Perception-Action Hierarchy and its Implementation Using Binons (Binary Neurons)

"If I have seen further it is by standing on the shoulders of giants"
Sir Isaac Newton (1643-1727 B.C.)

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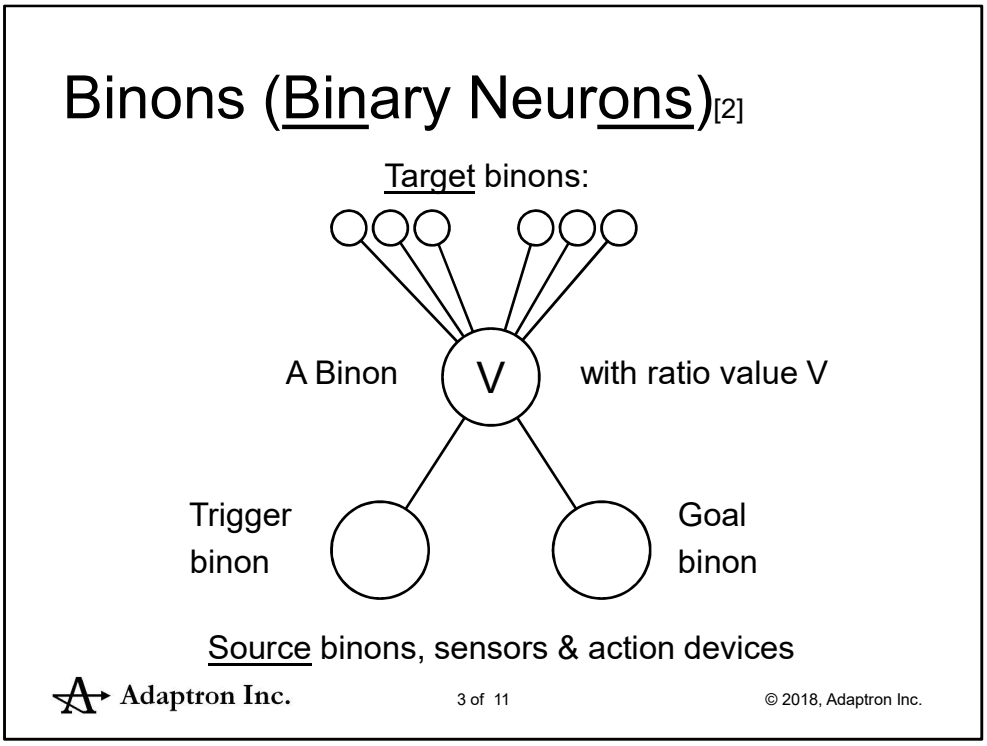
Abstract:
The perception-action hierarchy contains a model of the environment as experienced based on what has been recognized and done. This presentation gives a mechanistic/functional explanation of how binons(binary neurons) are used to represent and implement this hierarchy. Two kinds of temporal binons are used to learn and repeat experiences. They are the Action and Expectation control binons. They are equivalent to command neurons (production rules) and the prediction part of the motor control forward model. Learning takes place in the three stages of babbling(reusing), practicing and automaticity. The resulting hierarchy is a transparent, compositional, unsupervised, continuously growing, deep learning ANN.

The Perception-Action Hierarchy is part of the architecture used by Adaptron to remember what was recognized and what was done. An important emphasis here is on "WHAT". It is sense and action device independent. It does not remember where something was recognized or done. For example you can either see a square or feel it drawn on your back, sense independent. Or you can draw a square with your finger, toe, tongue or eyes, device independent. This presentation describes how this hierarchy is built out of binons and how it works. A lot more detail can be found in other presentations (see the references). A lot of these concepts are not new. What I have done is aggregate the ideas that too-many-to-mention brilliant scientists before me have invented and published in the areas of psychology, cognitive science, artificial intelligence, neuroscience, psychophysics and robotics.

Presentation link

- www.adaptroninc.com
  - Presentations [1]
    - Perception-Action Hierarchy
      - Video and Slides with comments

The full presentation can be found at this website.



Binons are the design and implementation of habits. We learn and can perform habits. Binons are learnt and can be performed.

Source binons are closer to sensors and motor/action devices so are more general. Two source binons are combined to form a target binon. This is a compositional structure, binons are combined together. Binons are reused by multiple target Binons. Source binons represent the more primitive properties, features and responses.

Target binons are more specific. They represent combinations of properties, features and responses.

Binons contain a ratio value that represents the relationship between its two source binons.

The words “Source” and “Target” are used to describe the roles played by binons based on their level of complexity.

The words “Trigger” and “Goal” are used to describe the roles played by binons based on their left or right relationship.

