INTRODUCTION

What is Artificial Intelligence?

(chapter 1)

Cse352

Lecture Notes (1)

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Introduction

- AI is a broad field. It means different things to different people.
- AI is concerned with getting computers to do tasks that require human intelligence.
  - Example 1 : Complex Arithmetic −Computers can do this very easily.
  - Example 2: Recognizing a face − People do easily, but it <u>was </u> very difficult to automate.

Introduction (Cont.)

- AI is concerned with difficult tasks , which require complex and sophisticated reasoning process and knowledge.

Why to automate Human Intelligence?

(and to which degree is it possible?)

Why to automate Human Intelligence ?

- Reason 1: To understand human intelligence better: We may be able to rest and refine theories of Human Intelligence by writing programs which attempt to simulate aspects of human behavior.

- Reason 2: To have smarter programs and machines; by studying human reasoning we may develop useful techniques for solving difficult problems.

Introduction (Cont.)

Science Fiction Human-like robots − whether such a goal is possible or even desirable − belongs to science fiction, but does have impact on the practical work of writing smarter programs and developing better models of human reasoning.

Introduction (Cont.)

- AI – for us is a technical subject; we put emphasis on "Computational Techniques" and less on psychological modeling and philosophical issues.

- AI is both a branch of science and a branch of engineering.
  - As ENGINEERING, AI is concerned with the concepts, theory and practice of building intelligent machines.

AI as a branch of Science and Engineering

Examples:

1. Expert Systems that give advice about specialized subjects; e.g., medicine, mineral exploration, etc.…
2. Question-Answering Systems for answering queries posed in restricted, but large subset of English and other natural languages.
3. Theorem Proving Systems.
4. Systems for program verifications. It is a very important field of CS.

Knowledge in Intelligent Entities

"Intelligent entities seem to anticipate their environments and the consequences of their actions."

We assume that they posses knowledge of their environments.

Knowledge in Intelligent Entities (Cont.)

- What is such knowledge?
- What forms can it take?
- How do entities use knowledge?
- How is knowledge acquired?

Knowledge in Intelligent Entities (Cont.)

We have:

- Procedural Knowledge.
- Declarative Knowledge.

We talk about and define:

- Knowledge Representation.
- Knowledge Base.

Forms of Knowledge

There are two major ways we can think about machine having knowledge about its world:

- IMPLICIT – Procedural
- EXPLICIT – Declarative

Procedural Knowledge

- Examples:
  - The knowledge represented by the actual running or execution of a program is procedural – It is difficult to extract the knowledge from the text of the program code for other uses. It is contained in the very procedures that uses it.
  - Spider knowledge about spinning the web and
  - Tennis knowledge used by a player are both procedural.

Declarative Knowledge

- Examples:
  - Tennis Knowledge as TAUGHT by the instructor is declarative knowledge.
  - Engineer designing a bridge is declarative.
- Declarative Knowledge – contains declarations about the world. Typically it is stored in symbol structures that are accessed by the procedures that use this knowledge.

Intelligent Machines

Intelligent Machines will need both procedural and declarative knowledge.

Declarative Knowledge
Focus of AI

- AI focuses more on the declarative knowledge.

- One of the most standard books by N. Nilson (Stanford) **Logic as foundations of AI**

  is concerned only with declarative knowledge.

Reasons for preferring Declarative Knowledge

- Reasons for AI researchers to prefer declaratively represented knowledge :
  - Can be changed easily.
  - Can be used for several different purposes.
  - The knowledge base itself does not have to be repeated or designed for different applications.
  - Can be extended by reasoning process that derive additional knowledge.

Conceptualization

- The formalization of knowledge in declarative form begins with "Conceptualization".
- The language of conceptualization is often predicate calculus.
- Definition presented here is from

  N. Nilson's book
- Logic as Foundations of AI.

Conceptualization (Nilson Def.) (Declarative Knowledge.)

