CSC 101-01 Spring 2011

Artificial Intelligence

By Dr. Marek A. Suchenek

What is AI?

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Artificial intelligence is ...

"the study and design of intelligent agents"

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where an intelligent agent is a system

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"the study and design of intelligent agents"

where an intelligent agent is a system

that perceives its environment

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where an intelligent agent is a system

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and takes rational actions

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Russell, Stuart J.; Norvig, Peter (2003), “Artificial Intelligence: A Modern Approach”

What is AI?

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Artificial intelligence is ...

"the science and engineering of making intelligent machines."

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John McCarthy (2007), “What is Artificial Intelligence?”

What is AI?

Four major definitions:

What is AI?

Four major definitions:

- Systems that think like humans

What is AI?

Four major definitions:

- Systems that think like humans
- Systems that act like humans

What is AI?

Four major definitions:

- Systems that think like humans
- Systems that act like humans
- Systems that think rationally

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- Systems that act like humans
- Systems that think rationally
- **Systems that act rationally**

The Turing Test

The Turing Test

The computer passes the intelligence test

The Turing Test

The computer passes the intelligence test iff

The Turing Test

The computer passes the intelligence test iff

a human tester

The Turing Test

The computer passes the intelligence test iff

a human tester cannot distinguish it

The Turing Test

The computer passes the intelligence test iff

a human tester cannot distinguish it from a person

The Turing Test

The computer passes the intelligence test iff

a human tester cannot distinguish it

from a person

based on his written questions

The Turing Test

The computer passes the intelligence test iff

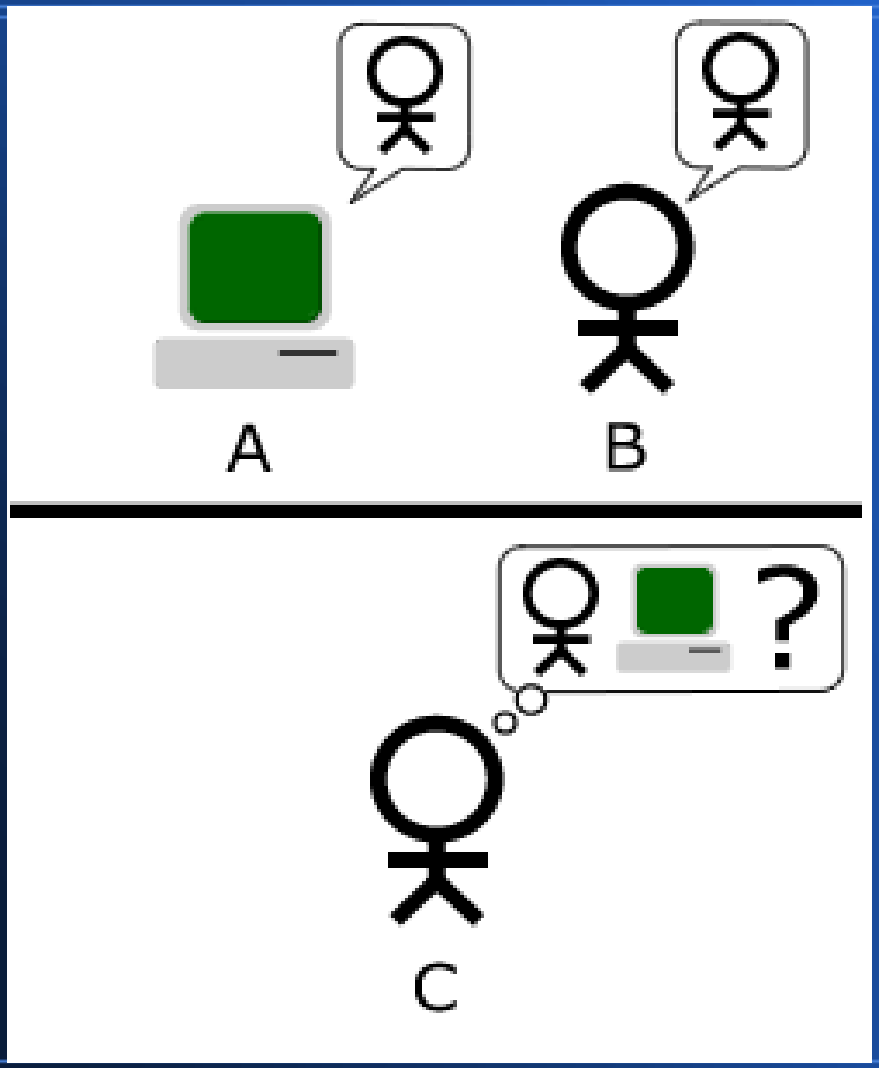
a human tester cannot distinguish it

from a person

based on his written questions

and computer's answers.

