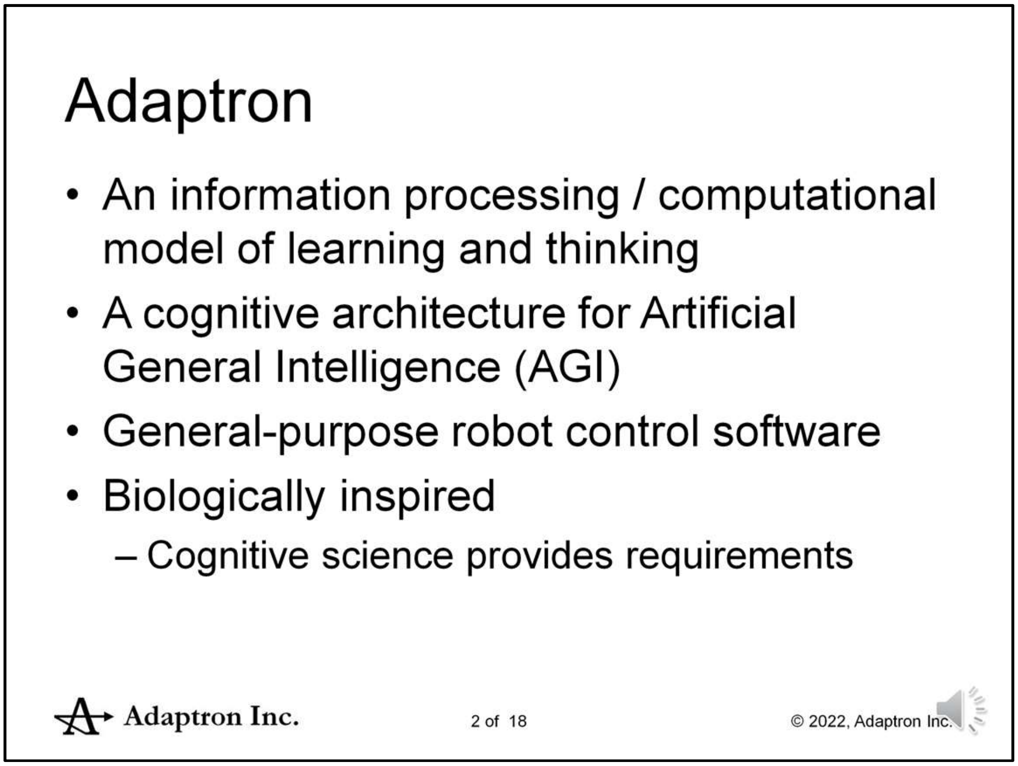
Introduction to Adaptron

Version 2.0
20th March, 2022

Adaptron Inc. 1 of 18

This introductory presentation provides a short overview of what Adaptron is and the objectives for its development.
It summarizes the key requirements and touches upon the subjects of:
- Autonomous robots and their motivations
- Perception, sensing and action
- Binons and the artificial neural network
- Action control
- Thinking / reasoning



I originally described Adaptron as an information processing model of learning and thinking.

Today it would be called a computational model.

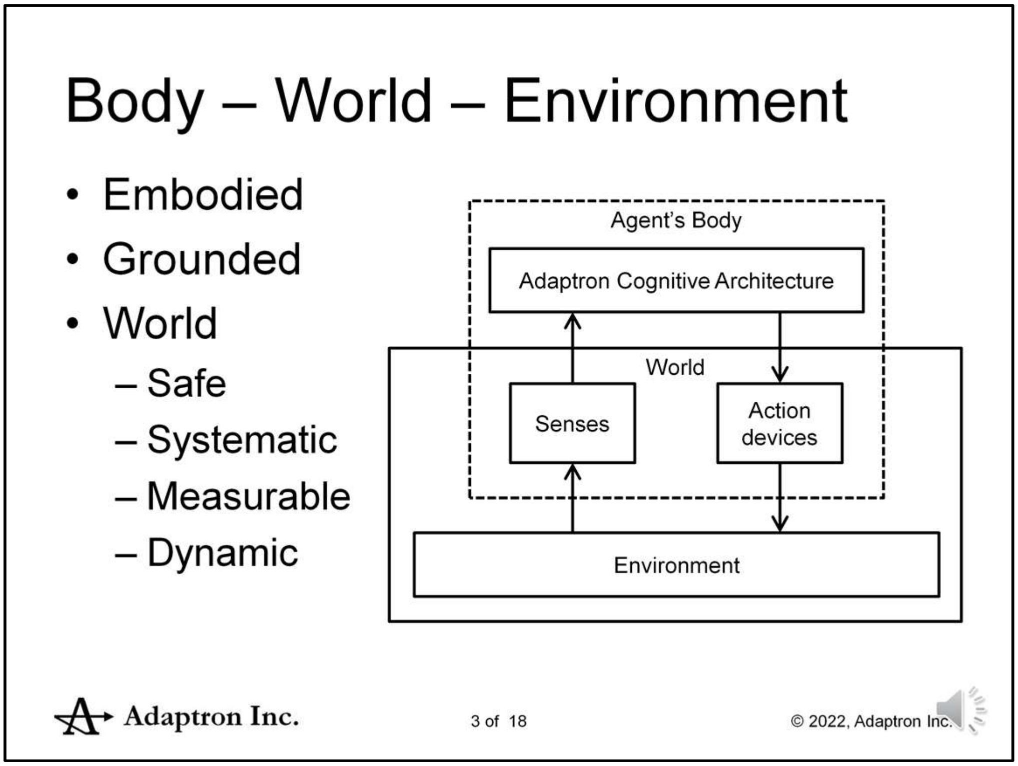
It is a cognitive architecture for Artificial General Intelligence.

