Q. Compare and contrast the following
- Rule-based cognitive architecture
- Connection-based cognitive architecture,
- Hybrid cognitive architectures.

1. Rule-based cognitive architecture

Rule-based architecture uses rules to provide suggestions or diagnoses, as well as to decide the best course of action in a given circumstance or to address a specific problem. Typical components of a rule based architecture are as follows.

- A database of rules or knowledge base
- A database of facts or statements
- Inference engine

The knowledge base is a set of rules that represent the system's knowledge. The facts database represents the system's inputs, which are utilized to draw conclusions or trigger actions. The inference engine is the system component that manages the process of drawing conclusions. It takes the rules and data and puts them together to come up with conclusions.

Some advantages of rule based architecture are as follows.

- The rule-based architecture is simple to comprehend.
- It can be designed to convey expert judgment in both simple and complex topics.
- In Rule-Based design, the cause-and-effect relationship is transparent.
- It provides the flexibility and method needed to model some basic mental processes as machines.
- The thinking process is mechanized.

And some disadvantages of rule based architecture are as follows.

- They require deep domain knowledge and manual work.
- Generating rules for a complex system is quite challenging and time-consuming.
- It has less learning capacity, as it generates results based on the rules .

2. Connection-based cognitive architecture

At a level of abstraction below the symbol level, connectionist models are frequently employed to model cognitive functions. Parallel distributed processing is another name for it. The key connectionist truths are that the brain is made up of a large number of components, each of which is connected to a large number of other components, and each of which executes a relatively simple computation slowly and mostly using input from its local connections.

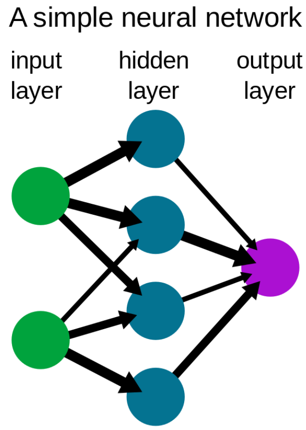
Connectionism's mental model is based on the nervous system metaphor: mental activity is analogous to a network settling into a stable configuration. Connectionist models operate at a degree of abstraction that is too low to be practical. Connectionists contains 3 major items:

- To find better methods of solving AI problems
- To model actual mechanisms of neural computation
- To explore mechanism of human information processing

Connectionism theory fundamentally claims that intelligent decision-making can be done through an interconnected system of small processing nodes of unit size. The degree or amount of connection between each neuron-like processing unit and other units is governed by the level of activation of each neuron. Each neuron processing unit becomes increasingly engaged or deactivated when the interconnected system is exposed to more information (learns). When trained with data, this system of transformations and convolutions can build in-depth models of the data production distribution and conduct intelligent decision-making, such as regression or classification. Models of connectionism contain seven basic characteristics.

- A set of units
- Activation states
- Weight matrices
- An input function
- A transfer function
- A learning rule
- A model environment

The units, known as neurons, are simple processors that mix incoming information based on the system's connectivity. The activation state of a neuron is determined by the combination of incoming inputs.



The main properties of connection based architecture are as follows.

1. There are two primary lineages in modern mind theory, which are Representationalist and Eliminativist, respectively. On the Representationalist side, there are Connectionists. Representationalists believe that positing representational (or 'intentional' or 'semantic') states is necessary for a theory of cognition; they believe that there are states of the mind that encode states of the world.

2. The labels have no bearing on the functioning of a Connectionist machine; in particular, the syntactic and semantic relationships that exist among the expressions employed as labels have no bearing on the machine's operation. Regardless of what labels we assign to the nodes, the machine represented in Figure 2 will continue to make the same state transitions.

3. The lack of combinatorial syntactic and semantic structure in Connectionist models is due to the fact that many Connectionists consider representations to be neurologically dispersed; therefore, presumably, anything that is distributed must have parts.

3. Hybrid Cognitive Architecture:

Hybrid Cognitive architecture combines the aspects of rule-based cognitive architecture and connection-based cognitive architecture. Hence, In practice, they use symbolic architectures to describe their reality and rule-based reasoning to reason about their knowledge. Lower-level, sub-symbolic systems examine the world and build their knowledge base through emergent activities.

