Artificial Intelligence

Module 3 Knowledge Representation

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Contents

- **Rule based system,**
- **Semantic net**
- **Reasoning in Semantic Net,**
- **Frames and slots**

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Problem solving by knowledge

- Search functions are important for problem solving.
  - But there is abstraction of domain specific knowledge.
  - Search function are limited to generality.
  - There more emphasis on generating next state.
- Knowledge representation allow for more specific and more powerful problem solving mechanism.
  - Spot is a dog
    - dog(spot)
  - All dogs have tail
    - $\forall x : dog(x) \rightarrow hastail(x)$
  - Deductive mechanism of logic hastail(spot) ?
    - Backward mechanism -> Spot has a tail

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Knowledge representation

- For solving complex problems in AI we need
  - A large amount of knowledge. A variety of ways of representing knowledge have been exploited in AI programs.
    - Facts
    - Truths in some relevant world.
    - The things we want to represent. Objects, Actions, Effects
  - Representations of facts in some chosen formalism. ??
    - Some mechanism for manipulating that knowledge
    - To infer
    - To create solutions to new problems.

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Knowledge, Representation and AI

- Knowledge is a description of the world. It determines a system's competence by what it knows.
- Representation is the way knowledge is encoded.
  - Mechanism to apply manipulate representation
  - It defines a system's performance in doing something.
- Different types of knowledge require different kinds of representation

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Knowledge representation

- Knowledge is a collection of 'facts'.
  - To manipulate these facts by a program,
  - A suitable representation is required.
  - A good representation facilitates problem solving
- **AI Techniques** depict how we
  - represent, manipulate and reason with knowledge in order to solve problems.
- Structuring the knowledge representation at two levels
  - Knowledge Level – Agent's behavior and current goals are described as facts in the domain of knowledge
  - Symbol levels – Symbols for each of the objects at knowledge level to be manipulated

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Mapping between facts and representation
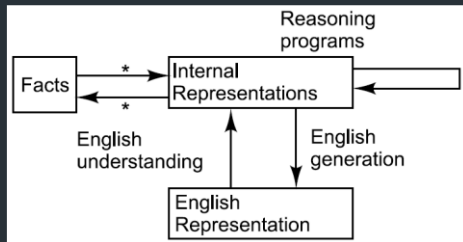
Knowledge representation in AI

- Representation of a new facts to
  - Cause to take action
  - Representation of additional facts.
  - Spot is a dog
    - dog(spot)
  - All dogs have tail
    - $\forall x : dog(x) \rightarrow hastail(x)$
  - Deductive mechanism of logic hastail(spot) ?
    - Backward mechanism -> Spot has a tail
- Mapping function is not one to one
  - Many to many
   - One object to many element and several element to one element /object

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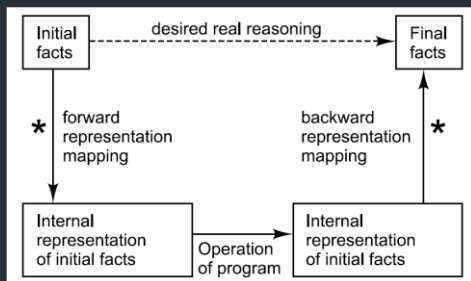
Knowledge representation

- Two sentence represent same fact
  - All dogs have tails
    - One tail or more tails
  - Every dog has a tail
- We need to decide what fact the sentence represent and
  - Convert those facts to new representation
- Role that internal representation of facts play on the program.
  - AI program manipulates the internal representation of the facts it has.
  - This manipulation results in new structure that can also be represented as internal representation of facts.
  - These may be answer to the problem starting by set of facts.

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Three Representations of a Mutilated Checkerboard
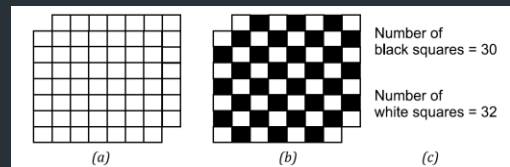
Number of black squares = 30

Number of white squares = 32

(a)   (b)   (c)

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Knowledge representation

- The result will not be desired one.
  - If the program's operation
  - one of the representation mapping is not faithful to the problem modeled.
    - Representation mapping is important considering program does what it is supposed to do to meet the goal.
  - Good representation mapping and faulty program.
- Concrete implementation of abstract concepts

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Knowledge representation approaches

- Good KR should have following four properties
- Representational adequacy - The ability to represent all kinds of knowledge that are needed in that domain
  - Inferential adequacy
    - The ability to manipulate the representational structures to derive new structures corresponding to new knowledge inferred from old.
  - Inferential efficiency
    - The ability to incorporate additional information into the knowledge structure that can be used to focus the attention of the inference mechanisms in the most promising direction
  - Acquisitional efficiency
    - The ability to acquire new information easily. Use of automatic methods wherever possible rather than reliance on human intervention.
- A KR does not have all the abilities, Multiple techniques for KR existes.