In more practical terms it is: general-purpose robot control software.

Biological evolution has already resulted in intelligent organisms,

so I reuse any designs that nature has created that are useful.

Cognitive science is an excellent source of requirements for modelling behaviour and thinking



The Adaptron software is designed to operate in an agent's body with sensors and action devices.

This means it is grounded on the real world and its interactions with it.

Senses and action devices are part of the world because they can change from damage or wear.

The world must be safe long enough for Adaptron to achieve its goals.

At some level of complexity it needs to be systematic otherwise it is random and nothing can be reliably perceived or done.

The world must have sources of measurable energy (light, noise etc.) for sensing.

It must also be a sink for energy when performing actions such as moving, speaking etc.

The world needs to be dynamic because a static world is quickly learnt and no change can take place or be performed.

General Requirements

- Simple
  - Occam's Razor
- Compositional
  - Reuse simpler behaviour
- Deterministic
  - Explainable behaviour
  - Completely observable, transparent

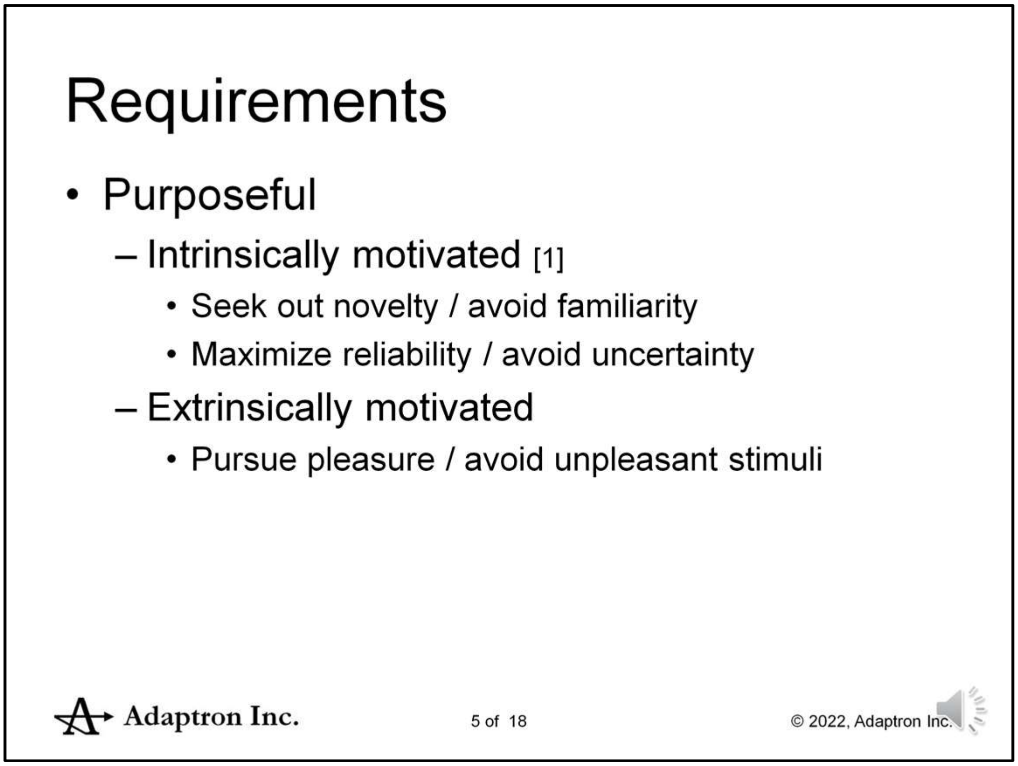
One of the driving principles for its design is to be as simple as possible and still provide the functionality required.

Compositional means Adaptron reuses its simpler behaviours to build more complex ones.

The simpler behaviours are learnt first and combined to achieve more complex behaviours.

Another requirement is that one can observe its internal functioning and explain in a deterministic way how it learns, acts and thinks.

This means that you will find all my definitions and descriptions are very strongly mechanistic / functional.



Its motivation to act must come from the need to explore, be certain and to pursue pleasant stimuli.

Exploration seeks out novelty and tries to avoid familiarity.

This is an intrinsic motivation because it arises from inside the agent.