The Turing Test



http://upload.wikimedia.org/wikipedia/commons/e/e4/Turing_Test_

Intelligent Capabilities

Intelligent Capabilities

- natural language processing

Intelligent Capabilities

- natural language processing
- knowledge representation

Intelligent Capabilities

- natural language processing
- knowledge representation
- automated reasoning

Intelligent Capabilities

- natural language processing
- knowledge representation
- automated reasoning
- machine learning

Intelligent Capabilities

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- computer vision

Intelligent Capabilities

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- machine learning
- computer vision
- robotics

Intelligent Capabilities

- natural language processing
- knowledge representation
- automated reasoning
- machine learning
- computer vision
- robotics
- planning

Example of AI

Example of AI

Playing and winning games with humans.

Example of AI

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Game (like chess) has:

Example of AI

Playing and winning games with humans.

Game (like chess) has:

- unambiguously defined rules

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http://demonstrations.wolfram.com/TicTacToe/

Problem solving

Problem solving

- Searching

Problem solving

Searching

Given a collection of possible situations

(a search space)

Problem solving

Searching

Given a collection of possible situations

(a search space)

and constrains that limit agent's actions

Problem solving

Searching

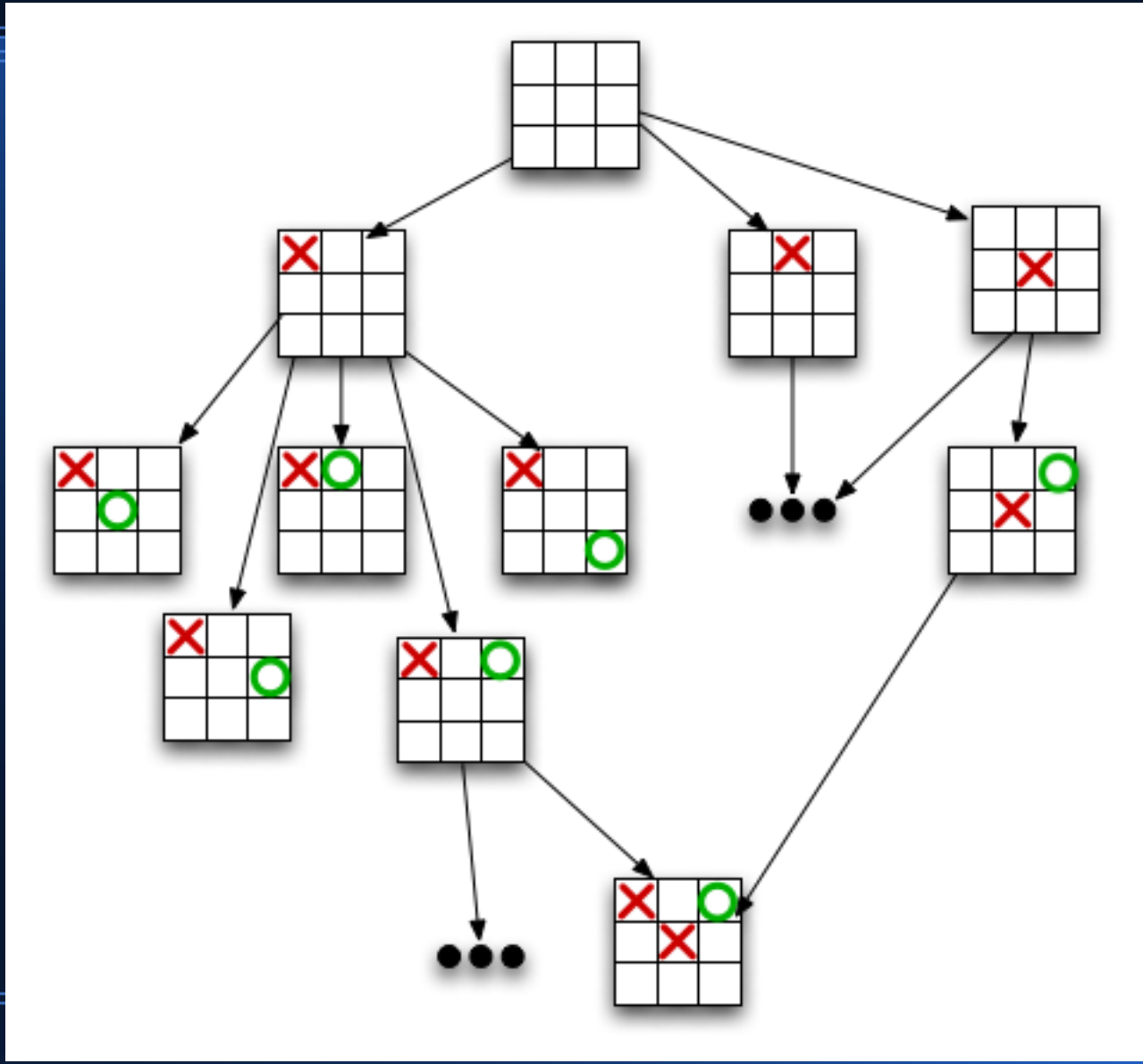
Given a collection of possible situations

