Chapter 6. Semantic Representations

The Quest for Artificial Intelligence, Nilsson, N. J., 2009.

Lecture Notes on Artificial Intelligence, Spring 2012

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Overview of Chapter 6

- In early 1960s, the way to represent semantics
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    - How to organize facts in the computer's memory
    - Early version of semantic network
  - Semantic network
    - Quillian’s network

Chapter 6. Semantic Representations

6.1 Solving Geometric Analogy Problems

Solving Geometric Analogy Problems

- Geometric-analogy
  - Thomas G. Evans(1934-)
    - Programmed a system that was able to perform well on some standard geometric analogy tests written in LISP
    - Each member of this class of problems consists of a set of labeled line drawings
- Evans's 1963 dissertation
  - Figure A is to Figure B as Figure C is to which of the following figures?
  - Problems of this type are widely regarded as requiring a high degree of intelligence for their solution and in fact are used as a touchstone of intelligence in some general intelligence tests used for college admission and other purposes
  - Example

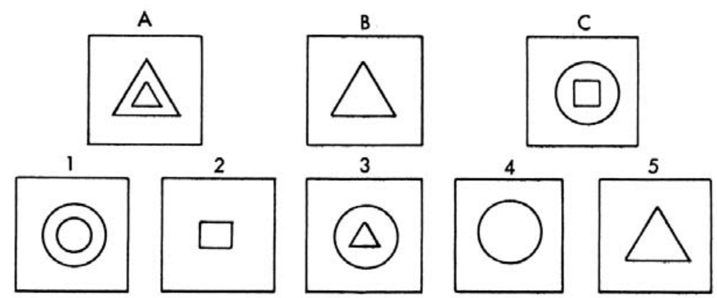

Figure 6.1: An analogy problem.

Solving Geometric Analogy Problems

- Evans represented diagrams and their parts as complex symbol structures consisting of rather elaborate combinations of lists and lists of lists whose elements indicated which parts were inside or outside (or above or below) which other parts, and so on.
- Specify “rules” how one diagram could be transformed into another

- Evans's result
  - Allowing ourselves only [the parts of the program actually implemented], our estimate would be that of the 30 geometric-analogy problems on a typical edition of the ACE tests, [the program] can successfully solve at least 15 and possibly as many as 20 problems.

Chapter 6. Semantic Representations

6.2 Storing Information and Answering Questions

Storing Information and Answering Questions

- Machine Understanding
  - Bertram Raphael(1936-)
    - A computer should be considered able to “understand” if it can converse intelligently, i.e., if it can remember what it is told, answer questions, and make responses which a human observer considers reasonable.
    - Raphael wanted to be able to tell things to a computer and then ask it questions whose answers could be deduced from the things it had been told
    - Examples

Storing Information and Answering Questions

- Problems
  - How to organize facts in the computer's memory?
    - For this problem Raphael put it, “The most important prerequisite for the ability to `understand' is a suitable internal representation, or model, for stored information. The model should be structured so that information relevant for question-answering is easily accessible.”
  - Raphael called his system SIR(Semantic Information Retrieval) by LISP

Storing Information and Answering Questions

- SIR(Semantic Information Retrieval)
  - The sentences that SIR could deal with involved “entities” and relations among these entities
  - Every time it was told new information add new entities and links
  - Had several mechanisms for making logical deductions and for doing simple arithmetic
  - Examples
    - Entities such as John and boy were represented by the LISP computer words JOHN and BOY, respectively
    - SIR would “link” a computer expression (SUPER-SET JOHN BOY) to the expression JOHN and link a computer expression (SUB-SET BOY JOHN) to the expression BOY
    - Thus, if SIR were asked to name a boy, it could reply “JOHN” by referring to BOY in its model, looking at its SUB-SET link and retrieving JOHN.