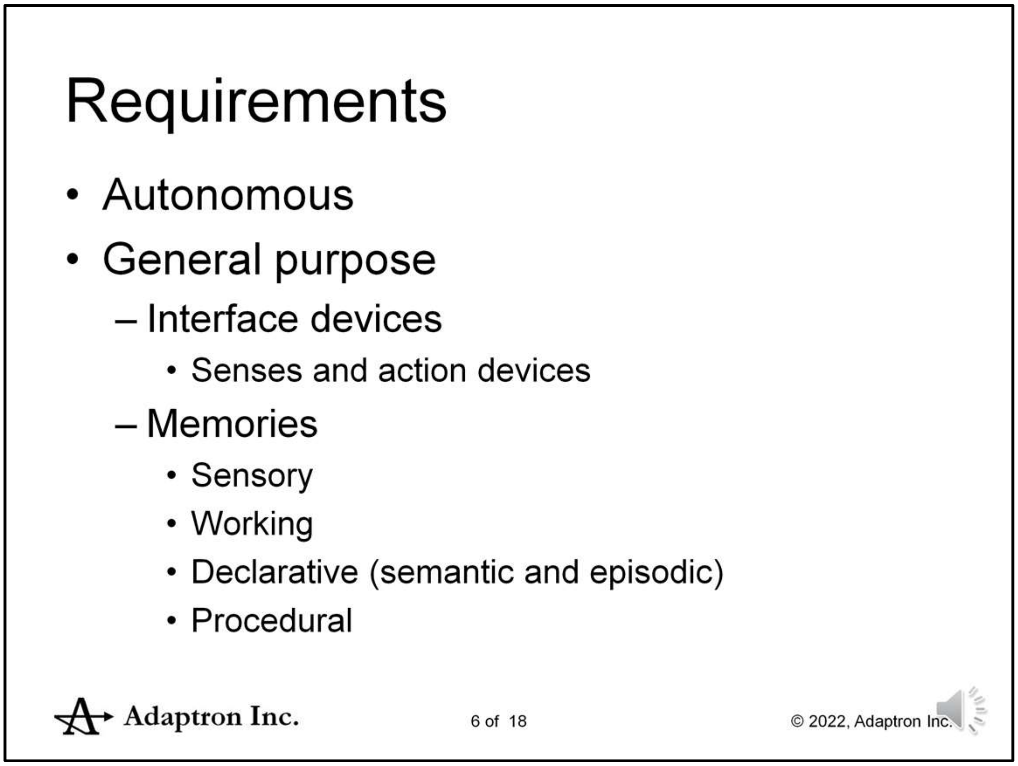
From a functional perspective it is just the comparison of current experiences with remembered ones.

If an experience matches a remembered one it is familiar, otherwise it is novel, worth memorizing and worth re-experiencing until it becomes familiar.

Maximizing reliable behaviour through practice is also an intrinsic motivation.

Pursuit of pleasant stimuli and avoidance of unpleasant ones is called extrinsic motivation because the reward comes from external things.

However, which stimuli are pleasant and unpleasant is built-in when the software is programmed.



Adaptron must not be controlled like a puppet. It needs to act independently, that is autonomously.

If we want it to do things that humans do it is going to have be general purpose.

This means it must work with a variety of senses and action devices.

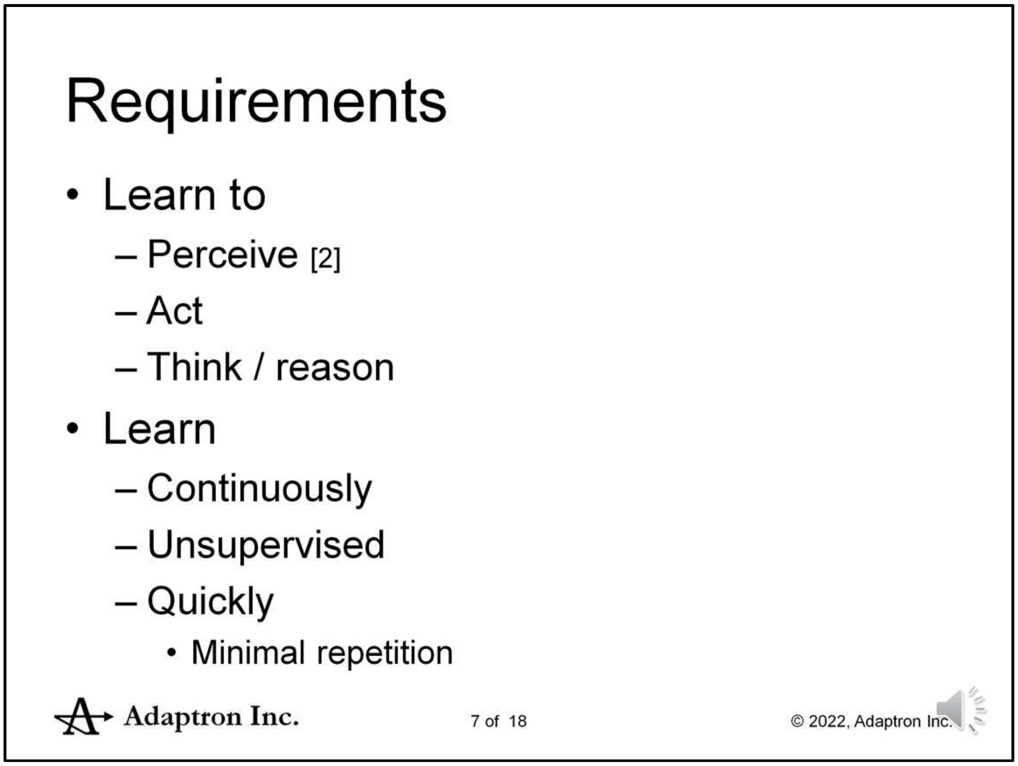
It must also have a variety of memories that span different time scales and purposes.

Sensory memory for events last for a maximum of a few seconds.

Working memory captures ones last few thoughts.

Declarative memory keeps ones knowledge about things and events that have happened.

Procedural memory contains the knowledge of how to do things.



Adaptron needs to learn to perceive both spatial and temporal pattern.

It needs to learn to perform actions simultaneously on more than one action device.

And it needs to learn to think / reason.