(a search space)

and constrains that limit agent's actions

find a situation that meets the defined goal.

Problem solving



Problem solving

Search can be carried on by:

Problem solving

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- brute force

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- heuristics

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- heuristics (a.k.a. informed search)

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  - may involve learning heuristics from experience

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Knowledge and Reasoning

Knowledge and Reasoning

Knowledge is represented as:

Knowledge and Reasoning

Knowledge is represented as:

- a set of sentences

Knowledge and Reasoning

Knowledge is represented as:

- a set of sentences (a.k.a. facts and rules)

Knowledge and Reasoning

Knowledge is represented as:

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  - the set of individual objects to which the sentences refer to.

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Hence: Knowledge Base

Knowledge and Reasoning

Reasoning is carried on by:

Knowledge and Reasoning

Reasoning is carried on by:

- inference

Knowledge and Reasoning

Reasoning is carried on by:

- inference
- a.k.a. automated deduction

Knowledge and Reasoning

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- a.k.a. (in more complicated scenarios)

Knowledge and Reasoning

Reasoning is carried on by:

- inference
- a.k.a. automated deduction
- a.k.a. (in more complicated scenarios)
  - automated theorem proving

Knowledge and Reasoning

Knowledge Base is:

Knowledge and Reasoning

Knowledge Base is:

- a data base with

Knowledge and Reasoning

Knowledge Base is:

- a data base with
- deductive capabilities

Knowledge and Reasoning

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- deductive capabilities

Hence, deductive data base.

Knowledge and Reasoning

Expert System is:

Knowledge and Reasoning

Expert System is:

- a knowledge base with

Knowledge and Reasoning

Expert System is:

- a knowledge base with
- inference engine, and

Knowledge and Reasoning

Expert System is:

- a knowledge base with
- inference engine, and
- user interface.

