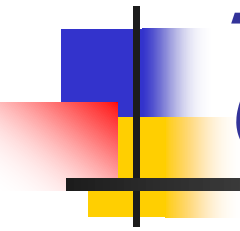


Introduction to Artificial Intelligence (G51IAI)

Dr Rong Qu

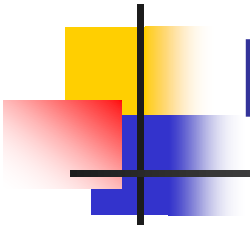
Knowledge Representation & Acquisition

Knowledge vs. Information

- We live in a time of information rich, but knowledge poor
  - J. Teresko. Information Rich, Knowledge Poor? - Data warehouses transform information into competitive intelligence. Industry Week, 3rd Feb, 1999.

- "The basic economic resource is no longer capital, nor natural resources, nor labor. It is and will be knowledge. Value is now created by productivity and innovation, both applications of knowledge at work."

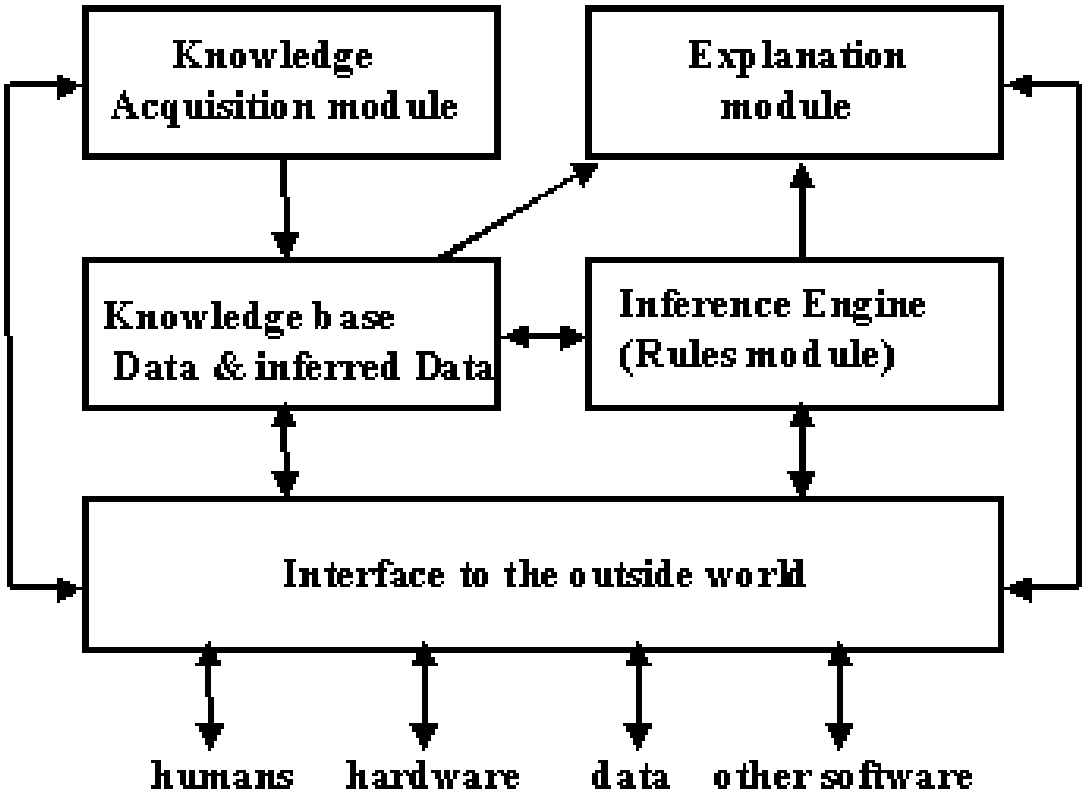
  Peter Drucker, Post-Capitalist Society , 1993



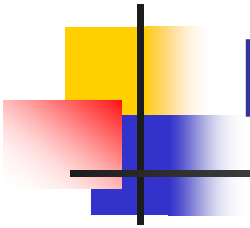
Knowledge Based Systems

- Humans use not only methods, but also domain specific knowledge, in problem solving
- Knowledge
  - Facts about the world
  - Necessary for intelligent behaviour (i.e. in robots)
- Much of AI involves building systems that are knowledge-based

Knowledge Based Systems



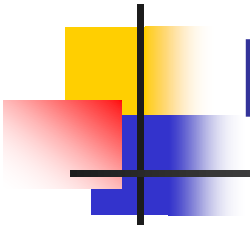
http://coventry.bcs.org/resources/artil.htm



Knowledge Based Systems

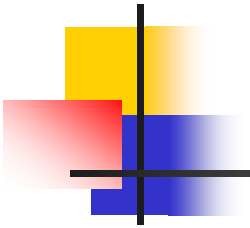
- An artificial intelligence system is capable not only of storing and manipulating data, but also of acquiring, representing, and manipulating knowledge.