- Conceptualization – step one of formalization of knowledge in declarative form.
- $C = (\mathcal{U}, \mathbf{F}, \mathbf{R})$
- $\mathcal{U}$ – Universe of discourse; it is a FINITE set of objects.

- **F** – Functional Basis Set; Set of functions (defined on $\mathcal{U}$). Functions may be partial.
- **R** – Relational Basis Set; Set of relations defined on $\mathcal{U}$.
- Remark: sets R, F are FINITE.

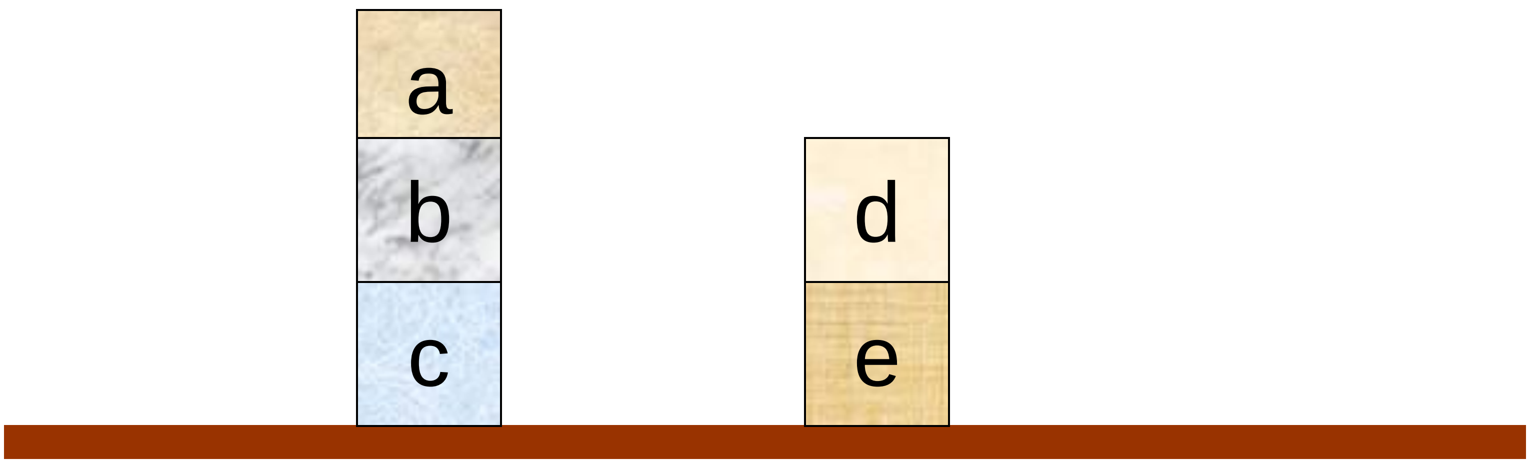
Conceptualization (Cont.)

- **R** − Relational Basis Set; Set of relations defined on $\mathcal{U}$.
- $\mathcal{R} \in \mathbf{R}$, $\mathcal{R} \subseteq \mathcal{U}^n$, $\# \mathcal{R} = n$

This is like in predicate logic:

M = ($\mathcal{U}$, **F**, **R**) is a Model. Where $\mathcal{U} \neq \emptyset$,
$\mathcal{F} \in \mathbf{F}$, f $\in$ FUN , $f_I = \mathcal{F}$, $f_I : \mathcal{U}^n \rightarrow \mathcal{U}$, etc.,
Satisfiability Model, etc., in Predicate Logic.

Example: Block World



(Example is continued on next slide.)

