Knowledge Representation

INT404

Knowledge Representation

✓Earlier it was believed that the best approach to solutions was through the development of General Purpose Problem Solver, that is, systems powerful to prove a theorem in geometry, perform a complex robotic task, or to develop a plan to complete a sequence of operations.

✓But it was deduced that the systems became effective only when the solution methods incorporated domain specific rules and facts, i.e. after gaining specific knowledge.

✓It eventually led to knowledge based systems.

Knowledge Representation

- **Importance of Knowledge**
  - Knowledge can be defined as the body of facts and principles accumulated by human-kind or the act, fact or state of knowing.
  - In actuality it is more than this, it also includes having a familiarity with language, concepts, procedures, rules, ideas, abstractions , places, customs, facts associations along with ability to use these notions effectively in modeling different aspects of the world.
- **How is knowledge stored in biological organisms and computers?**
  - Human brain weighs 3.3 pounds - estimated number of neurons 10^{12} - potential storage – 10^{14}
  - In computers, knowledge is also stored as symbolic structures, in the form of collections of magnetic spots and voltage states.

Knowledge Representation

- ✓Let’s take the following examples
  - ✓A is tall.
  - ✓A Loves B.
  - ✓C has learned to use recursion to manipulate linked lists in several programming languages.

- ✓1st one represents a fact, an attribute possessed by a person.
- ✓2nd expresses a complex binary relation between two persons.
- ✓3rd is most complex, expressing relations between a person and more abstract programming concepts.

Knowledge Representation

- ✓Knowledge can be of following types
  - ✓Declarative (statements)
  - ✓Procedural (facts)
  - ✓Heuristics (rule of thumb / experience)
- ✓We should not confuse Knowledge with data.
  - – Physician example
- ✓Belief v/s Hypothesis
  - ✓Belief is any meaningful and coherent expression that can be represented.
  - ✓Hypothesis is a justified belief that is not known to be true.
- ✓Epistemology – study of nature of knowledge.
- ✓Metaknowldge – knowledge about knowledge.

Knowledge Representation

✓Knowledge alone cannot serve the purpose, we need to include understanding, learning, thinking, remembering & reasoning.

✓Knowledge based systems get their power from expert knowledge that has been coded into facts, rules, heuristics and procedures.

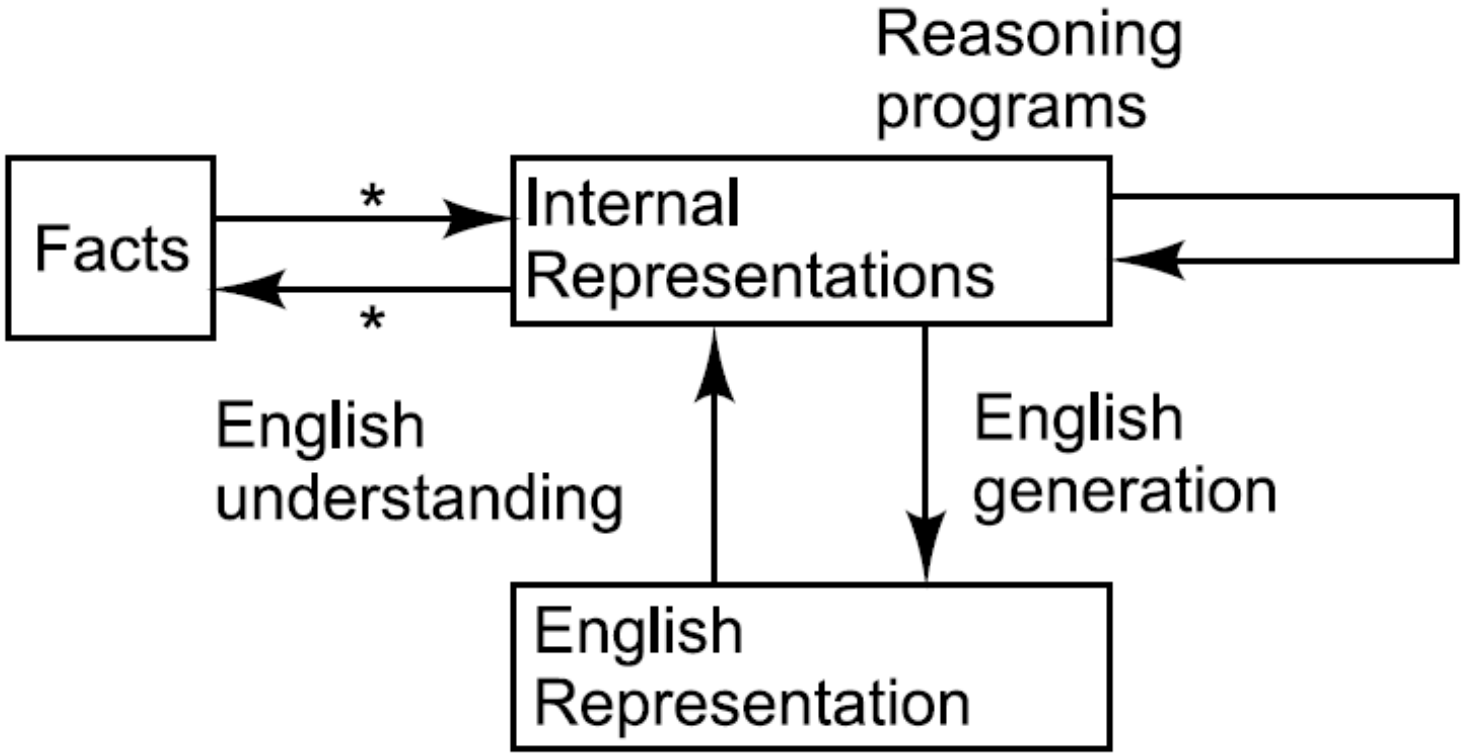
✓Knowledge is stored in a knowledge base separate from the control and inferencing components , this makes it possible to add new knowledge or refine existing knowledge without recompiling the control and inferencing programs.

