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requirements:
- 3 exams
- assignments
  - CLIPS
- participation, attendance
- academic integrity

sign up for the listserv

Introduction to Human Information Processing

OUTLINE

1. Motivations

2. Cognitive Psychology and Science (nature of)
   & introduction to cognitive simulation

3. History of Cognitive Psychology / Science

4. Role of Neuroscience

1. Motivations

Intellectual Curiosity

Foundations for Other Fields
- clinical, social psychology
- political science
- economics
- sociology
- linguistics

Information Science:

Humans are at center of information systems
(which are extensions of human functionality)

⇒ What are those functions

⇒ Human Factors Issues

Information Systems carry out or involve human functionality

⇒ Intelligent Systems Issues

Human Information Processing

- Inputs
  - Sensation
  - Attention
  - Perception
  - Pattern Recognition
- Storage
  - Interpretation
    - Knowledge Representation
  - Memory Storage and Retrieval
- Processing & Utilization
  - Learning
  - Decision Making
  - Problem Solving
  - Reasoning
  - Planning
- Communication
  - Language

Information Systems Involve:
- problem solving & decision making
- information storage and retrieval
  - databases
  - text retrieval
  - image retrieval
  - semantic web
    - knowledge representation
- language processing
  - summarization

Cognitive engineering:
- information capacity
- limits of attention
- pragmatics of communication
- cognitive task analysis

Human Computer Interaction (HCI), Human Factors
- interface design
- natural language interfaces
- visual interfaces
- multimedia/multimodal interfaces

Direct Applications and Implications

Education, training and performance
- Computer-based education & testing
- Intelligent Tutoring Systems (ITS)

Expert Systems, Knowledge Engineering, Robotics
- heuristic vs. algorithmic programming

2. Cognitive Psychology and Cognitive Science

Mature Systems vs. Research Science

Need for Abstract Analysis

Formal Information Processing Models

separation from physical instantiation
patterns and manipulations of patterns
finite "rules" ⇒ infinite applicability

Cognitive Psychology vs Cognitive Science

Research Techniques:

1. Experimental
   Independent and Dependent Variables
   patterns of errors
   reaction time
   memory performance

   functional relations between variables

2. Formal Theories
   linguistics, philosophy, comp. science

3. Computer Simulation

Production Systems Newell & Simon 1972

Architecture: three parts

1. KB Knowledge Base (aka working memory, fact list)
   facts and/or objects known to the system
   (including goals)

2. RB Rule Base
   set of rules system uses to reach conclusions
   based on contents of the KB

3. Inference Engine
   how the system works (using KB and RB)

KB and RB are problem specific (written by programmer)
Inference Engine is very general (provided to programmer)

1. KB Knowledge Base (aka working memory)
facts and/or objects known to the system

facts: (connected input1 output3)

objects: (typical syntax)

```
(deftemplate person
        "This defines the concept person"
                (slot name)
                (slot age)
                (slot eye-color)
                (slot hair-color)
                (slot weight)
                (slot height)
                (multislot hobbies)
                (multislot address)      )

(person
                (name John)
                (age 30)
                (eye-color brown)
                (hair-color brown)
                (hobbies programming hiking) )
```

2. RB Rule Base

set of rules system uses to reach conclusions based on contents of the KB

rule: condition(s) -> action(s)

condition: pattern of objects/properties

action: changes KB

add, delete, modify representations

cause I/O, external action

```
(defrule find-houses-with-same-name
        ?f1 <- (house (name ?n1))
        ?f2 <- (house (name ?n2))
        (test (neq ?f1 ?f2))
        (test (= ?n1 ?n2))
        =>
        (print ?n1) )
```

```
(defrule change-valve-status
        ?f1 <- (status (valve open))
        ?f2 <- (close-valve)
=>
        (retract ?f2)
        (modify ?f1 (valve closed)))
```

3. Inference Engine

1. selects which rules (operators) match into KB
   -> instantiations

2. selects instantiation (conflict resolution)

3. takes action of instantiation
   which generates new states

So: Heuristic Problem Solving:

Model facts and objects
Model what is done under different circumstances
Run rules untill solution or nothing else to do

3. History of Cognitive Psychology & Science

3.1 Greeks: Plato and Aristotle

memory and thought
empiricist vs. nativist (rationalist) views
associationism

3.2 Classical Philosophy:

Nativism — Descartes, Kant

British Empiricism — Locke, Hume, Mill, Berkeley
- associationism:
  - direct perceptions ->
    - faint copies of percepts ->
      - associations of copies

Rationalism — Leibniz, Hobbes
- thinking as formal reasoning,
  - manipulation of non-numeric symbols
    - e.g., Boole

3.3 Structuralist Psychology (19th century)

Wundt 1879 first laboratory
- elementatrism, reductionism
  - reduction screen, introspection,

Wurzburg School, Kulpe
- imageless thought debate

⇒ need for objective methods

3.4 Behaviorism Watson, Skinner

mistake: since all that is objective is external
can only study environment and behavior

further: that is all that is real - anti-mentalism,

study stimulus-response bonds,
reinforcement
a simple version of associationism

3.5 Reemergence of Cognitive Psychology
Effects of WWII, Developments in 1950's

Failure of Behaviorism
WWII evaluation and training of personnel

Human Factors
instrumentation, aviation, detection
Broadbent - theories of attention
active role of individual

Information Theory
information theory: Shannon
coding, translation etc.
signal detection theory
cybernetics (Wiener), technology
missiles, radar, communication etc.

Computer Science
flow and structure of information
control analogies
neural analogy: perceptrons
formal algorithms for cognitive procedures
1956 Newell and Simon

Linguistics Chomsky 1957
productivity, regularity
formal theoretic nature
rules, plans, organization
deep vs surface structure
criticism of Skinner (behaviorism)
lack of objectivity
unanimity in linguistics

4. Neuroscience and Cognition

differentiating between cognitive theories
vs. explaining how things work:

neural representation?

levels of abstraction/analysis

computer analogy

example: perception
low level – lines, edges, etc.
very explicit neural models

mid level – interpreting vectors of world shapes
that cause retinal shapes
very sketchy neural models

high level – interpreting known objects
no neural models