Example: Block World

- $\mathcal{U}$ = { a, b, c, d, e}
- **F** – functions. **F** = {h}
- Intuitively: h maps a block into a block on the top of it. (h = Top)
- Formally: h = {(b,a) , (c,b), (e,d)}
- h(b) = a ; h(c) = b; h(e) = d.
- h is a partial function and h : $\mathcal{U} \rightarrow \mathcal{U}$
- Domain of h = {b,c,e} $\subset \mathcal{U}$

Example: Block World

- **R** – Set of Relations.
- **R** = {Above, On, Table, Clear}
- Above $\subseteq \mathcal{U} \times \mathcal{U}$, On $\subseteq \mathcal{U} \times \mathcal{U}$
- Table $\subseteq \mathcal{U}$, Clear $\subseteq \mathcal{U}$

Example: Block World

- Intuitively: Above (x,y) iff x is anywhere above y.

FORMALLY (definition):

- Above = {(a,b), (b,c), (a,c), (d,e)

(two argument relation)

- Intuitively: On (x,y) iff x is immediately above y.

- FORMALLY (definition):

On = {(a,b), (b,c), (d,e)} , On $\subseteq \mathcal{U} \times \mathcal{U}$

Example: Block World

- Intuitively:
- Clear(x) iff there is no block on top of x.

- Formally(definition)

  Clear = {a, d} $\subseteq \mathcal{U}$
  (one argument relation.)

- Intuitively: Table(x) iff x is resting directly on the table.

Formally(definition)

- Table = {c,e} $\subseteq \mathcal{U}$
- (one argument .relation.)

Example: Block World

- Observe:
- On $\subseteq$ Above; Clear $\cap$ Table= $\emptyset$.
  We choose in our Conceptualization only

Above defined relations and functions but – depending on what we want to tell about our world – we can have less or more of them.

Example: Block World

- On $\subseteq \mathcal{U} \times \mathcal{U}$
  On = {(a,b), (b,c), (d,e)} (Math. Definition)
- This is "Prolog" like statements:
  On(a,b) , On(b,c) and On(d,e)
  It is equivalent to your definition (declaration) of what "On" means, i.e.
- We write On(a,b) for (a,b) Є On.

Facts in Prolog

Intended Interpretation

- On = {(a,b), (b,c), (d,e)}
- We can also use other symbols, e.g. :
  = {(a,b), (b,c), (d,e)} (Math. model)
- This is the same as:
  (a,b) , (b,c) and (d,e)
- Intended Interpretation of the symbol is "x is immediately above y."

Representation in Predicate Logic

- Facts about our Universe:

On(a,b)	Above(a,b)	Clear(a)
On(b,c)	Above(b,c)	Clear(d)
On(d,e)	Above(a,c)	Table(c)
Top(b,a)	Above(d,e)	Table(e)
Top(c,b)	Top(e,d)	

Representation in Predicate Logic (Cont.)

- Remark: Intended Interpretation
  ≡ Conceptualization,
  and all other statements that are True in the Intended Interpretation.

- Rules (general properties) of our Universe (Axioms of our Universe) :
  - $\forall x \forall y\ (On(x,y) \Rightarrow Above(x,y))$.
  - $\forall x \forall y (\ (Above(x,y) \sqcap\ Above(y,z)) \Rightarrow Above(x,z)\ )$.
  - etc

Reasoning: Resolution i.e., Prolog

- To be able to use Prolog we have to convert our Axioms (rules) in “non qualifier” form (Skolemization).
- Good PROLOG compiler does it for us.
- Resolution – Inference Engine (of Prolog)

Plan for Logic Part

1. Gentzen type Proof System-

   Automated search for proofs

2. Propositional Resolution.

(Proof of Correctness =

Completeness Theorem.)

Resolution Strategies (to go faster!)

3. Predicate Resolution- introduction (if we have time)

Major AI Areas History

1. Game Playing:
   In early 1950 Claude Shannon (1950) and Alan Turing (1953) were writing chess programs for von Neumann computers.
2. But, in fact Shannon had no real computer to work with, and
3. Turing was denied access to his own team's computers by the British government on the grounds that
4. research into AI was frivolous !

