Meaning Based Knowledge Representations

OUTLINE

1. memory for meaning
2. knowledge representation
    - what it is
    - approaches
        - propositions, object, (rules)
3. propositional representation
    - what is a proposition
    - analyzing propositions in sentences
    - aggregations of propositions
    - propositional networks
        - Case grammar
        - retrieval in propositional networks
4. object representations
    - relationship to propositional representation
    - schemas and the organizsation of knowledge
    - fuzzy categories
    - semantic networks

MEMORY FOR MEANING

What do we remember?
--gist, meaning

Verbal Information

Sacks 1967
memory for gist vs. surface structure
Wanner 1968
instructions can alter this

Visual Information

Mandler & Ritchey 1977 "token/type" distractors

Bower et al. 1975 droodles & explanations

Gernsbacher 1985 orientation

implications: meaningful interpretation

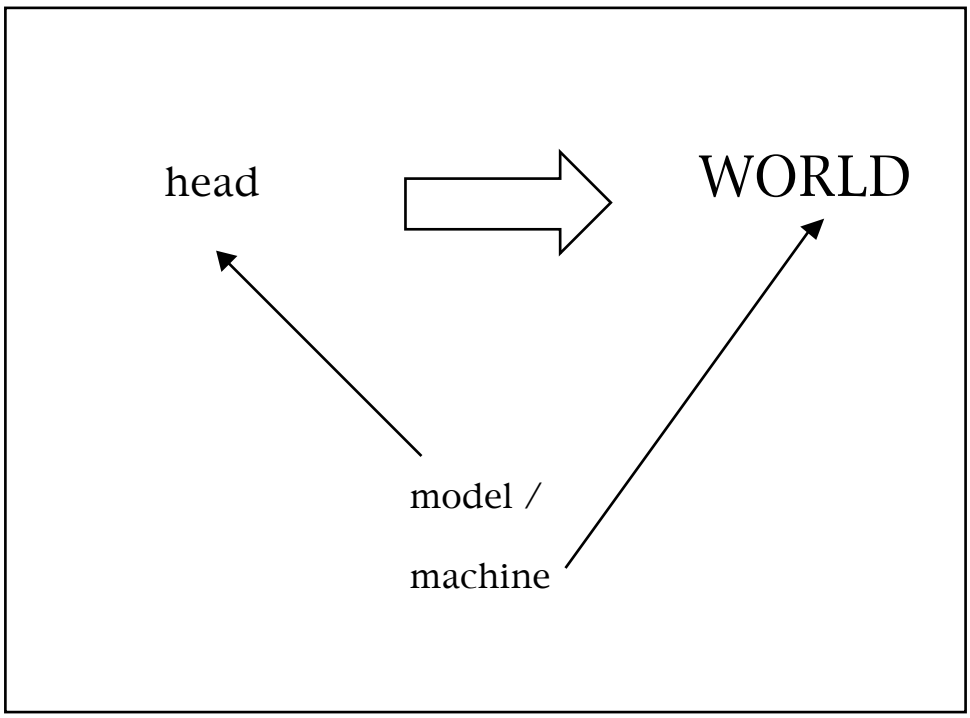
what is this gist/meaning?

KNOWLEDGE REPRESENTATION

How can we represent what we know?

What is the basic format of what we know?

Representation mappings:
in the head, of the world
in the machine/model, of the head
in the machine/model, of the world



Approaches to Knowledge Representation

facts:
- propositional representation

concepts:
- objects, schemas, frames

rules:
- connect conditions and actions

Facts and concepts can be represented in network formalisms:

- propositional networks
- conceptual networks
  - semantic networks
  - frame systems
  - inheritance hierarchies
  - “is-a” hierarchies
  - ontologies

PROPOSITIONAL REPRESENTATION:

1. What is a proposition?

it is:	basic unit of meaning
it has a:	truth value
syntax:	relation + arguments (r a a a a a .....)

simple propositions

(father john)	unary	(relation argument)
(father bill john)	binary	(relation arg arg)

more complex (higher arity)

(give, mary, present, john, past)

arguments are ordered* and all are necessary

*order is arbitrary but must be consistent

2. Analyzing the propositions in sentences

a complex sentence* can contain multiple propositions

"Lincoln, who was president of the US during a bitter war, freed the slaves."

Lincoln was president of the US during a bitter war.
The war was bitter.
Lincoln freed the slaves.