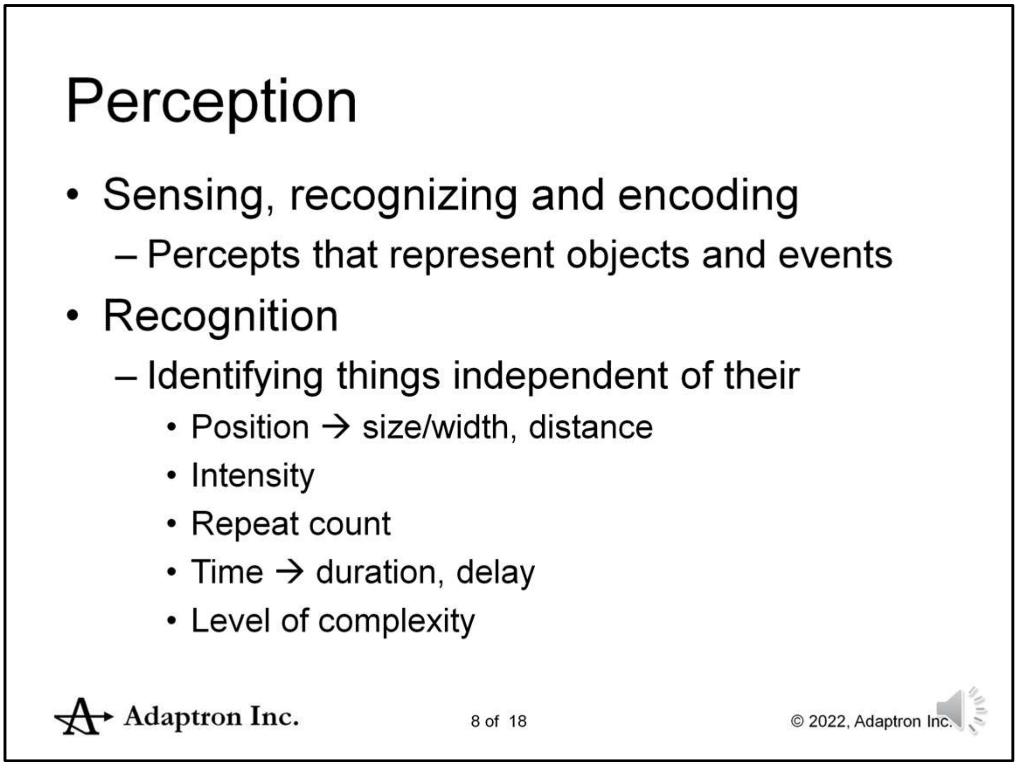
It needs to learn continuously in the real world in an unsupervised manner.

By unsupervised I mean there is no training stage and then a test stage in its growth.

It must continuously learn the patterns in the world and adapt its actions based on its motivations.

Learning also needs to be based on as few experiences as possible.

Adaptron should not have to repeat an experience more than a few times to learn it, provided it is based on less complex behaviour that it already knows.



Perception in the process of sensing, recognizing and encoding percepts that represent objects and events

Sensing measures the environment. Encoding forms memories of the things sensed (i.e., percepts)

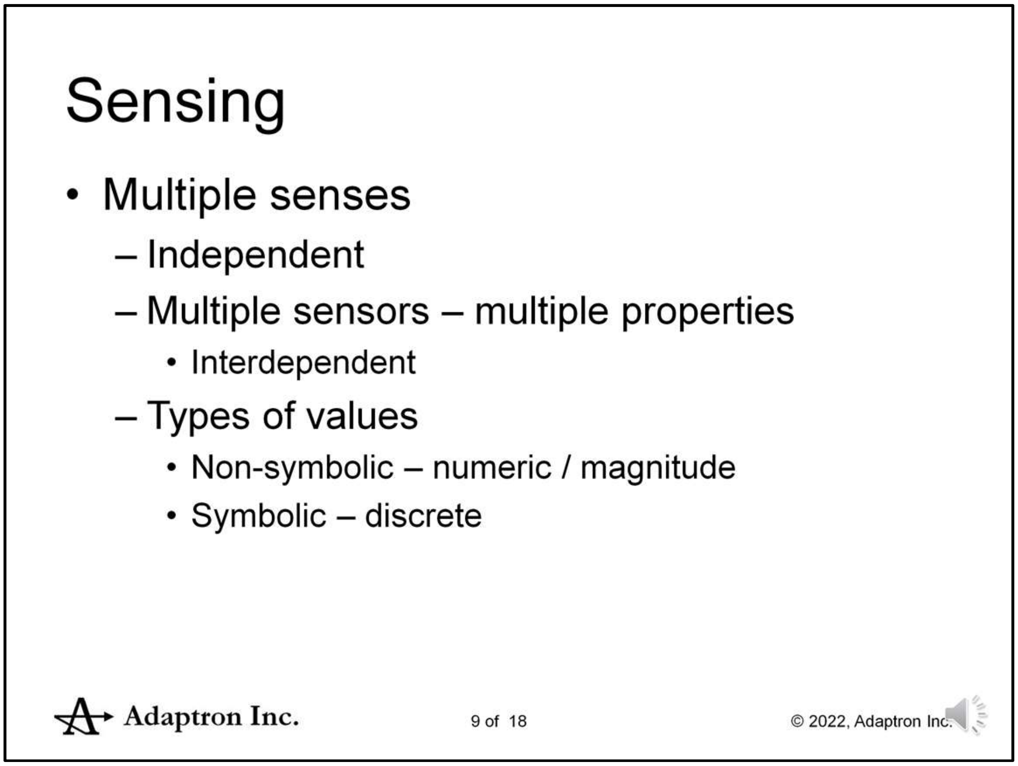
Recognition is the process of identifying what something is.