Major AI Areas History

- Search as a Major AI Technique:
  Search is a problem solving technique that systematically explores a space of problem states, i.e., stages of problem solving process.
  - Example:
    Different board configurations in a game form a space of alternative solutions. The space is then searched to find a final answer.

Search as AI

- Much of early research in State Space Search was done using common board games: checkers, chess, 16-puzzle.
- Games have well defined rules, and hence it is easy to generate the search space.
- Large space – Heuristic Search.
- 1984 book by Pearl , "Heuristics" – First Comprehensive Mathematical treatment of heuristic search.
- Heuristic Search is widely used now in Theorem Proving and Data Mining.

Major AI Areas (cont)

2. Automated Reasoning and Theorem Proving:
   - Origin: Foundations of Mathematics.
   - Mathematics can be considered as "axiomatic theory."
   - Hilbert Program (1910) – to formalize all of mathematics in such a way that a proof of any theorem can be found automatically.
   - Gentzen(1934) – positive Propositional Logic
   - Partial (semi-decidable) answer for first order logic.

Major AI Areas, Automated Reasoning and Theorem Proving

- Gödel (1933) – negative answer for arithmetic; incompleteness theorem.
- Robinson (1965) – Resolution.
- Program Verification – uses theorem proving techniques.

Major AI Areas: Expert Systems

3. Expert Systems:
   - Obtaining knowledge from human experts, or databases (automated rules generators) and representing it in a form that computer may apply to similar problems.
   - Rule Based Systems.
   - Expert Systems grew into information systems.
   - Always developed for a specific domain.

Expert Systems History

- First Examples:
  - Dendral, Stanford 1960:
    built to infer the structure of organic molecules from their chemical formulas.
  - MYCIN, Stanford 1970:
    diagnostic system, plus prescribes treatment for Spinal Meningitis and bacterial infection in the blood.
    It was the first program to address the problem of reasoning with uncertain and/or incomplete information.
    Still on the Web ! (Medical Information Systems.)

Expert Systems
(Our handout #1 – Modern Approach)

Managing Uncertainty in E.S:
(Jerzy Busse, Kluwer, NY)

1. Knowledge acquisition by using Machine Learning

2. Rule Induction from databases. (Rough Sets approach)

3. Uncertainties in Quantitative approach:
   - Bayes rules and network (probabilistic approach)
   - Belief networks. (probabilistic)
   - Dempster − Shafer Theory:
     Dempster Rules.

Managing Uncertainty in E.S.

3. Uncertainties – Set Valued, Quantitative Approach:

- Fuzzy Sets (Zadek, 1965)
- Rough Sets (Pawlak, 1985)
- Machine learning / data mining techniques.

4. Uncertainties – Qualitative Approaches:

- Modal Logics.
- Non-monotonic logics.
- Default logic
- Plausible Reasoning.