- In automated AI systems, how do we
  - Represent knowledge
  - Acquire knowledge
  - Apply the knowledge, i.e. reasoning

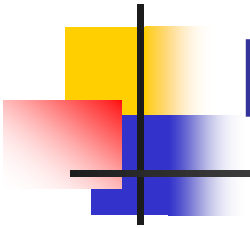


Knowledge Based Systems

- Representation
  - as a set of sentences of first order logic
  - symbolic encoding of propositions
- Acquisition
  - the transfer of potential problem-solving expertise from some knowledge source to a program
- Reasoning
  - deducing logical consequences
  - manipulation of symbols encoding propositions to produce representations of new propositions



Knowledge representation



Knowledge Representation

- English or natural language is an obvious way of representing and handling facts.

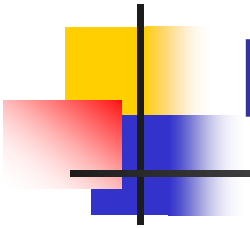
  spot is a dog

  all dogs have tails

- We can then deduce:

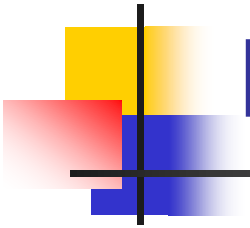
  spot has a tail

- Problems with natural language
  - Natural language is often ambiguous.
  - Syntax and semantics are not fully understood.
  - There is little uniformity in the structure of sentences.



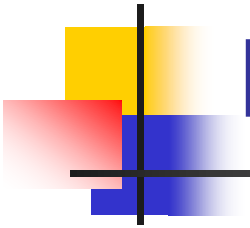
Knowledge Representation

- Logic enables us to consider the following fact as :
  spot is a dog as dog(spot)
- We could then represent that all dogs have tails with
  $dog(x) \rightarrow hasatail(x)$
- We can then deduce:
  hasatail(spot)
- Using an appropriate backward mapping function the English sentence spot has a tail can be generated



Knowledge Representation

- Four General Representation Types
  - Logical Representations
  - Semantic Networks
  - Production Rules
  - Frames