Their objects should be represented as invariant combinations of precepts and responses, with object attributes learned through manipulating them. The goal of creating such systems is for them to learn tasks for which they were not originally built. With newer models of multi-agent systems, it attempts to find a form of focal point.

A hybrid intelligent system is a software system that uses a combination of methods and techniques from various artificial intelligence subfields at the same time. Like,

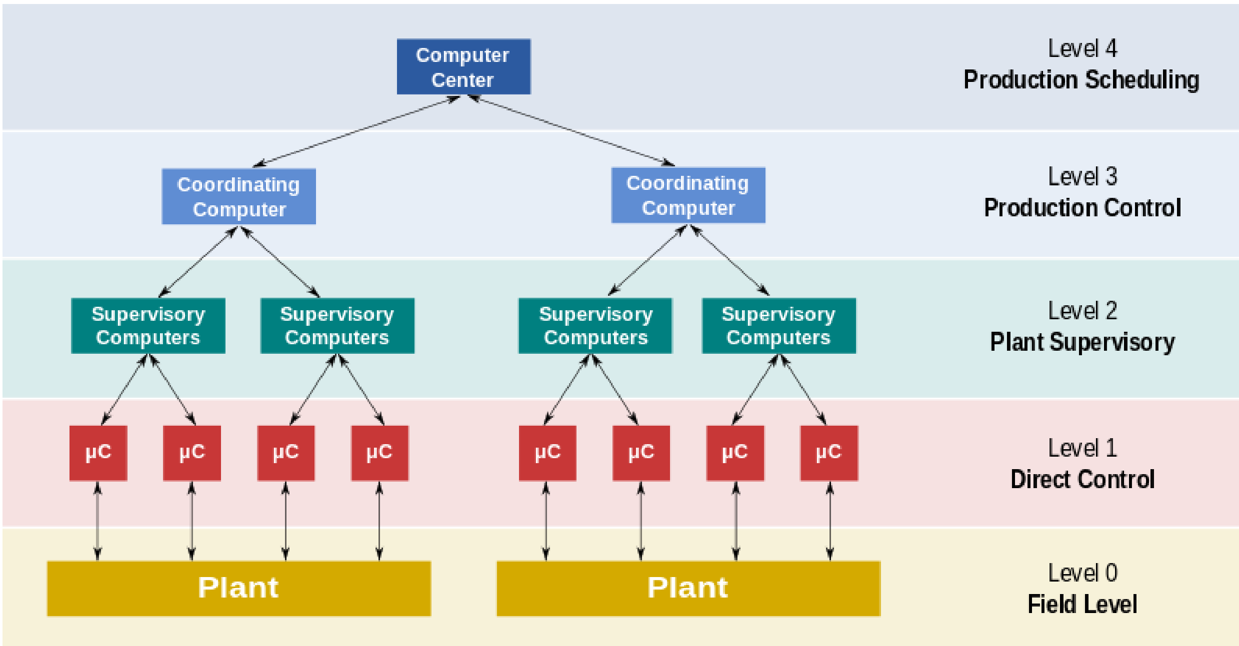
- Neuro-fuzzy systems
- Connectionist expert systems
- And many more

Every natural intelligence system is hybrid, according to cognitive science, because it executes mental operations on both the symbolic and subsymbolic levels.

The importance of A.I. Systems Integration has been discussed more frequently in recent years. Based on the assumption that simple and specific AI systems have already been established, and that now is the time for integration to create wide AI systems.

A hierarchical control system in which the lowest, reactive layers are sub-symbolic is an example of hybrid architecture. With their temporal limitations eased, the upper layers are capable of reasoning and planning from an abstract world model. Hybrid reasoning procedures, such as induction, deduction, abduction, and reasoning by analogy, are commonly used in intelligent systems.

A general hierarchical model is shown in the accompanying diagram, which depicts functional production stages using computerized control of an industrial control system.



Reference: Wikipedia

- Field devices like flow and temperature sensors, as well as final control elements like control valves, are found on Level 0.
- The industrialized Input/Output (I/O) modules and their associated distributed electronic processors are found on Level 1.
- Level 2 houses the supervisory computers, which collect data from the system's processor nodes and display the operator control panels.
- Level 3 is the production control level, which is focused with monitoring production and meeting targets rather than directly controlling the process.
- Production scheduling is at level four.