Expert Systems

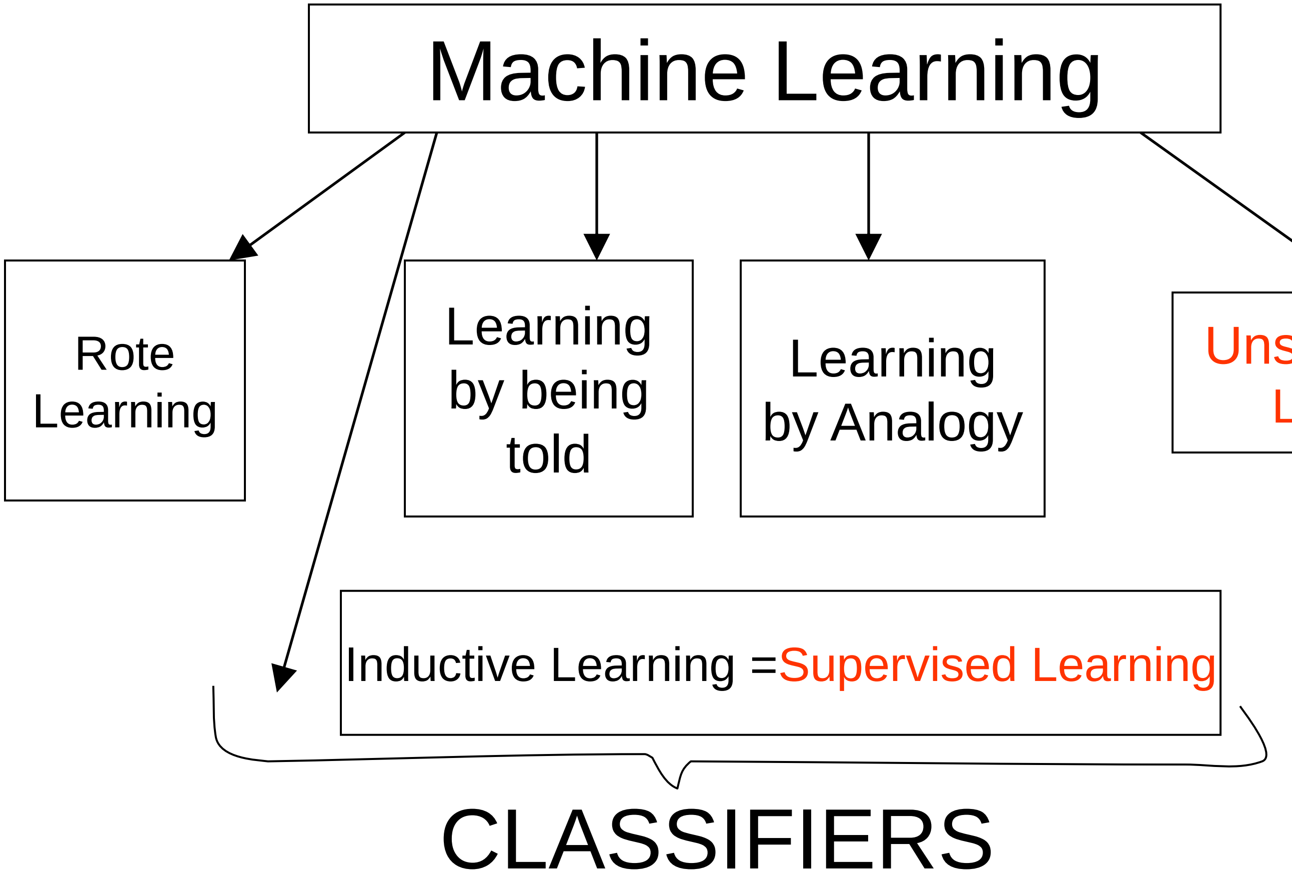
MYCIN Story:

MYCIN asked if the patient was pregnant even though it has been told that the patient was male.

Expert Systems

- Modern Expert Systems always have Machine Learning Components. (Supervised Learning=Classification)
- Supervised (Classification) Learning in large databases is called Data Mining.
- Supervised Learning Techniques are:
  1) Genetic Algorithms. (Evolutionary)
  2) Neural Networks
  3) Decision Tree
  4) Rough Sets
  5) Classification by Association

Machine Learning



Other AI Areas

- Natural Language Processing.
- Natural Language Understanding
- Robotics
- Intelligent Visualization.

Short History

- The Name, “AI” , was suggested in 1956 by McCarthy (at Dartmouth at that time, and then at Stanford, Yale) during a two month long workshop at Dartmouth.
- The Workshop was devoted to programs that could perform:
  - Elementary Reasoning Tasks
  - Proving Simple Theorems.
  - Answering Simple Questions.
  - Playing Board Games.

  - ALL Non computational (in a sense of numbers) tasks.

Short History

- All together there were 10 people. For the next 20+ years the field would be dominated by them, their students and colleagues at MIT, CMU (Carnegie-Mellon University) , Stanford and IBM.