✓This simplifies the construction and maintenance of knowledge-based systems.

Mappings between Facts and Representation

Facts: Truths in some relevant world. These are the things we want to represent

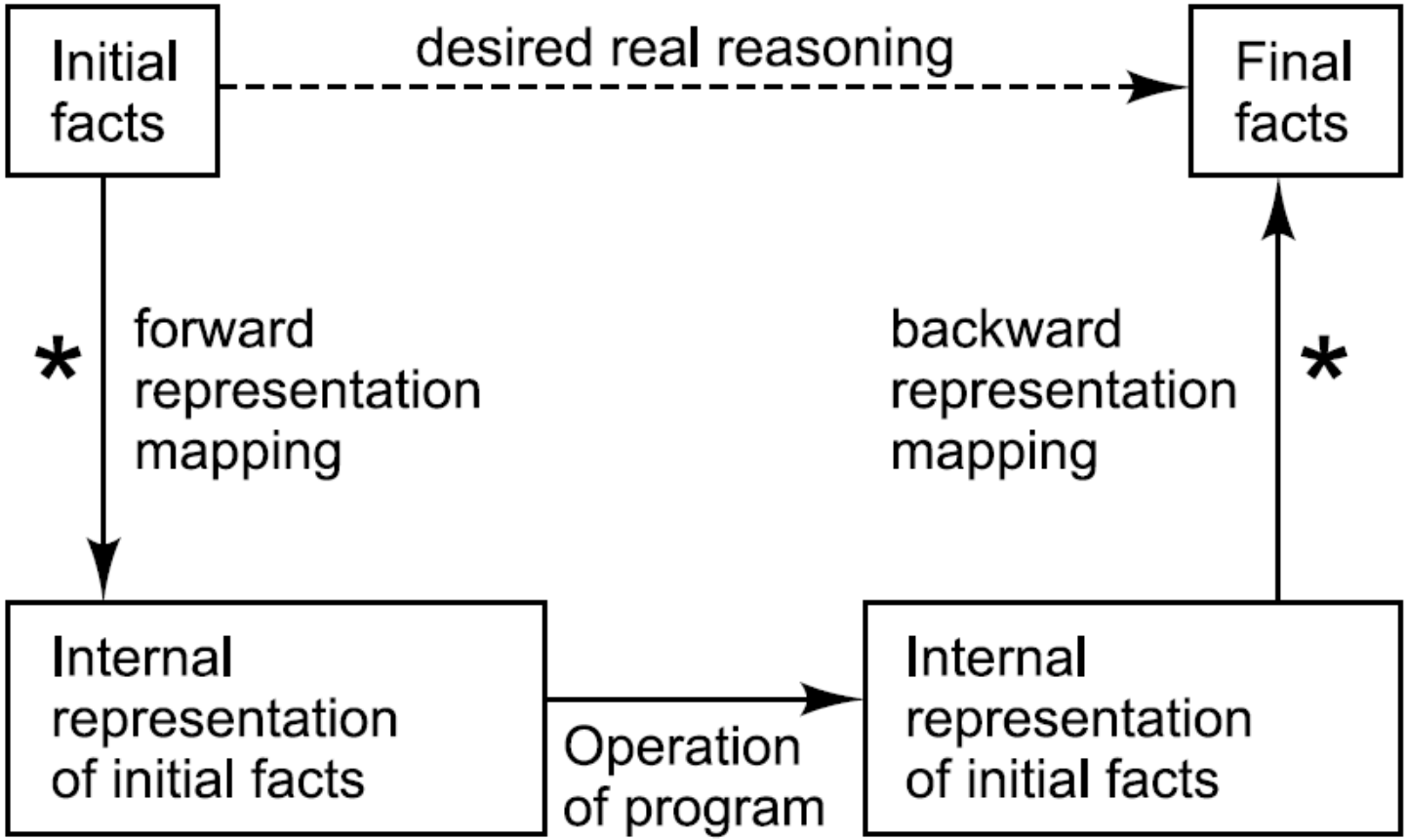
Representation of fact in some chosen formalism. These are the things we will actually be able to manipulate