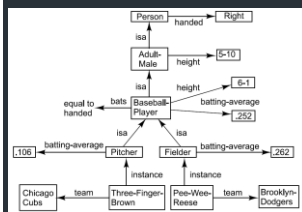Prof. Rajesh Kumar VIT Chennai

Simple relational knowledge

Player	Height	Weight	Bats-Throws
Hank Aaron	6-0	180	Right-Right
Willie Mays	5-10	170	Right-Right
Babe Ruth	6-2	215	Left-Left
Ted Williams	6-3	205	Left-Right
player_info('hank aaron', '6-0', 180,right-right).			

- Declaration of facts in a relational database,
  - Set of attributes and associated values – describe objects of KB
  - support for relational knowledge
- Weak inferential capability, input to powerful inference engine
  - Who is the heaviest player ?(no answer) Needs a procedure
  - Set of rules to find bats – left, throws - right hand player as combination of hitter-pitcher.

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## Inheritable knowledge: Semantic network

- Property inheritance is one the useful inference mechanism
  - Elements of specific class inherit attributes and values from more general classes
  - In which they are included (isa).
  - Objects must be organized into classes.
  - Classes must be arranged in a generalization hierarchy
  - Line – attributes
  - Box – Node – objects and value of attribute
  - Object -> Arrow ->attribute -> value
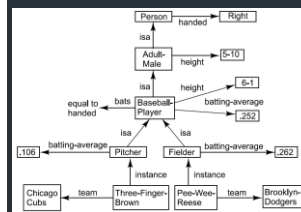
Slot filler structure: Collection of frames

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Inheritable knowledge: Semantic network

- Property inheritance is by
  - Isa attributes – class inclusion
  - Instance attribute – class membership
  - Inference technique
- Baseball domain - All the objects, attributes
  - No general significance
- KB can support of retrieval of fact
  - Explicitly stored
  - Derived facts from explicitly stored

Slot filler structure: Collection of frames

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Nodes as frame

Baseball-Player	
isa:	*Adult-Male*
bats:	(EQUAL *handed*)
height:	6-1
batting-average:	.252

- Support inference using knowledge they contain
- Baseball domain - All the objects, attributes
  - No general significance
- Frame system implies more structure on
  - The attributes
  - The inference mechanism
  - Than semantic network
- High level of flexibility
  - To solve representation problem
- It is difficult to reserve precise words for particular representation

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Algorithm : Property Inheritance

To retrieve a value V for attribute A of an instance object O

1. Find O in the knowledge base.

2. If there is a value there for the attribute A, report that value.

3. Otherwise, see if there is a value for the attribute instance. If not, then fail.

4. Otherwise, move to the node corresponding to that value and look for a value for the attribute A. If one is found, report it.

5. Otherwise, do until there is no value for the is a attribute or until an answer is found: (a)Get the value of the is a attribute and move to that node.

(b) See if there is a value for the attribute A. If there is, report it.

Team(Pee-Wee-Reese) = Brooklyn-Dodgers,   height(Pee-Wee-Reese) = 6-1

Batting-average(Three-finger-brown) = .106   Bats(Three-finger-brown) = right

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Semantic network

- Simple procedure
- Describes basic mechanism for inheritance
- Not clear what we should do if there is more than one value for
  - Instance
  - Isa

Inferential knowledge

- Traditional logic describes the required inference
  - Powerful structure to describe relationship among values
- Requires an inference procedure to use it
  - Implements the standard logical rules of inference
  - Forward reason – Facts to conclusion
  - Backward reason – Conclusion to facts
  - Resolution – Contradiction strategy
- Algorithm was required in semantic network
- Combine the logic with isa/instance type of powerful description language
- None are complete or incomplete KR,
  - Building block of complete representational system