- Allen Newell and Herbert Simon from CMU stole the show with Logic Theorist (LT) – first program to think non-numerically.

Short History

- LT proved most of the theorems in Chapter 2 of Russell and Whitehead's "Principia Mathematica".

- Herb Gelernter (Stony Brook) constructed first (1959) Geometry Theorem Prover.
- Now Theorem Proving is a separate field.
- Anita Wasilewska (now Stony Brook) invented and wrote first theorem prover (in LISP-ALGOL) for MODAL LOGIC in 1967

Short History

- 1952-1969 : Time of Early Enthusiasm and Great Expectations.
- 1952 :

  Arthur Samuel wrote a tournament level checkers program.
- In February 1956 the program was demonstrated on national TV.
- A. Samuel, like Alan Turing had a hard

  time to obtain computer time; worked only at night.

Short History

- 1958 :
  McCarthy moved from Dartmouth to MIT and invented LISP. (Second oldest programming language still in use; Which is the Oldest?)
- LISP is now being replaced by Prolog as a dominant AI language (in many areas.)
- McCarthy and his group also invented Timesharing and formed Digital Equipment Corporation (DEC) to produce time sharing computers.

Short History

- 1958 :
  - Marvin Minsky moved to MIT. He represented Anti-logic outlook.
  - McCarthy was Pro-logic. Hence McCarthy moved to Stanford.
  - McCarthy's Logic agenda was busted by Robinson's discovery of Resolution → (Kowalski) "Prolog logic programming", founded SRI, Stanford Research Institution – main area of research is general purpose methods for logical reasoning.

Short History

- 1969:
  - Green’s Question – Answering and Planning Systems.
  - Shakey Robotics Projects; first integration of logical reasoning and physical activity.

- 1963:
  - J. Slagle’s program SAINT was able to solve closed form integration problems. (first year calculus.)

Short History

- 1968 :

  T. Evans program “Analogy” solved geometric analogy problems from IQ tests.

- 1967:

  D.Bobrow’s program “student” solved some SAT problems.

Short History

- 1971:
  D. Huffman’s “vision” project did rearrangement of the blocks, put on top of the table, using a Robot hand that picked one block at a time.

- 1970:
  P. Winston – first learning theory.

Short History (Cont.)

- 1972:
  T. Winograd – first natural language understanding theory.

- 1974:
  Planner of Scott Fahlman.

- 1966 – 1974:
  A Dose of Reality !

Short History (Cont.)

- In 1958 H. Simon predicted that in 10 years a computer would be a chess champion and that it would prove important mathematical theorems,
  But:
  Many programs often were based mainly on simple syntactic manipulations.

- ELIZA (1965) by Weizenbaum:
  - Search on the web ! Weizenbaum is still alive.
  - The machine ELIZA had no understanding.

Short History (cont.)

- 1966:

  All american governmental funding for machine translations were cancelled !

- 1973:

  british government stopped AI support to all but 2 universities.

Short History (cont.)

- Genetic Algorithms formulated in 1958-59, but computers were not yet up to it.
  Now all over the place!

- The same happened to Neural Networks – mathematical model and theoretical research was rampant, but computers were not strong and fast enough to give meaningful results.

- 1980 – back propagation (NN) algorithm and first applications followed.

Knowledge-Based Systems the (1969-79)

- Narrow the area of expertise and then solve.

- Dendral (1969):
  - Buchanan, a philosopher turned Computer Scientist, and Joshua Lederberg (a nobel geneticist) at Stanford, brought forward the first successful knowledge-intensive system, “Dendral”.
  - Knowledge base is a large number of special purpose rules.
  - With Dendral, there is a clean separation of the knowledge base (Rules) and the reasoning component. (following McCarthy.)

