort is directed at natural language processing, linguistic and semantic information carried by speech.

## Attention

### **Task 1.9**

Perceptual attention has an important role in human cognition. It mediates the selection of relevant information and filters out irrelevant information from incoming sensory data. There are three classes of information reduction mechanisms.

- Selection, choosing one object or events to focus on.
- Restriction, choosing some objects or events out of many. These can be chosen based on a variety of factors such as knowledge or external stimuli
- Suppression, suppressing some from many. The objects or events to be suppressed can again be chosen based on a number of factors.

### **Task 1.10**

The selection of visual data can be data-driven (bottom-up) or task-driven (top-down). In a data-driven approach the regions with distinct features are identified. This can be done using factors such as color, edges or motion. Other approaches find unusual motion patterns or discrepancies between observed and expected data. In a task-driven approach the objects are identified via heuristics. A classical example of task-driven attention is a visual search.

## Action Selection

### **Task 1.11**

There are two major approaches to action selection, the first approach is a planned action selection. In a planned approach, the agent determines a sequence of actions beforehand. The second major approach to action selection is a dynamic action selection. In a dynamic action selection, the actions are chosen based on the knowledge available at the time, thus being dynamic. Planning action selection is more prevalent in symbolic architectures, but also found in some emergent and hybrid approaches. Dynamic action selections is more prevalent in sub-symbolic architectures.

## Memory

### **Task 1.12**

The multi-store concept of memory is dominant in psychology, but its utility for engineering is questioned by some authors. The model asserts that human memory has 3 distinct components. A sensory register where sensory information enters memory. A short-term store which receives and holds inputs from both the sensory register and the long-term store. A long-term store where information can be stored indefinitely.

### **Task 1.13**

It is common to distinguish between short-term and long-term memory. This separation comes from the research field of introspection, the examination of human conscious thoughts and feelings

### **Task 1.15**

In a symbolic architecture knowledge is represented by symbols, whilst in a sub-symbolic architecture the architecture uses a distributed representation of knowledge, and is capable of processing this distributed representation of knowledge in a meaningful way.

## Soar

### **Task 1.16**

The input phase of the soar model is where all relevant data inputs are read. This data is then used to select an operator for the task. Impasse is an event that arises when Soar cannot resolve operator preferences. Soar may use different strategies to solve the impasse. In the operator application phase, the operator is applied to the situation. To solve a problem, operators must be applied to move through the problem space.