Procedural knowledge

Fact –
Statement about specific object

Constant

Rules – Statement about class of objects

Variable

- A representation in which the control information that is necessary to use the knowledge is embedded in the knowledge itself
  - e.g. computer programs, directions, and recipes
  - These indicate specific use or implementation
- Rules to encode knowledge
  - AI as commercial products??
- Programs are written in many ways
  - LISP, Python
- Low score for inferential adequacy
  - A program can not reason for other program behavior, infer some facts
- Low score for inferential efficiency
  - Difficult to debug, update large code
- What to do when facts are
  - Not static, declarative

Procedural knowledge

If:	ninth inning, and
	score is close, and
	less than 2 outs, and
	first base is vacant, and
	batter is better hitter than next batter,
Then:	walk the batter.

- Procedural knowledge that can be manipulated by program or human.
  - As production rules
  - Operational KB by baseball player
- The production rules that can be augmented with information
  - On how the rules should be used
- How the procedure uses knowledge to manipulate the knowledge
- A set of rules that can represent knowledge about
  - Relationship in world
  - How to solve problems using rules

Declarative vs. Procedural KR

- **Declarative Knowledge representation**
  - A statement in which knowledge specified, but the use to which that knowledge is to be put is not given.
  - To use declarative knowledge a program is required that says how and what to do with the knowledge.
    - The logical assertion may be steps of program rather than data to a program
- **Procedural knowledge representation**
  - The control is part of knowledge. The control is embedded in the knowledge
    - It need a interpreter that follows instruction in the knowledge
      - Identifies the control information
  - Examines order in which assertion will be made.

Man (Marcus)		*Man (Marcus)*
Man (Caesar)	Y = Marcus	*Man (Caesar)*
Person (Cleopatra)	Y = Caesar	*∀x: Man(x) → Person(x)*
∀x: Man(x) → Person(x)	Y = Cleopetra	*Person (Cleopatra)*
∃y: person(y) Answer: y		

Frames and slots

Baseball-Player	
isa:	*Adult-Male*
bats:	(EQUAL *handed*)
height:	6-1
batting-average:	.252

- What is true about a situation, object?
- Information coded in to structure and termed as frames
- It is a record structure

- Frames have attributes,
  - also called slots and
  - associated values for the slot.
  - The values are also known as filler.
- These represent a real word entity.
- Student
  - Name
  - Register no.
  - Program
  - Year
  - Region

Frames and slots

- Frames contains information on
  - How to use the frame,
  - what to expect next
  - What to do when these expectations are not met.
- Some information in the frame is generally unchanged
- Slots/ variables/ Terminals change.
  - value might change with the new information encountered
  - Need not always true
  - Different frames may share the same Slots/Variables/terminals
- Top level frames carry information, that is always true about the problem in hand.

Frames and slots

- Network of frames
- Cricket Team

- Batsman

- Baller

- Financier

- Strategy

- Facts about particular object and event types
  - Arrange the types into a large taxonomic hierarchy analogous to a biological taxonomy".
- Procedure attachment to Frames
  - If needed - deferred evaluation
    plays – cricket, lives – in Chennai
  - If added – updates linked information
    Innovative, Perseverance,
  - Defaults – Data for procedure
    Hostelite, Studious

Frames and slots

- It is possible to generate a semantic network using frames
- Friend of A Friend (FOAF)
  - Part of the Semantic Web as a foundation for social networking and calendar systems.
  - *Person*.
    - Slots - person's *email, home page, phone,* etc .
  - Space of business
  - Entertainment
  - The slot *knows* links between person.
  - Default values for a person's interests
    - Can be inferred by the web of people they are friends of

Frames and slots

- Frames are focused on
  - explicit and intuitive representation of knowledge
  - originated in AI research
  - Frames originated in AI research
- Objects focus on
  - Encapsulation
  - Information hiding
  - Software engineering

Classification/Regression

- "What will the temperature be in Mumbai tomorrow?"
- "Is this email spam or not spam?"
- "How many copies of this book will sell?"
- "Will the customer buy this product?"
- "Is this comment written by a human or a robot?"
- "What price will this car sell for?"
- "Is this product a book, movie, or clothing?"
- "Which category of products is most interesting to this customer?"
- "Is this movie a romantic comedy, documentary, or thriller?"

Approaches to knowledge representation

- Production rules of the form 'if x then y',
- Slot and filler systems and
- Statements in mathematical logic.