Storing Information and Answering Questions

- Conclusions
  - SIR was the first AI system to use the “exception principle”
    - General information about “all the elements” of a set is considered to apply to particular elements only in the absence of more specific information about those elements.
    - In the program, this idea is implemented by always referring for desired information to the property-list [that is, links] of the individual concerned before looking at the descriptions of sets to which the individual belongs
  - The exception principle was studied by AI researchers in much more detail later and led to what is called default reasoning and non-monotonic logics

Chapter 6. Semantic Representations

6.3 Semantic Networks

Semantic Networks

- Semantic Networks
  - SIR was an early version of what would become an important representational idea in artificial intelligence, namely, semantic networks
  - Oldest known semantic network was drawn in the 3rd century AD by the Greek philosopher porphyry in his commentary on Aristotle's categories

Semantic Networks

- Quillian's network (M. R. Quillian)
  - Interested in computational models of human mental processes, specifically memory organization
  - Developed memory model consisting of a semantic network
  - Nodes were interconnected by what he called “associative links”
  - Central Question of this research
    - What constitutes a reasonable view of how semantic information is organized within a person's memory? In other words: What sort of representational format can permit the `meanings' of words to be stored, so that humanlike use of these meanings is possible?
  - Example

Semantic Networks

- What way is Quillian's network a model of human memory organization?
  - Comparing and contrasting two different words = “spreading activation.”
  - Total “distance” along this path between the two words could be used as a measure of their similarity
  - The path can be used to produce an account comparing the two words.
  - Examples
    - Compare the words “cry” and “comfort.”
    - The spreading activations would intersect at the word “sad,” and the English account would express something like “to cry is to make a sad sound, and to comfort is to make something less sad.”

Semantic Networks

- Quillian “disambiguate”
  - “After the strike, the president sent him away.”
  - The network can encode different meanings of the word “strike.”
  - One such might involve a labor dispute, another might involve baseball, and yet another involve a raid by military aircraft.
  - Which of these meanings is intended by the sentence?
    - president" would eventually reach concepts having to do with labor disputes before reaching concepts having to do with baseball or the military.
    - Thus, the “labor dispute“ meaning would be preferred because it is “closer,” given that the word “president” is in the sentence
- Quillian’s model
  - Quillian's model differs from some later semantic networks in that it does not have a predetermined hierarchy of super classes and subclasses.

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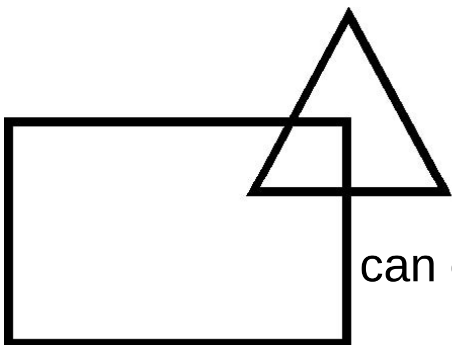
Appendix

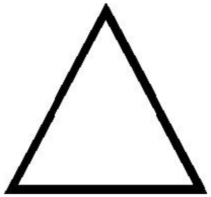
Solving Geometric Analogy Problems

- Evans's program
  - First transformed the diagrams presented to it so that they revealed how they were composed out of parts called “articular” representations

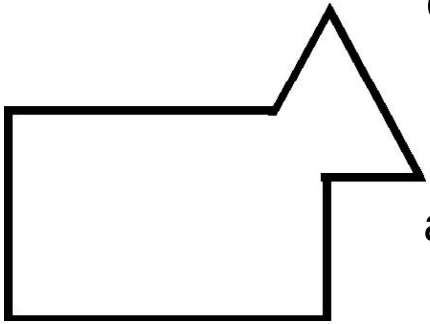


can either be decomposed into

and



or



and

  - Then, the first decomposition would be chosen

Storing Information and Answering Questions

- Bertram Raphael example
  - Every boy is a person.
  - A finger is part of a hand.
  - There are two hands on each person.
  - John is a boy.
  - Every hand has five fingers.
  - Then query “How many fingers does John have?"

Semantic Networks

- Examples
  - Consider the different meanings of the word “plant.”
  - One such meaning is given by linking the node PLANT to other nodes, such as LIVE,LEAF, FOOD, AIR, WATER, and EARTH, through connections that represent that a plant (according to this meaning of the word) is alive, has leaves, and gets its food from air, water, and earth.
  - Another meaning of “plant” links PLANT to other nodes, such as PEOPLE, PROCESS, and INDUSTRY, through connections that represent that a plant (according to this other meaning of the word) is an apparatus that uses people for engaging in a process used in industry
- Result
  - The meaning of a term is represented by its place in the network and how it is connected to other terms.