Knowledge Representation

- ✓Some mathematical ways of representing the representing sentences
  - ✓Spot is a dog. → dog(spot)
  - ✓All dogs have tails. → Vx : dog(x) → hastail(x)
  - ✓Then using the deduction method of logic, we may generate they new representation object : hastail(spot)
  - ✓So we can , using backward mapping function : Spot has a tail.

Representation of Facts



Knowledge Representation

✓Approaches to Knowledge representation

✓A good system for the representation of knowledge in a particular domain should possess the following properties :

- ✓**Representational Adequacy** – the ability to represent all of the kinds of knowledge that are needed in that domain
  - ✓**Inferential Adequacy** – The ability to manipulate the representational structures in such a way as to derive new structures corresponding to new knowledge inferred from old.
  - ✓**Inferential Efficiency** – The ability to incorporate into the knowledge structure additional information that can be used to focus the attention of the inference mechanisms in the most promising direction.
  - ✓**Acquisitional Efficiency** - Acquiring new information easily.

Knowledge Representation

✓**Simple Relational Knowledge**

Player	Height	Weight	Runs
Dhoni	6-0	150	3000
Sachin	5-4	140	15000
Zaheer	6-2	160	1000

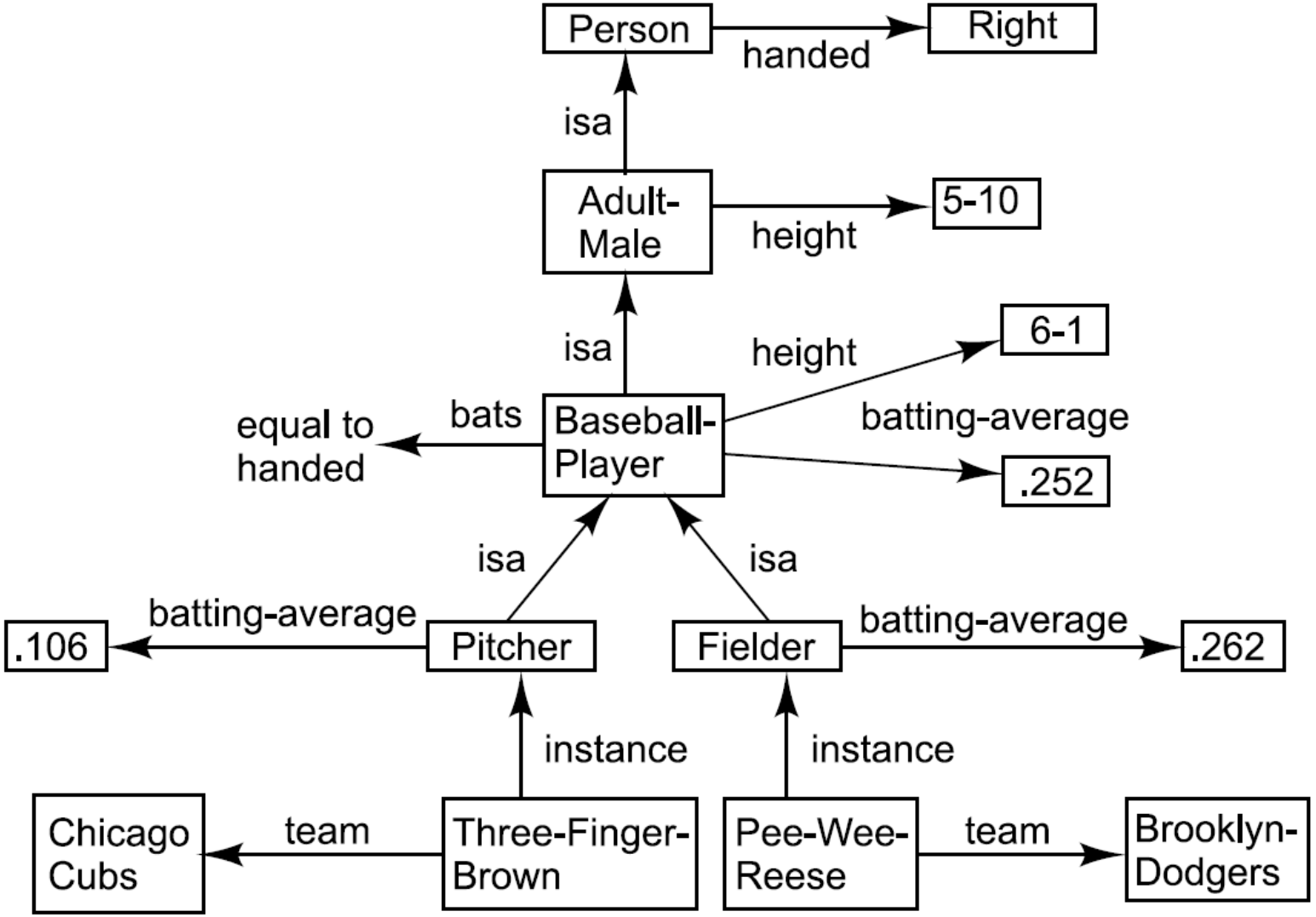
This even does not tell us that who is the heaviest player?

A procedure should be defined to figure out the result.

Knowledge Representation

- **Inheritable Knowledge**
  - It is possible to enhance the basic representation with inference mechanism that operate on the structure of the representation.