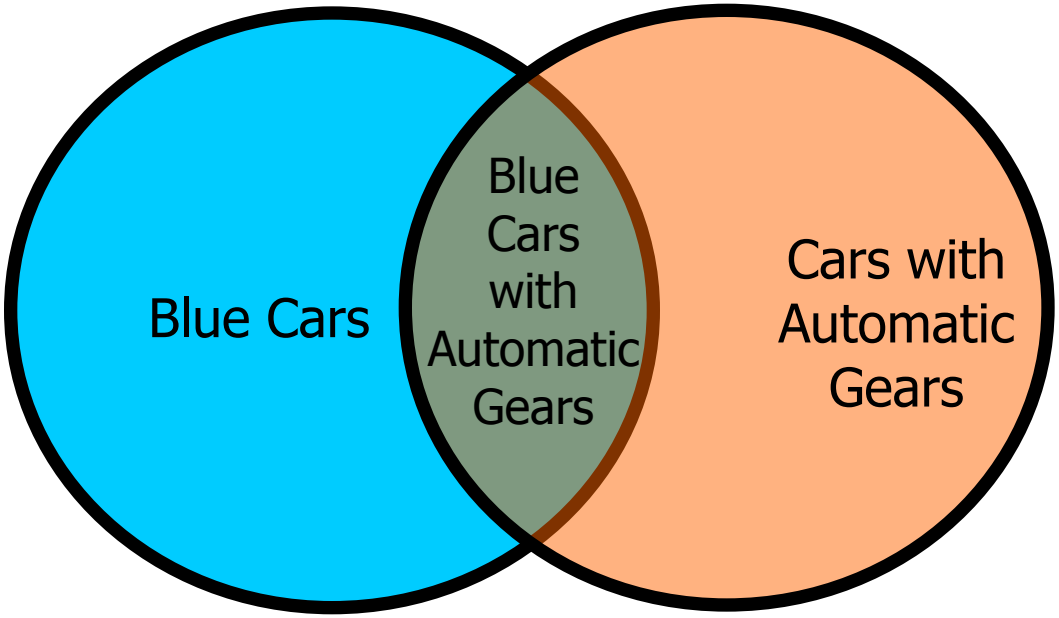


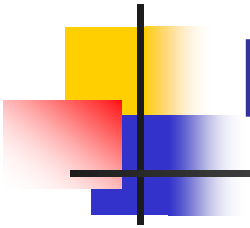
Predicate Logic

- First order predicate logic
  - Formal general language to represent knowledge
  - Expressive logic compared with propositional logic
  - A powerful way of deriving new knowledge from old, through mathematical deduction.
- Syntax
  - Symbols
  - Constants, variables, predicates, functions, quantifiers

Predicate Logic

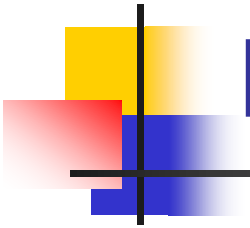
Set Theory





Predicate Logic

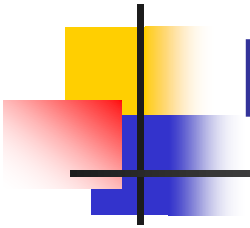
- Conjunctives and Disjunctives
  - The logical **and** called the **conjunction** of two logical propositions
  - The logical **or** called the **disjunction** of two logical propositions
  - The negation, or **not** connective
  - The **implies** connective



Predicate Logic

- Vocabulary

" $\rightarrow$ "	material implication (implies)
" $\neg$ "	not
" $\vee$ "	or
" $\wedge$ "	and
" $\forall$ "	for all
" $\exists$ "	there exists



Predicate Logic

It is raining.

RAINING

It is sunny.

SUNNY

It is windy.

WINDY

If it is raining, then it is not sunny.

$\text{RAINING} \rightarrow \neg\, \text{SUNNY}$

Predicate Logic

- Example: elephant
  1. x am an elephant
     - Elephant (x)
  2. Elephants are animals
     - Animals (elephants)
  3. x like fruit
     - Like (x,fruit)
  4. All animals eat fruit or meat
     - $\forall$ (x) : animal (x) $\rightarrow$ eat (x, fruit) $\vee$ eat (x,meat)

Predicate Logic

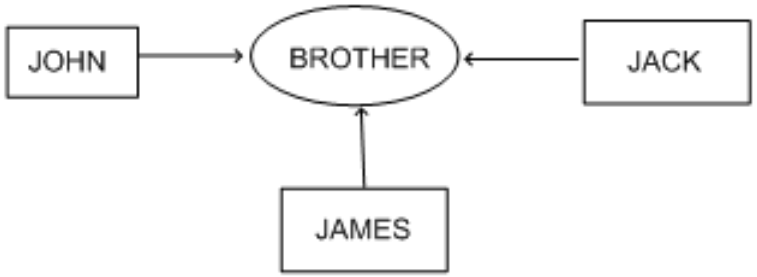
- Example: elephant

5. Elephants are grey
   - Grey (elephant)
6. All animals eat the food they like
   - $\forall$ (x) $\exists$ (y): animal (x) $\wedge$ food (y) $\wedge$ like (x,y) $\rightarrow$ eat (x, y)
7. Elephants are not carnivores
   - Elephant (x) $\rightarrow \neg$ carnivore (x)
8. Fruit is food
   - Food (Fruit)