And Adaptron needs to learn to recognize things in its environment.

And once such things have been learnt it must be able to re-identify them no matter where they are, how big they are, how bright they may be or how many there are.

It must be able to recognize things as they change in time. A rotating object is a good example. It might look quite different from one angle to another.

It must also be able to do this for things at all levels of complexity.



Adaptron must to be able to take in stimuli from multiple types of senses and sensors.

Examples of senses include sight, hearing and touch.

These three senses are independent of each other because they detect different sources of energy.

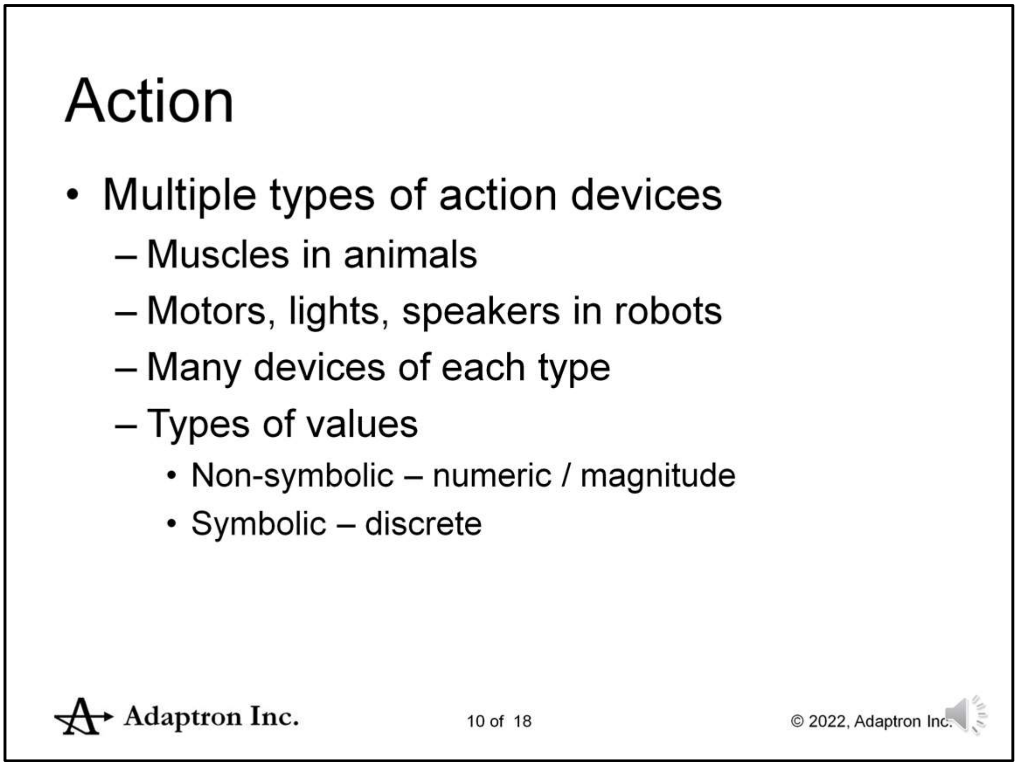
Within each sense there are multiple types of sensors and many of each type.

For example in sight there are two types of sensors. The rod sensors for brightness and the cone sensors for colour. And there are many sensors of these two types covering the surface of the retina.

Sensors of the same type are beside each other, (e.g. in the retina) they are interdependent, they have an adjacency relationship.

Biological sensors measure the magnitude or intensity level of the property they detect. They produce non-symbolic numeric values

But a robot could have more intelligent sensors that identify things and return symbolic information such as A, B, C, car, tree, house, pedestrian, pencil, stop sign, etc.



Adaptron needs to have an effect on its environment by producing responses on its action devices.

There are many types of such devices.

Biological action devices are usually muscles that control limbs, eyes, breathing and the larynx for ones voice.

Robotic examples are motors to control limbs or wheels, lights and speakers.

And a robot could have many of each type.

Simpler action devices are given non-symbolic numeric valued responses indicating the change they should make.