(president-of Lincoln US war)
(bitter war)
(free Lincoln slaves)

some complications:
"free" as action vs. state
(free US 1780)
how many arguments to use
generality of relations

* distinguish

complex sentence: composed of multiple simple sentences / propositions

complex proposition: uncertain number of args.
(see section on concepts)

Analysis: (can vary, but this is typical)

adjective => relation (noun is argument)

(bitter war)

can reify the adjective,
make it an argument with a more
general relation

(holds property-arg thing-arg)

(holds bitter war) or (is bitter war)

verbs => relation (subject, objects are arguments)
(time, place, manner as arguments?)

(free, Lincoln, slaves, past)

copula verbs

1. treat as regular verb (is => relation)

(is Lincoln President USA war)

2. drop "is", make property into relation

(president-of Lincoln USA war)

3. How propositions aggregate into larger
cognitive data structures

Bransford & Franks 1971

(eat ant jelly past)
(sweet jelly)
(on jelly table past)
(in ants kitchen past)

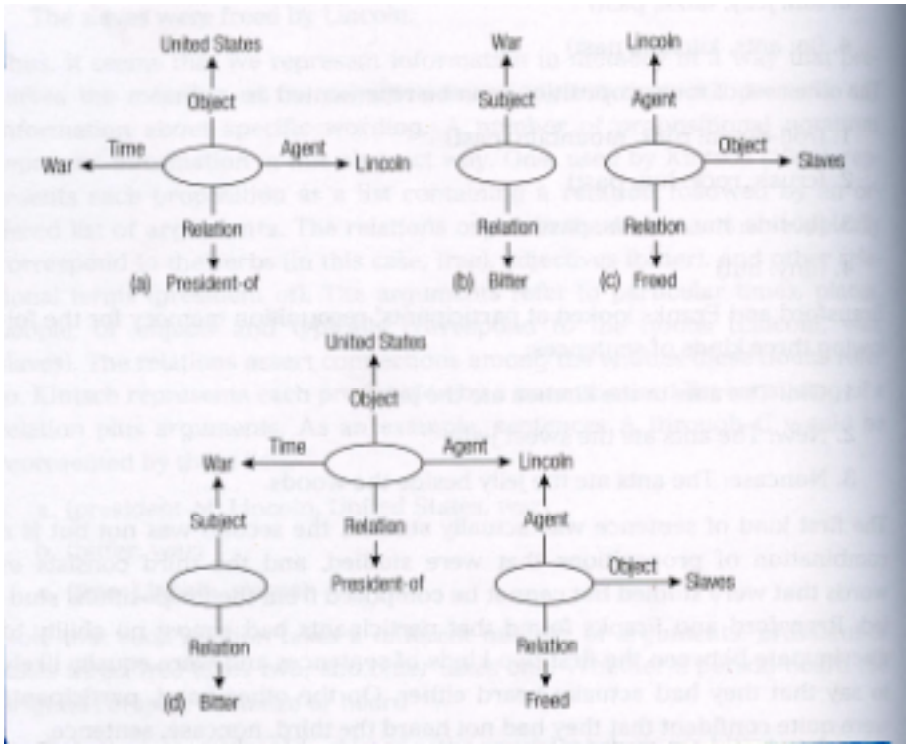
materials:
stories containing four propositions

hear:
sentences from these stories, (1-3 propositions)

dependent variables:
hear various sentences
some old (identical to what was heard)
some new (rearrangements of propositions)
some noncase (not true)
judge
whether heard before (exactly)
how confident

results:
old = new, vs. noncase
*memory & confidence function of
propositions in old or new

4. Propositional Networks



nodes and links

overlapping nodes =>
complex interconnected network

* importance of naming nodes consistently

network notation reveals connectivity
any other differences?

standard: (predicate arguments ....)
network:
empty node
labeled arcs ....
concepts ... pointed to by arcs

so we see in the graphs
- nodes = proposition itself
  - (like the parens of standard notation)
- labeled arcs:
  - relation (predicate/relation of logic)
  - small set of labels:
    - agent, object, subject, time, etc.
- concepts pointed to by labeled arcs:
  - the actual predicate and arguments

Case grammar:
- propositions have typical structure
- arguments can be classified
  - agent/subject
  - instrument
  - objects (various kinds)
  - time, location, etc.

reasons:

- reduce large number of slots of verbs to
  - small number of slots

1. constraints on natural language understanding

e.g., prepositions "on" -> location or time

e.g., verbs have structures indicating
- argument types

  transitive vs. instransitive verbs
  - John shot at the wall (object)
  - John cried at the wall (location)
    - cried intransitive (preference)