Knowledge-Based Systems the (1969-79)

- MYCIN and certainty factors.
- Prospector (1979, Rutgers):
  - Provided recommendations of exploratory dwellings at geological sites.

Short History
AI becomes an Industry (1980-now)

- 1982:

  First successful Expert System, “RI”, at DEC (McDermot) was made.
  The Program helped configure orders for new Computer Systems and by 1986 was saving the company $40 million a year.

Short History
AI becomes an Industry (1980-now)

- 1988:
  - DEC's AI group had 40 E.S.!
    Du Pont had 100 E.S. in use and 500 in development, saving $10 million a year.
  - Every major US corporation had (has) its own AI group.
- Information Systems – in all Industries and new University departments.

Short History

AI becomes an Industry (1980-now)

- 1981:
  - Japan announced “Fifth Generation” project.
  - The “Fifth Generation Project” used Prolog to achieve full-scale natural language understanding.
  - USA formed a company MCC (Microelectic and Computer Technology Corporation) to compete with Japan.

    Others:
        Cornegie Group, Inference, Intellicop,
        Lisp Machines.

Short History
AI becomes an Industry (1980-now)

- Industry went from a few million in sales in 1980 to 2 Billion in 1988.

- For the "Fifth Generation Project" FGP, a progress had been made but the project failed.

- Prolog is just one of many programming languages.

- Prolog is still prominent in Linguistics and Natural Language processing and translation.

PROLOG – Logic Programming Short History

- 1964–65 :
  Robinson, (Syracuse University), introduced Resolution.

- 1968–70:
  Kowalski, University of Edinburgh, England, created first version of Prolog.

- David Warren (British) made the prolog machine.
- Stony Brook's D. Warren was a president of Association for Logic Programming. Prominent !

Philosophical Issues

- AI research makes the assumption that human intelligence can :

1) be reduced to the (complex) manipulations of symbols, and

2) It does not matter what Medium is used to manipulate these symbols. (It does not have to be a biological brain.)