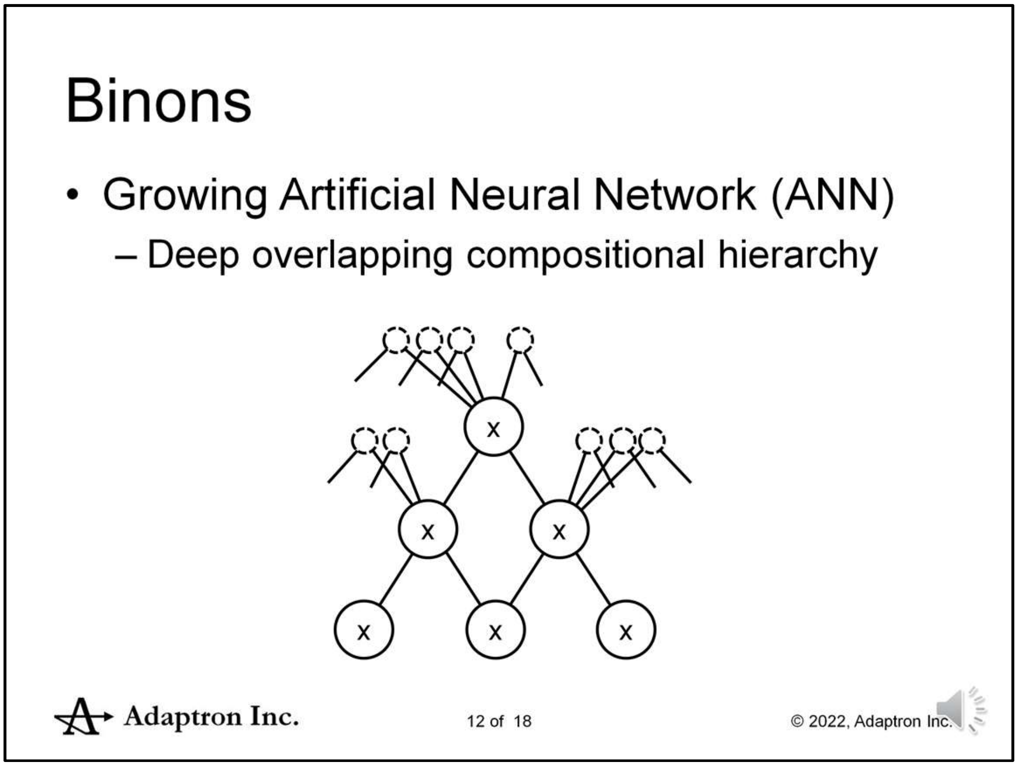
More intelligent action devices are given symbolic responses such as a desired position, a final result.

Binons (Binary Neurons)

- Mental representations for
  - Properties
  - Objects and Events → Percepts
    - Spatial and temporal
  - Acts
    - Spatial and temporal
  - Concepts
  - Relationships between them

Adaptron Inc. 11 of 18

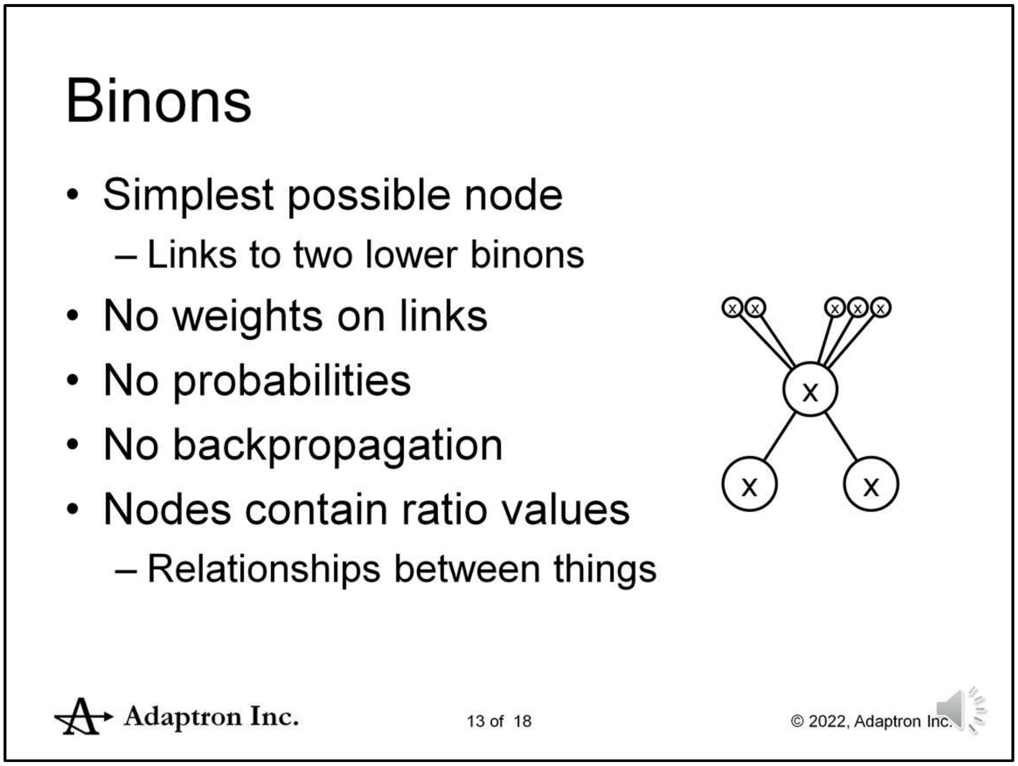
Binons are binary neurons. They are artificial neural nodes used to represent things.
They are binary because they are composed of two lower source nodes.
They can represent such things as properties which have values.
They can represent spatial objects and temporal events which are percepts,
spatial and temporal acts, concepts and relationships between these things.



Binons are combined in a growing multi-level tree structure which reuses lower level binons to form more complex binons.

This is a deep overlapping compositional architecture.

Binons are reused and shared in combinations to represent higher level ones.