Knowledge and Reasoning

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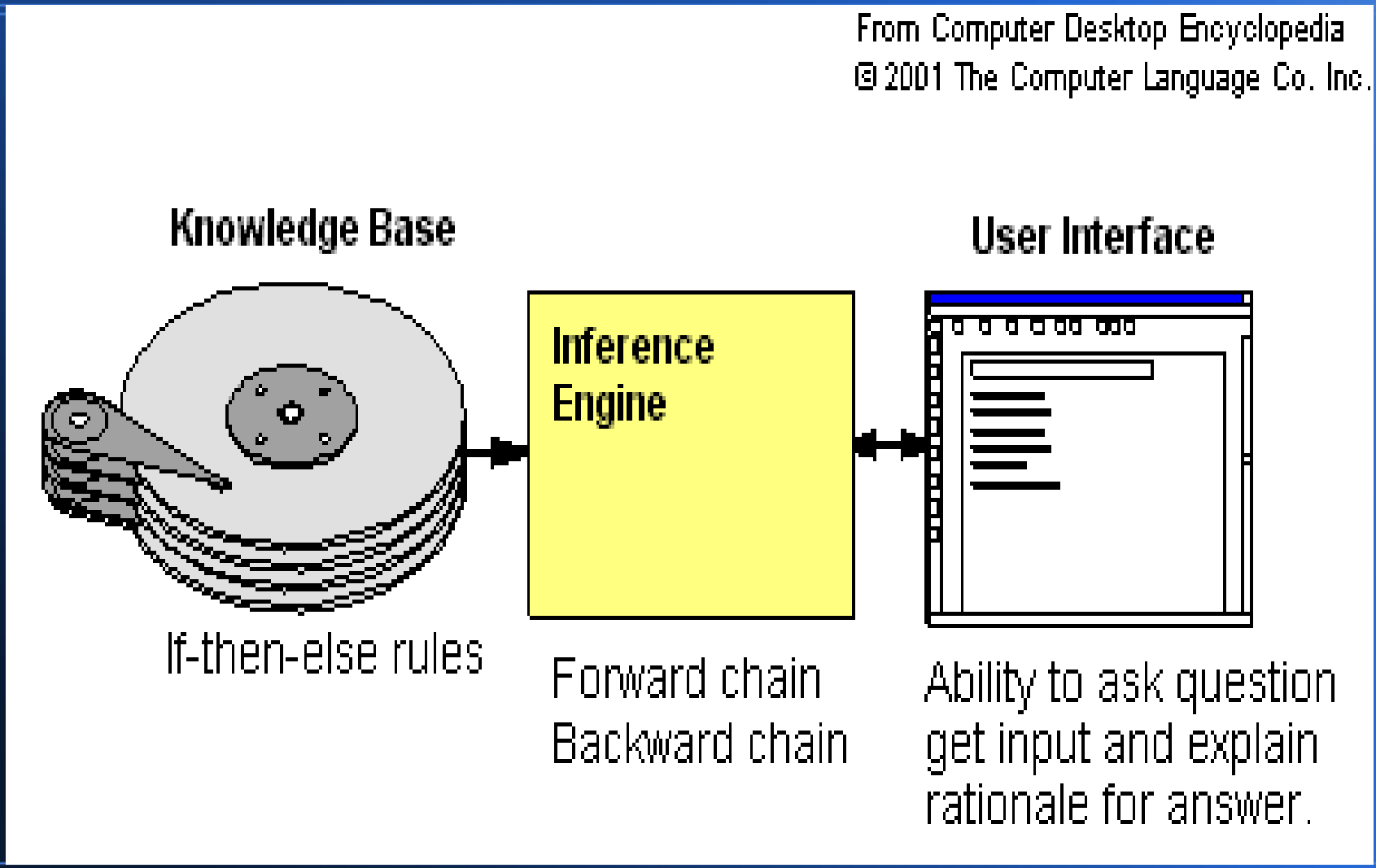
http://images.yourdictionary.com/images/computer/EXPERT.GIF

Knowledge and Reasoning



Knowledge and Reasoning

Common sense logic and reasoning

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- different than classic (mathematical) logic

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- makes use of implicit assumptions

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- concludes from a lack of knowledge

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Common sense logic and reasoning

- different than classic (mathematical) logic
- makes use of implicit assumptions
  - closed-world assumption
- supports decision in a lack of complete information
- concludes from a lack of knowledge
  - non-monotonic logic

Knowledge and Reasoning

Example

Knowledge and Reasoning

Example

If I had a brother ...

Knowledge and Reasoning

Example

If I had a brother ...

I would have known that I have one.

Knowledge and Reasoning

Example

If I had a brother ...

I would have known that I have one.

So ...

Knowledge and Reasoning

Example

If I had a brother ...

I would have known that I have one.

So ...

If I don't know that I have a brother

Knowledge and Reasoning

Example

If I had a brother ...

I would have known that I have one.

So ...

If I don't know that I have a brother

then I don't have a brother.

Knowledge and Reasoning

Example

Hence, from a lack of knowledge one concludes:

Knowledge and Reasoning

Example

Hence, from a lack of knowledge one concludes:

“I have no brother”

Knowledge and Reasoning

Example

Hence, from a lack of knowledge one concludes:

“I have no brother”

But what if my parents didn't tell me ...?