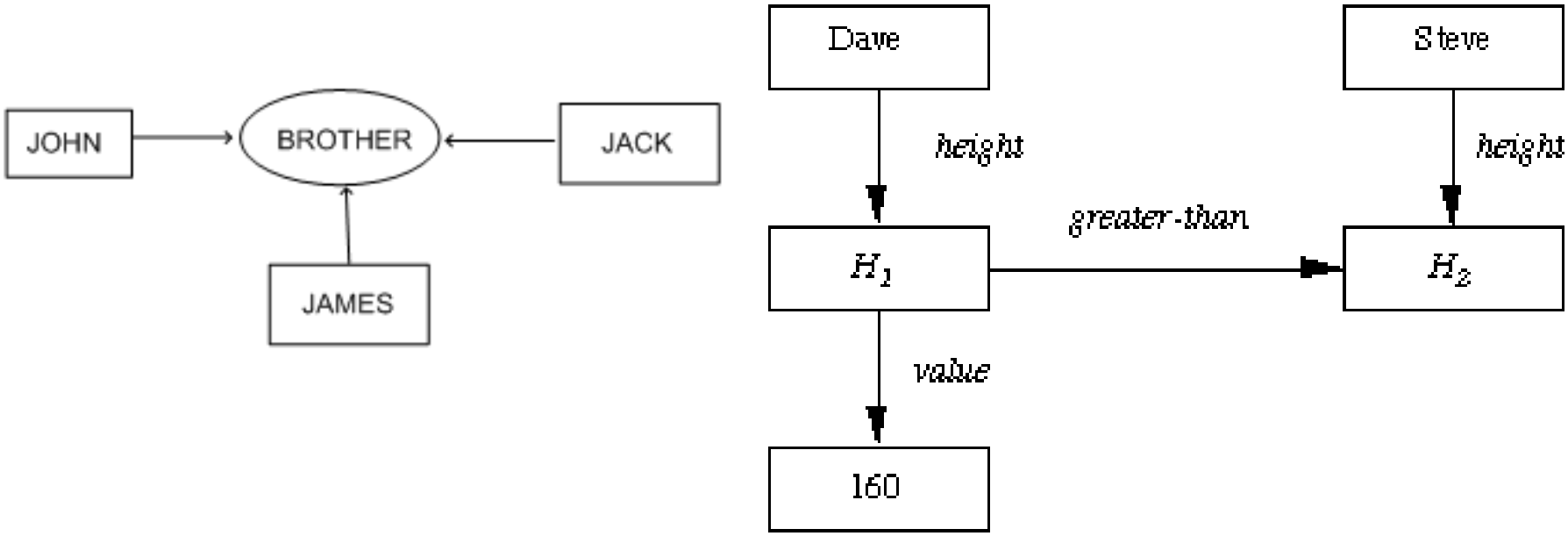
Semantic Networks

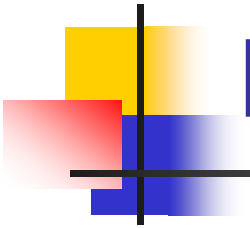
- A formal graphic language representing facts about entities in some world about which we wish to reason.
- The meaning of a concept comes from the ways in which it is connected to other concepts

- Conceptual graphs
  - Concepts are nodes
  - Relationships are edges



Semantic Networks

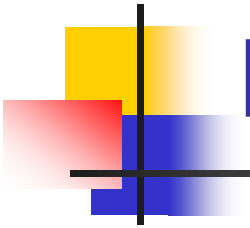




Production Rules

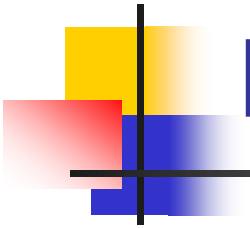
- The term production rule system refers to several different knowledge representation schemes based on the general underlying idea of **condition-action** pairs, which are also called **if-then** pairs, **situation-action** pairs, **production rules**, or just plain **productions**.

- <condition, action> pairs
  - Agent checks if a condition holds
  - If so, the production rule "fires" and the action is carried out
  - This is a recognize-act cycle



Production Rules

```
(rule (name)
      (if (trigger fact 1)
          (trigger fact 2)
                :
                :
          (trigger fact n))
      (then (conclusion fact 1, or action 1 )
            (conclusion fact 2, or action 2)
                :
                :
            (conclusion fact n, or action n)))
```



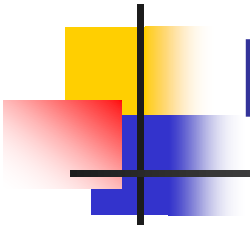
Production Rules

if it is raining then the ground is wet

if height of X > height of Y then X is taller than Y
where X and Y are variables

it is raining
the ground is wet

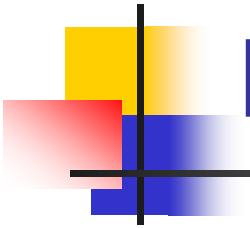
height of Tom = 6
height of Tim = 5
Tom is taller than Tim



Frames

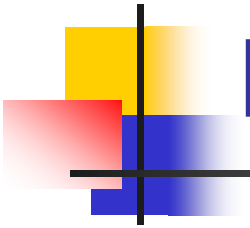
- Frames represent an alternative method of structuring and organising knowledge.
- A frame language is a meta-language. A frame system is a hierarchy of frames.