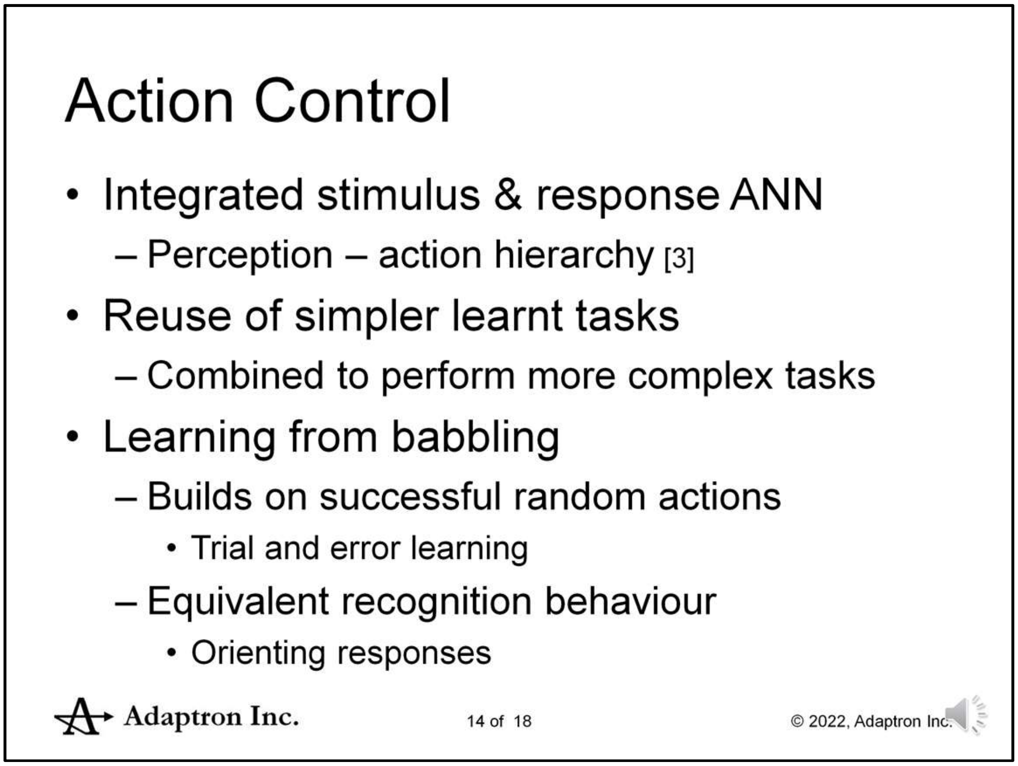


Binons are the simplest possible artificial neural node that can be used to represent things.

They differ from the nodes in deep learning architectures in that they have no weights on the links and make no use of probabilities or backpropagation.

This allows one to explain exactly how Adaptron makes decisions and behaves (i.e. deterministic)

However the binons contain ratio values that quantify the relationships between things.



Adaptron’ s ANN is a tightly integrated network of the things it recognizes and the actions it performs.

Actions are represented as binons just like things that are recognized.

The same rules and processes used for learning to recognize things are also used for learning how to perform more complex action from simpler ones.

The one important difference is that action binons result in responses while recognition binons result from stimuli.

An example of the similarity between learning to recognize something and to perform an action is babbling.

Babbling is the random performance of actions and the memorization of those that produce interesting results.

These are then repeated to obtain the same results or combined with other learnt actions.

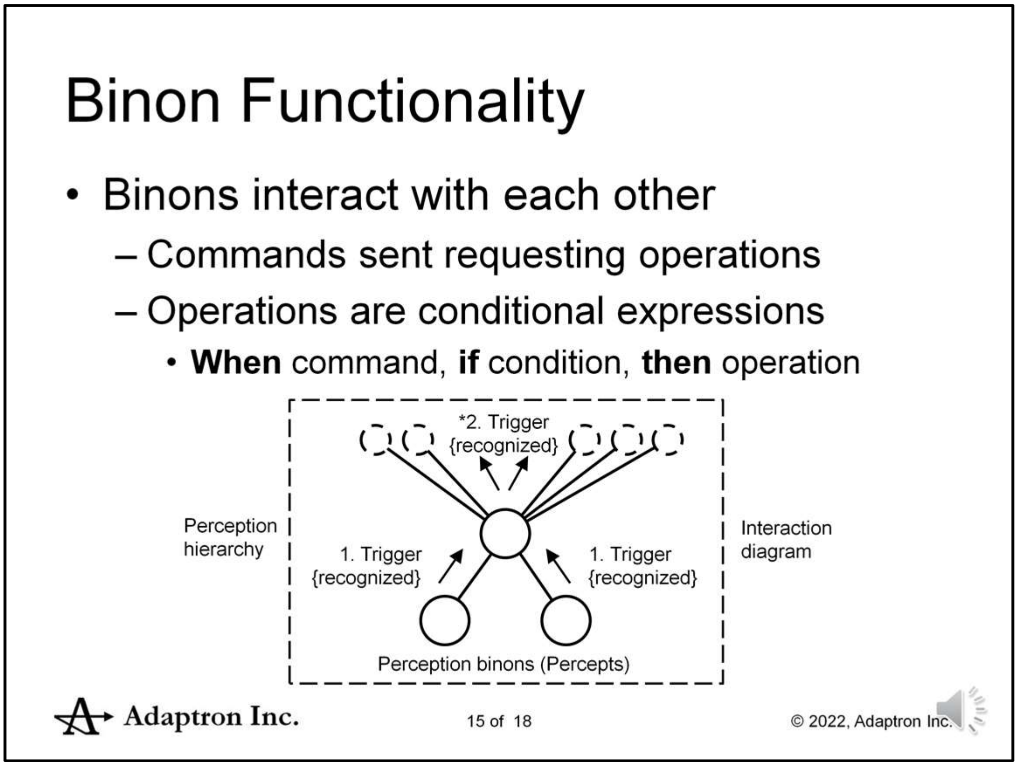
Most people are familiar with speech babbling. It is a subset of motor babbling.

The orienting response is the recognition equivalent to motor babbling.

