

Semantic Nets and Description Matching

— Winston, Chapter 2

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Topics

- role of representation
- examples of representations:
 - semantic nets
 - “describe and match” — an important problem solving method
- illustrated with: describe-and-match program working on a semantic net description
 - can solve geometric analogy problems
 - can recognize instances of abstractions in story plots
- describe-and-match and feature-based approach to object identification
- objective: how to evaluate representations

The Power of Representation

for background reading — see D. Norman: “Things That Makes Us Smart”, Addison-Wesley, 1993

- the power of the unaided human mind is highly overrated
- real power come from devising external aids / cognitive artifacts
 - that enhance cognitive abilities
 - that allow computational mechanisms to do work for us
- most important of our external aids:
 - pencil and paper
 - computational media
 - question: how do computational media transcend pencil and paper?
- two essential ingredients of a representational system:
 - the represented world
 - the representing world

Important Dimensions of Representation

- capture the important, critical features of the represented world while ignoring the irrelevant
- appropriate
 - to the person, enhancing the process of interpretation
 - to the task (from “human computer interaction” to “human problem-domain interaction”, domain-oriented design environments)
- computationally tractable
- representations are themselves objects that can be perceived and studied ---> meta-representations
- Herbert Simon (in “Sciences of the Artificial”) : *“Solving a problem simply means representing it so as to make the solution transparent.”*

An Example: Representations of the Official Airline Guide Worldwide

- a major design criteria: to pack as much information as possible into the smallest amount of space
- variety of tasks:
 - departure time
 - arrival time
 - flight duration
- some representations are good for some tasks and poor for other tasks
- computational media: can generate representations at “use time” in response to task descriptions — challenges:
 - at design time: a class of representations must be anticipated
 - the specific tasks must be communicated to the system at “use time”

Semantic Nets

An example problem: The Farmer, Fox, Goose and Grain

A farmer wants to move himself, a fox, a goose and some grain across a river.

Unfortunately, his boat is so tiny that he can take only one of his possession across on any trip.

Worse yet, an attended fox will eat a goose, and an unattended goose will eat grain, so the farmer must not leave the fox alone with the goose or the goose alone with the grain. What is he to do?

one of Winston's **powerful ideas** — the representation principle (compare to Simon's quote):

*once a problem is described using an appropriate representation,
the problem is almost solved.*

Four Fundamental Parts of a Representation

lexical part:

- determines which symbols are allowed in the representation's vocabulary
- in semantic nets: nodes (denoting objects), links (denoting relations between objects), and link labels (denoting particular relations)
---> compare to Hypermedia

structural part:

- describes how the symbols can be arranged
- in semantic nets: nodes are connected to each other by labeled links

procedural part:

- specifies access procedures (for creation, modification and questions)
- in semantic nets: constructors, readers, writers, and erase procedures
---> compare to abstract data types

semantic part:

- establishes a way of associating meaning with the descriptions
- in semantic nets: meaning of nodes and links depends on the application

Theoretical Equivalence is Different from Practical Equivalence

Informational and Computational Equivalence

- **informational equivalence:**
two representations are informationally equivalent if all of the information in the one is also inferable from the other, and vice versa. Each could be constructed from the information in the other.
- **computational equivalence:**
two representations are computationally equivalent if they are informationally equivalent and, in addition, any inference that can be drawn easily and quickly from the information given explicitly in the one can also be drawn easily and quickly from the information given explicitly in the other, and vice versa
- **examples:**
 - In principle, I can walk from Los Angeles to Boston on foot.
 - Number Scrabble versus Tic-Tac-Toe

The “Describe-and-Match” Method

in procedural English

feature-based object identification illustrates the “Describe-and-Match” method:

an unknown object is identified with an idealized object if their feature points are nearest neighbors in feature space

to identify an object using describe and match

1. describe the object using a suitable representation
2. match the object description against library descriptions until there is a satisfactory match or there are no more library descriptions
3. if you find a satisfactory match, announce it; otherwise announce failure

example: retrieval from a digital library

“Describe-and-Match” and Geometry Analogy Problems

The ANALOGY Program (Evans, 1963)

a geometric analogy net is a semantic net representation in which

1. the nodes denotes dots, circles, triangles, squares, rectangles and other geometric objects
2. some links denote relations among figures objects — specifically inside, above and to the left of
3. other links describe how figure objects are transformed — the possibilities are addition, deletion, expansion, contraction, rotation, and reflection, and combinations of these operations

Some Details of the ANALOGY Program

- geometric analogy problems: “A is to B as C is to X”
 - A: source figure
 - B: destination figure
- **describe** rules how A becomes B
- **match** the rule that explains how A becomes B to each rule that explains how C becomes an answer
- the best match between rules identifies the best answer

Describe-and-Match” and Recognition of Abstractions

— Example: Story Plots

story₁: Thomas and Albert

Thomas and Albert respected each other’s technical judgment and decided to form a company together. Thomas learned that Albert was notoriously absentminded, whereupon he insisted that Albert have nothing to do with the proposed company’s finances. This angered Albert so much that he backed out of their agreement, hoping that Thomas would be disappointed.

story₂: John and Mary

John and Mary loved each other and decided to be married. Just before the wedding, John discovered that Mary’s father was secretly smuggling stolen art through Venice. After struggling with his conscience for days, John reported Mary’s father to the police. Mary understood John’s decision, but she despised him for it nevertheless; she broke their engagement knowing that he would suffer.