  - The most useful form of inference is **Property Inheritance**, in which elements of specific classes inherit attributes and values from ore general classes in which they are included.
  - In order to do this, objects must be organized into classes, classes must be arranged into generalization hierarchy.

Inheritable Knowledge



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.

Knowledge Representation

✓**Inferential Knowledge**

✓Sometimes all the power of traditional logic is necessary to describe he inferences that are needed.We can represent inferential knowledge about a domain using first order predicate-logic.

1. Marcus was a man.
   $man(Marcus)$
2. Marcus was a Pompeian.
   $Pompeian(Marcus)$
3. All Pompeians were Romans.
   $\forall x : Pompeian(x) \rightarrow Roman(x)$
4. Caesar was a ruler.
   $ruler(Caesar)$

✓But all this knowledge is useless unless there is also an **inference procedure** that can exploit it. The required inference procedure now is one that implements the standard logical rules of inference.

✓There are many procedures, some of which *reason forward from given facts to conclusions*, some *reason backward from desired conclusions to given facts*. One most common procedure is **RESOLUTION**, which uses contradiction strategy.

Knowledge Representation

- **Procedural Knowledge**
  - The previous forms deal with Static, Declarative facts. This knowledge specifies what to do and when.
  - This knowledge can be represented in programs in many ways. The most common way is simply as code for doing something.
  - The machine uses the knowledge when it executes the code to perform a task.
  - Eg : If – then else etc.

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.

Thank You!!!