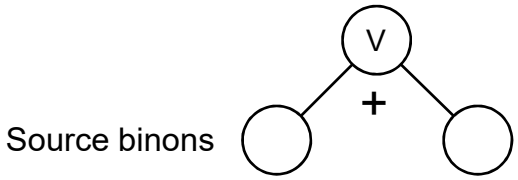
Features

- Simple and deterministic hierarchy
  - No weights on the links
  - No stochastics
  - No back propagation
    - feed-forward only
- 100% Explainable behaviour
- Grounded
  - Multimodal sensors and action devices

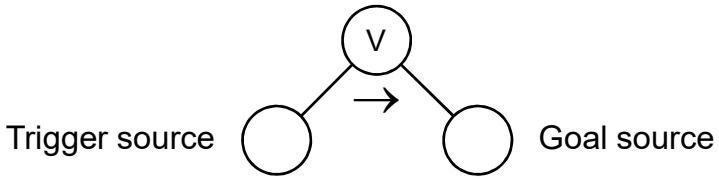
Binons are deterministic. There are no probabilities involved and there are no weights on the links. This means that what they do and why they do it can be clearly explained

Pattern Recognition

- Spatial – Simultaneous



- Temporal – Sequential



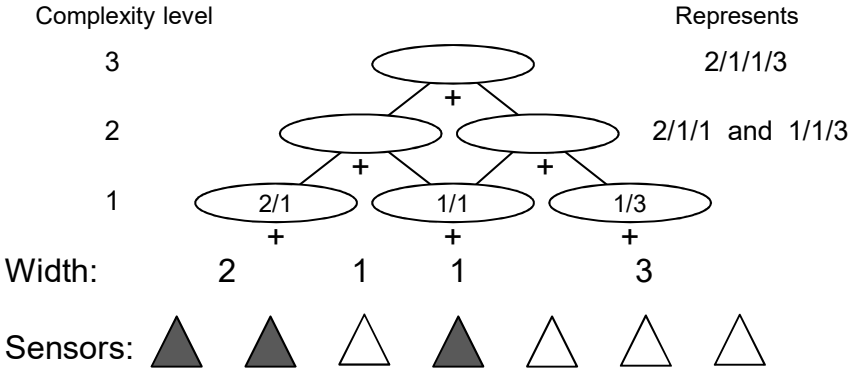
There are two types of binons: spatial and temporal. The "+" and "→" symbols appear under a binon to indicate these two types.

For spatial recognition a binon represents a pattern of things in which the two parts (source binons) have occurred simultaneously (in parallel).

Temporal binons represent things that take place in sequence. They are necessary to recognize patterns such as speech but also to control actions and thinking.

Recognizing Shapes

- Shape patterns, ratios of adjacent widths



Ratios of widths are used to represent shapes. Widths are the number of adjacent sensors with the same intensity readings. Widths are magnitude values.

Level 1 binons contain values representing the ratios. Higher levels of overlapping binons actually contain zero values because only the links to the two source binons are required.

Features

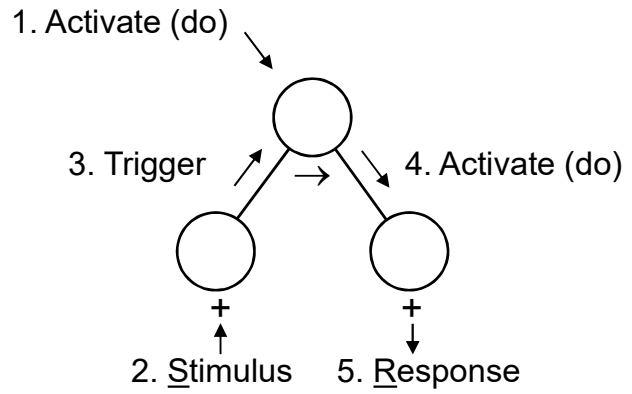
- Compositional hierarchy
  - Reuses simpler parts
    - Represent more complex patterns
  - Growing network [3]
    - Add a new binon for a novel pattern
    - If the two source binons are familiar

A network of binons is continuously learning. New binons are added to represent new patterns of stimuli and responses.

This means a binon network is an un-supervised ANN. However the growth rate is gradual and controlled – see the presentation on Learning for more details.

Temporal Action Control Binon [1]

- **If** recognize stimulus **then** perform response



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This interaction diagram captures the order in which an action control process takes place. It is a production rule (If condition then action) as used in ACT-R and SOAR.

The trigger source binon represents and recognizes a stimulus from the environment (via the senses) or a simultaneous combination of stimuli to represent concepts and objects.

The goal source binon represents and activates a simple or complex action (a response) in the environment (via action devices).

The temporal control binon in the center represents and controls what response to perform when a stimulus is recognized.

The process starts when the action binon is activated (1). It is primed waiting for the stimulus to be recognized. When the stimulus is recognized (2) the action binon is triggered (3). The action binon then activates (4) the response which gets done (5). The temporal binon notifies all it trigger targets (not shown) that it is done. Any previously activated trigger targets will then be triggered. If there are no previously activated trigger targets then the action control process is finished.

Features

- Spatial and temporal
  - Perception
  - Action control

The Resulting Hierarchy is a:

- Transparent
- Compositional
- Unsupervised
- Continuously growing
- Deep learning
- Artificial Neural Network

Thank you

[1] www.adaptroninc.com/BasicPage/presentations-and-slides

[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] www.adaptroninc.com/sites/default/files/inline-files/Learning%20V1.pdf