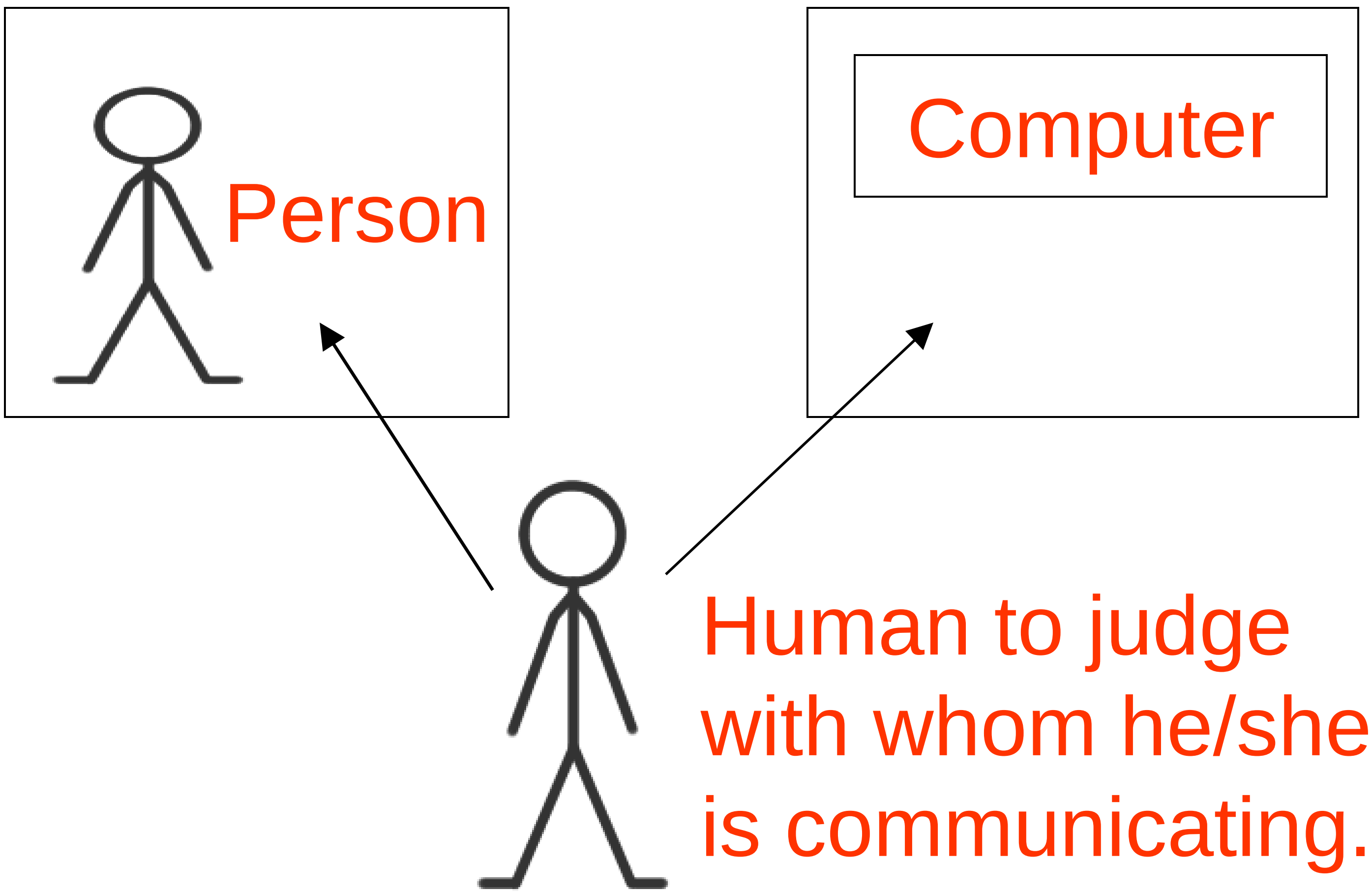
Philosophical Issues

- Turing's test (1950) and Charles Searle' Chinese room (1980) are the most known contributions to the philosophical debate.

- Loebner Prize Contest – competition started in 1991 & inspired by Turing test.
  - Best program − $2,000.
  - Grand Prize - $100,000. (No one claimed yet.)

Philosophical Issues (Cont.)

- Turing Test:



Philosophical Issues (Cont.)

- Turing test (Cont.):
  - The human can ask the other person/computer any question; including very subjective questions, like:
    - “What is your favorite color?” and
    - “What do you think of the privatization of the British Rail” ?
  - Computer is Intelligent – If it answers so well that the judge cannot distinguish it from a person.

Philosophical Issues (Cont.)

- Searle “Chinese Room” Critique:

  If you have a huge rule book on Chinese you can “talk” Chinese even if you do not understand it; so, T. Test does not measure the Intelligence.

Questions – Answers Systems. The Loebner Prize Contest

- 10 judges type questions at a computer which are responded by a person or a program.
- The best program receives $2000.
- The Winning program : $100,000.
  - No one won yet, but one program fooled 5 judges out of 10.

Questions – Answers Systems. The Loebner Prize Contest (Cont.)

- 1996 Winning Fragment:

  P: No worries ! Hey! I did not come here to be subjected to bad language! How rude.

  J2: Sorry, sorry. Did not mean to offend. How old are you?

The Loebner Prize Contest 1996 Winning Fragment (Cont.)

P: That is ok. Just don't do it again. Well, should my age really matter? Just for the record, I am 24. How old are you then?

J2: I am 21.

P: If you are 21, it is your business! Would you like to hear a joke? Knock, knock.

Questions – Answers Systems.

- Programs like these don't really understand the conversation. They use various stores of amusing replies and use keywords in the question to select the reply.
- Example: 1960 a program, "ELIZA" attempted to imitate a psychotherapist.