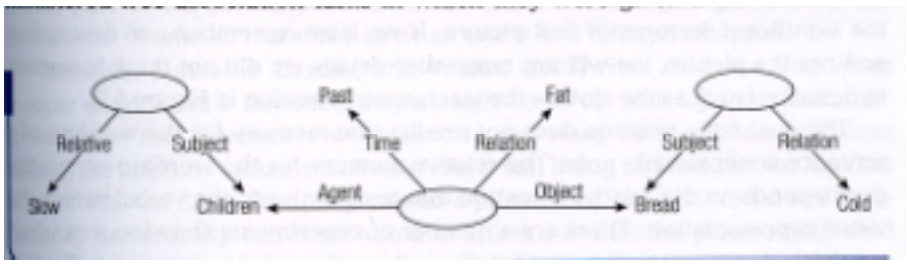
e.g., typing of arguments
- John talked with a microphone (instrument)
- John talked with Mary (object/coagent)

2. -> potential inferences about the arguments
   - agents are intentional, have "reasons"
   - objects are effected by actions

Retrieval in propositional networks

Weisberg 1969

Children who are slow eat bread that is cold
(slow children)
(eat children bread past)
(cold bread)



free association to slow -> children
bread -> cold

Memory is function of
hierarchical propositional structure,
not physical proximity of words in
actual sentence.

Problem: distinction between
concepts (or classes) vs. instances (of the classes)
e.g., all children, vs. set of them (with property)

diagram should have nodes for something like
children-01 instead of children
bread-01 instead of bread

and have links indicating that these are
subconcepts of, or subsets of the concepts
children and bread

e.g., (isa/subset children-01 children)
(isa/subset bread-01 bread)
(slow children-01)
(cold bread-01)
(eat children-01 bread-01 past)

Amodal vs Perceptual Systems:

Stanfied & Zwann 2001

nail pounded into wall or floor
recognition related to orientation

perceptual representation?
or schema invocation

inferences of the unstated
e.g., hammer was used

CONCEPT / OBJECT REPRESENTATION

1. Complex propositions -> object representations

problem: a complex relation (thing or event) has
lots of parts, may not mention all of them each time.

so - large (high arity) proposition is inflexible-
(how to leave out unknown arguments)

(similar to problems of argument lists, databases)

John happily gave Mary a necklace in Paris last summer to celebrate his promotion.

(give giver gift recipient time place reason emotion)

What to do with....
John gave Mary a necklace.

(give giver gift recipient time nil nil nil)

a solution:
a complex proposition can be broken into binary
propositions- "reification" (verb is reify)

(give, john, necklace-01, mary, past)

give a name to the particular event/thing....
"give-001" names this event

(instance give-001 give)
(agent give-001 john)
(recipient give-001 mary)
(direct-object give-001 necklace-01)
(time give-001 past)

can now add information using e.g.,
(location give-001 paris)

this leads to schema/object/frame

(give-action
(name give-001)
(agent john)
(recipient mary)
(direct-object necklace-01)
(time past)

(location moscow))

(action
(type give)
(name give-001)
....
(location moscow))

so we have three ways to represent the components of a complex proposition:

1. simple proposition
   (r a a a a a)
2. decompose it to binary relations
   (set of simple propositions including instance name)
3. object structure
   with named slots for the arguments

1. (rel a1 a2 a3 a4)

2.
```
(instance   object/event-name   type-of rel)
(rel-a1-of  object/event-name   a1)
(rel-a2-of  object/event-name   a2)
(rel-a3-of  object/event-name   a3)
(rel-a4-of  object/event-name   a4)
```

3.
```
(object/event-name
      (instance       type-of rel)
      (rel-a1-of      a1)
      (rel-a2-of      a2)
      (rel-a3-of      a3)
      (rel-a4-of      a4) )
```

2. Concepts / Schemas / Frames / Objects

As General Approach to Organization of Knowledge
- Classic Statements:
  - Bartlett, Piaget, Zen

Generality: "objects" can be
- concrete things
- events
  - Schank et al.
    - Scripts
      - (e.g., going to a restaurant)
        - slots.....
- ideas, goals etc.

Evidence:
- Brewer & Treyens 1981
  - false inclusions and omissions

part hierarchy....

3. Fuzzy Boundaries

Rosch, prototype theory

central tendency, notion of variance
not necessary and sufficient conditions
not firm boundaries

typicality judgements
reaction time to categorization
hedges
sensibleness in sentences
order of acquisition

Labov 1973

can this be accomodated in Schema Theory?

4. semantic networks

Quillian 1966, Collins & Quillian 1969

inheritance
spreading activation

redundancy ok
frequency affects strength of link
link traversal takes time