- Each **frame** has:
  - a **name**.
  - **slots**: properties of the entity that has the name, and they have values.



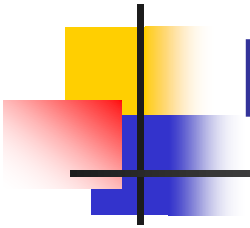
Frames

- there is a category of things called cars
- a car has 4 wheels, is moved by an engine, and runs on petrol or diesel



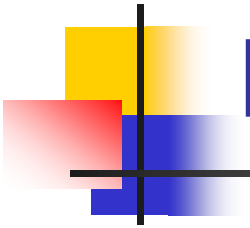
Frames

- there is a particular type of car called a VW, manufactured in Germany
- slots and values in the previous frame will be inherited



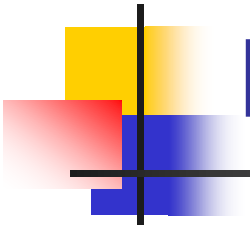
Frames

- there is a particular type of VW called a Golf, which has a sun-roof



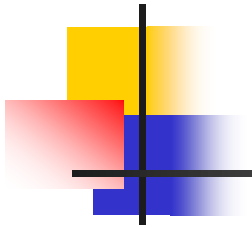
Frames

- there is a particular type of Golf called a TDi, which runs on diesel. A TDi has 4 cylinders, and an engine capacity of 1.8 litres

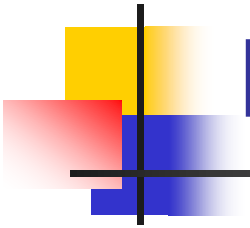


Frames

- my car, called C637SRK, is a Golf Tdi. It hasn't got a sun-roof
- an instance frame.
- The top slot appears here as the value contradicts (overwrites) the value which would otherwise be inherited

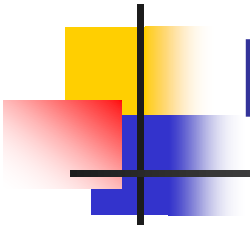


Knowledge acquisition



Knowledge acquisition

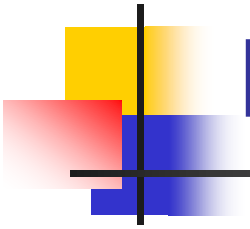
- Human knowledge is complex, unstructured and usually ill formulated.
- Often the expert is so close to the problem under consideration they have difficulty in seeing it objectively.
- This situation is worse when the knowledge source comprises of several experts



Knowledge acquisition - stages

1. Define task
2. Build-up Domain Vocabulary
   - Words, phrases, formulae that make up the natural language of the task.
3. Develop a Model of the Reasoning Involved and how it is applied.
   - Flowcharts and decision trees often used.
   - Paper exercise - no programming at this stage.
   - Iterative procedure with Experts

Knowledge acquisition - example



- *MILTON*: "Well, the routers are usually OK, so always check the server first. If the traffic coming from the server is OK, then check the routers. Check the mixer temperature, if it's above 20C° then the cooling fan has gone and needs replacing. If it's not then check the connections they may be loose and need re-soldering. If they're OK it has to be the cabling that is problem, so check that and replace if necessary. If the cabling is not damaged then it is beyond me, call in the manufacturer's repair team."
- *MILTON*: "If the problem is in the server, check the disks first – repairing any bad sectors should fix it. If not check the power supply, if the supply is spiking, replace it. If none of this works then the problem must be with the processor."

Knowledge acquisition - example

- Create a domain dictionary for the above problem

Traffic OK	**Yes, No**
Problem Machine	**Router, Server**
Router Connection	**Loose, Not Loose**
Cabling	**Damaged, Not Damaged**
Temperature	**Numeric value**
Disks	**Bad Sectors, No Bad Sectors**
Power Supply	**Spiking, Steady**
Problem Solution	**Change Cooling Fan, Re-solder Connections, Replace Cabling, Call Manufacturer's Repair Team, Fix Bad Disk Sectors, Replace Power Supply, Processor Problem**

Knowledge acquisition - example