**Explain the following terms:**

1. **Frame problem (McCarthy and Hayes 1969)**

A fundamental problem in artificial intelligence research, first identified by John McCarthy and Pat Hayes (‘Some Philosophical Problems from the Standpoint of Artificial Intelligence’, Machine Intelligence, 1969).

The frame problem was initially formulated as **the problem of expressing a dynamical domain in logic without explicitly specifying which conditions are not affected by an action**. In philosophy, it is formulated as the problem of limiting the beliefs that have to be updated in response to actions (automatic constraints on belief).

For example, if a proposition **p** is true at one time, and event **e** occurs, we just know whether **e** is relevant or not to whether **p** is true at a later time. We ignore beliefs that are obviously irrelevant to our goals and we keep track of salient changes, despite the holism of change, or the fact that virtually anything can affect anything else. The frame problem is that of programming ‘frame axioms’ to reproduce this ability in any remotely realistic device supposed to mimic human intelligence

The name "frame problem" derives from a common technique used by animated cartoon makers called framing where the currently moving parts of the cartoon are superimposed on the "frame," which depicts the background of the scene, which does not change. In the logical context, actions are typically specified by what they change, with the implicit assumption that everything else (the frame) remains unchanged.

1. **Subsumption architectures (Brooks 1886)**

Subsumption architecture is **a reactive robot architecture heavily associated with behavior-based robotics**. The term was introduced by Rodney Brooks and colleagues . Subsumption has been widely influential in autonomous robotics and elsewhere in real-time AI.

**Description**

**A subsumption architecture is a way of decomposing complicated intelligent behaviour into many "simple" behaviour modules**, which are in turn organized into layers. Each layer implements a particular goal of the agent, and higher layers are increasingly abstract.

 Each layer's goal subsumes that of the underlying layers, e.g. the decision to move forward by the eat-food layer takes into account the decision of the lowest obstacle-avoidance layer. As opposed to more traditional AI approaches ,**subsumption architecture uses a bottom-up design**.

Attributes of the architecture

**Advantages :**

· **The modularity**

· The emphasis on **iterative development & testing of real-time systems** in their target domain

· The emphasis on **connecting limited, task-specific perception directly to the expressed actions** that require it.

These innovations allowed the development of the first robots capable of animal-like speeds.

 **Disadvantages :**

· **The inability to have many layers**, since the goals begin interfering with each other,

· The **difficulty of designing action selection** through highly distributed system of inhibition and suppression

· The rather **low flexibility at runtime**.

1. **Behavior-based architectures (Arkin 1998)**

These are all of architectures based on behavior. These are concerned with behavioral control. The behavior architecture consists of three interconnected hierarchies for sensors, behaviors, and control.



**Summarize the principles of EAP actuator and air muscles (as well as the advantages and disadvantages)**

1. **Electroactive polymers (EAPs)**

Electroactive Polymers or EAPs are polymers whose **shape is modified when a voltage is applied to them**. They can be used as actuators or sensors.

**As actuators**, they are characterized by being able to undergo a large amount of deformation while sustaining large forces. Due to the similarities with biological tissues in terms of achievable stress and force, they are often called artificial muscles, and have the potential for application in the field of robotics, where large linear movement is often needed.

EAP can have several configurations, but are generally divided in two principal classes:

1. **Dielectric EAPs**, in which actuation is caused by electrostatic **forces between two electrodes which squeeze the polymer**. Dielectric elastomers are capable of very high strains and are fundamentally a **capacitor** that changes capacitance when voltage is applied by allowing the polymer to compress in thickness and expand in area due to the electric field. This kind of EAP typically **requires a large actuation voltage to produce high electric fields** (hundreds to thousands of volts), but **very low electrical power consumption**. Dielectric EAPs **require no power** to keep the actuator at a given position. Examples : electrostrictive polymers , dielectric elastomers.
2. **Ionic EAPs**, in which actuation is caused by **the displacement of ions inside the polymer**. Only a **few volts are needed** for actuation, but the ionic flow implies a **higher electrical power needed** for actuation, and **energy is needed** to keep the actuator at a given position. Examples of ionic EAPS are conductive polymers, ionic polymer-metal composites (IPMCs), and responsive gels. Another example is a Bucky gel actuator, which is a polymer-supported layer of polyelectrolyte material consisting of an ionic liquid sandwiched between two electrode layers consisting of a gel of ionic liquid containing single-wall carbon nanotubes.
3. **Pneumatic artificial muscles (PAMs)** are contractile or extensional devices **operated by pressurized air**. Similarly to human muscles, PAMs are usually grouped in pairs (see figure): one agonist and one antagonist.

PAMs were first developed (under the name of McKibben Artificial Muscles) in the 1950s for use in artificial limbs. The Bridgestone rubber company (Japan) commercialized the idea in the 1980s under the name of Rubbertuators.

The retraction strength of the PAM is limited by the sum total strength of individual fibers in the woven shell. The exertion distance is limited by the tightness of the weave; a very loose weave allows greater bulging, which further twists individual fibers in the weave.

**Advantages**

* **Very lightweight** because the main element is a thin membrane. This allows PAMs to be directly connected to the structure they power, which is an advantage when considering the replacement of a defective muscle. If a defective muscle has to be substituted, its location will always be known and its substitution becomes easier. This is an important characteristic, since the membrane is connected to rigid endpoints, which introduces tension concentrations and therefore possible membrane ruptures.
* **Inherent compliant behaviour**: when a force is exerted on the PAM, it "gives in", without increasing the force in the actuation. This is an important feature when the PAM is used as an actuator in a robot that interacts with a human, or when delicate operations have to be carried out.

**Disadvantages**

* **The** **force is not only dependent on pressure but also on their state of inflation**. This is one of the major disadvantages, because the mathematical model that supports the PAMs functionality is a non-linear system, which makes them more difficult to control precisely. However, the relationship between force and extension in PAMs mirrors what is seen in the length-tension relationship in biological muscle systems.
* **Gas is compressible**, so a PAM that uses long tubes must have a control system that can deal with a delay between the movement control signal and the effective muscle action. A PAM actuator system needs electric valves and a compressed air generator too, which are neither light nor small.
* **The loose-weave nature of the outer fiber shell** : If a gap is created by externally pushing an object into the loose weave, this gap allows nonuniform swelling of the internal bladder, which may inflate through the gap and rupture the internal bladder.Therefore,it is important for the surface fibers to stay evenly distributed and undisturbed across the internal bladder

**Hydraulic operation**

Although the technology is primarily pneumatically (gas) operated, there is nothing that prevents the technology from also being hydraulically (fluid) operated. Using an incompressible fluid increases system rigidity and reduces compliant behavior.

Reference

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2. <http://en.wikipedia.org>
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4. Behavior-Based Robotics: Ronald C. Arkin; The MIT Press, Cambridge, MA, 1998.