Neural Basis of Analogical Processing

- Yoonsuck Choe
- Department of Computer Science
- Texas A&M University
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Paper is available under the topic Neural Basis of Analogical Processing at:

http://www.cs.tamu.edu/faculty/choe/publications/bytopic.html

Locke’s Isomorphism

Relation between:

- objects and events in the world
- internal representations

Common Interpretations of S&C’s Theory Lead To:

- Need an explicit comparison process.

Shepard & Chipman’s 2nd Order Isomorphism

Relation between:

- relations in the world
- relations in the internal representations
Another View of S&C’s Theory

- Still need an explicit comparison process, to **evaluate** the relational representation.

New Approach: Active Relations and Representations

- Once a representation is activated, it **invokes** the other representation.
- Cooccurrence statistics become important in determining what other representations to invoke.

Active Units: They Are Just Like Neurons!

- Neurons in our brain does just that!

Difficulties in Current Neuroscience

Research is focused on what kind of information neural spike trains **encode**, i.e. what they **represent**.

1. Neurons receive encoded signal.
2. Neurons decode and perform transformations.
3. Neurons transmit new information for **further analysis**.

→ problem of **infinite regress** (problem of homunculus).
How the Active Neurons Approach Differ

- What other neurons a single neuron can invoke becomes important.
- That is, what action is taken by a neuron becomes important.
- With this, two things become equally important:
  1. the features a neuron is sensitive to (representation)
  2. what other neurons it can potentially invoke (relation)

Thus, relation now becomes active.

Collection of Active Neurons: Analogical Power

World of Fruits

[q] Big Apple : Small Apple = Big Orange : ?

Which neuron’s activity was not input-driven?

- the Word-Orange detector.

Note that this is the exact answer to the analogical query above!

Neural Basis of Analogical Processing

- Cortico-cortical connections: analogical completion
- Thalamo-cortical connections and nRt: analogical filtering
Analogy

Analogy is the ability to:

- see similarities in attributes (surface similarity)
- see similarities in attributes relations (structural similarity)
- power of mapping one totally different domain into another!

Power of analogy:

- Crux of high-level cognition and creativity.
- Basis of language and culture (in the form of metaphor).
- Basis of significant scientific discovery.

Summary

- Brain may be a massive analogical device.
  - Not only cognition, but also perception and motor function may work under similar mechanisms!
- Cooccurrence in sensory and motor events is very important in establishing active relational links.
- Statistical regularities in nature can give us a clue on how things are organized in the brain.