It is a biological reflex that attracts attention to unexpected changes in stimuli.

Initially it is quite random because all stimuli are unexpected. One has no experience, no memory.

The orienting response causes a change in attention which is then learnt and repeated to obtain the same stimuli.



Binons interact with each other like objects in object oriented software.

They send commands to each other requesting that operations be performed.

Operations are simple conditional programs that take the form of **When** command received, **if** condition is true **then** perform the operation.

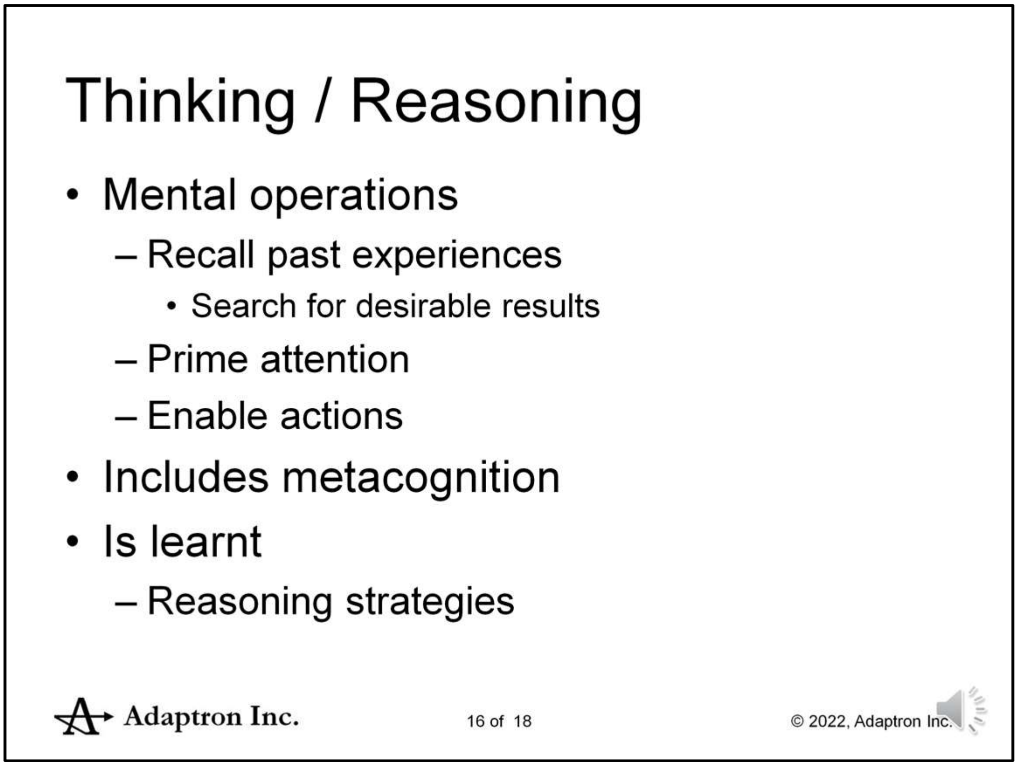
The operation performed may send a command to another binon as shown in the perception hierarchy.

After the lower binons have recognized their features they 1. trigger their upper binon.

If both binons have triggered the upper binon in the same time interval and its integer value “x” is matched then it 2. triggers all of its upper binons.

The result is a feed forward wave of activation up the perception hierarchy as illustrated in the binon interaction diagram.

For action hierarchies the wave of activation flows down the tree.



Adaptron needs to think / reason. It needs to use its memories as its model of reality.

It uses this model to search the possible consequences of its actions before doing them.

Percepts become concepts when recalled. Thinking is always searching for desirable results.

Searching memory results in the traversal of the network. Up the tree for more specific things, down the tree for more general concepts and across the tree for associated things in space or time, i.e. what is expected to happen next.

A train of thoughts comes to an end when an action is thought about that would result in something desirable. The decision is then made to perform that action. The action may be to pay attention to something or perform some kind of motion.

But thoughts are not just recalled experiences. They also include feedback about how well the thinking process is working.

They include information such as “I know I knew it but I can’t remember it”, “It’s on the tip of my tongue” and “I know I don’t know that”.

This is called metacognition.

Thinking is not pre-programmed, it is learnt. Adaptron learns different reasoning strategies based on the subject being thought about.

Detailed Presentations

- Requirements
- Perception
- Recognition
- Action and Thinking
- Adaptron Architecture
- Senses, Sensors and Action Devices
- Binons
- Temporal Recognition
- Perception–Action Learning
- Thinking

Adaptron Inc.

This is a summary of the content of the more detailed presentations as currently planned.

References

[1] Baldassarre, Gianluca and Mirolli, Marco Editors. (1998). Intrinsically Motivated Learning in Natural and Artificial Systems, Springer, Publishers

[2] Martensen, B. N. (2013). Perceptra: A New Approach to Pattern Classification Using a Growing Network of Binary Neurons (Binons). In R. West & T. Stewart (eds.), Proceedings of the 12th International Conference on Cognitive Modeling, Ottawa: Carleton University.

[3] NIPS 2007 Workshop. Hierarchical Organization of Behavior: Computational, Psychological and Neural Perspectives, http://www.princeton.edu/~yael/NIPS_workshop

Adaptron Inc. 18 of 18

1/ A good book about intrinsic motivation

2/ My paper on binons and

3/ a link to excellent presentations on the Hierarchical Organization of Behavior.