Knowledge and Reasoning

Example

Hence, from a lack of knowledge one concludes:

“I have no brother”

But what if my parents didn't tell me ...?

Knowledge and Reasoning

Example

Then I will have to withdraw my conclusion.

Knowledge and Reasoning

Example

Then I will have to withdraw my conclusion.

Hence: non-monotonic logic.

Machine Learning

Machine Learning

- Learning from observations

Machine Learning

- Learning from observations
- Knowledge in learning
  - extracting knowledge (rules) from examples

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- Learning from observations
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  - making discoveries

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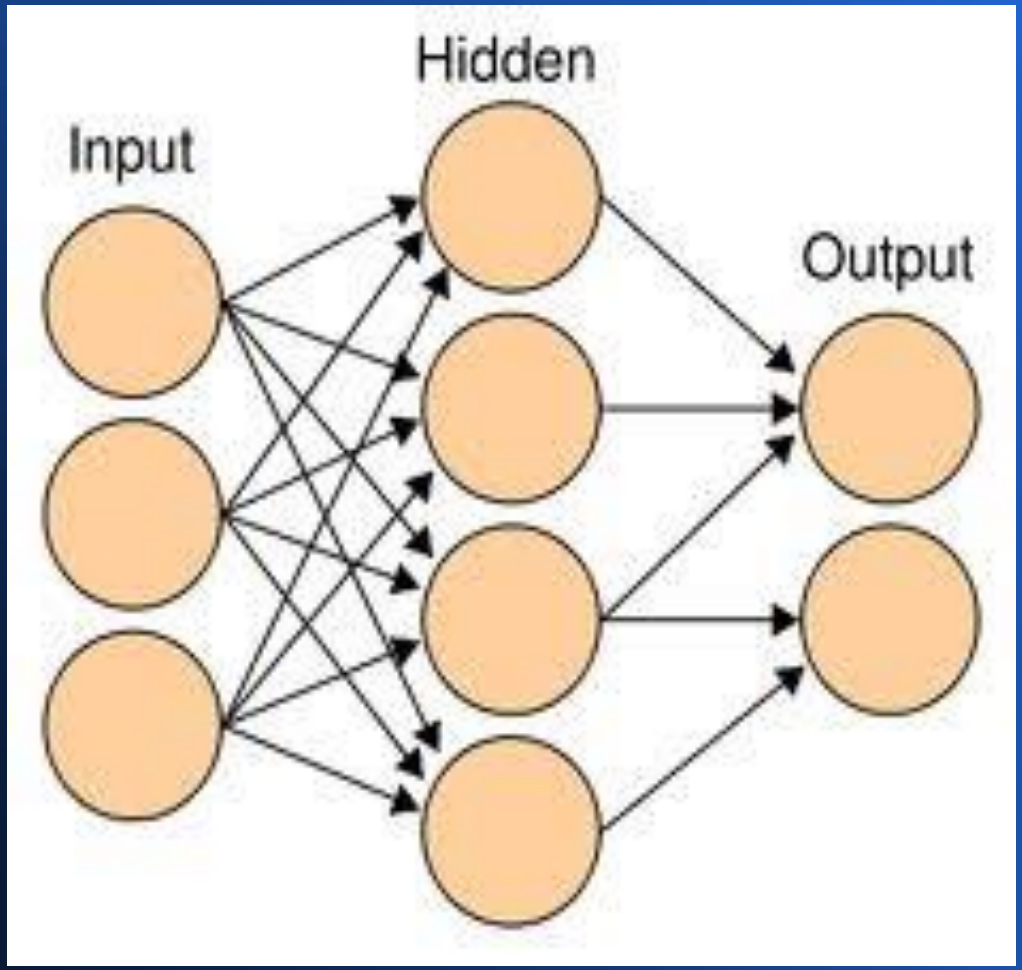
  - example: handwriting recognition

Machine Learning

- Learning from observations
- Knowledge in learning
  - extracting knowledge (rules) from examples
  - making discoveries
- Statistical learning
  - example: handwriting recognition
  - Neural Networks

Machine Learning

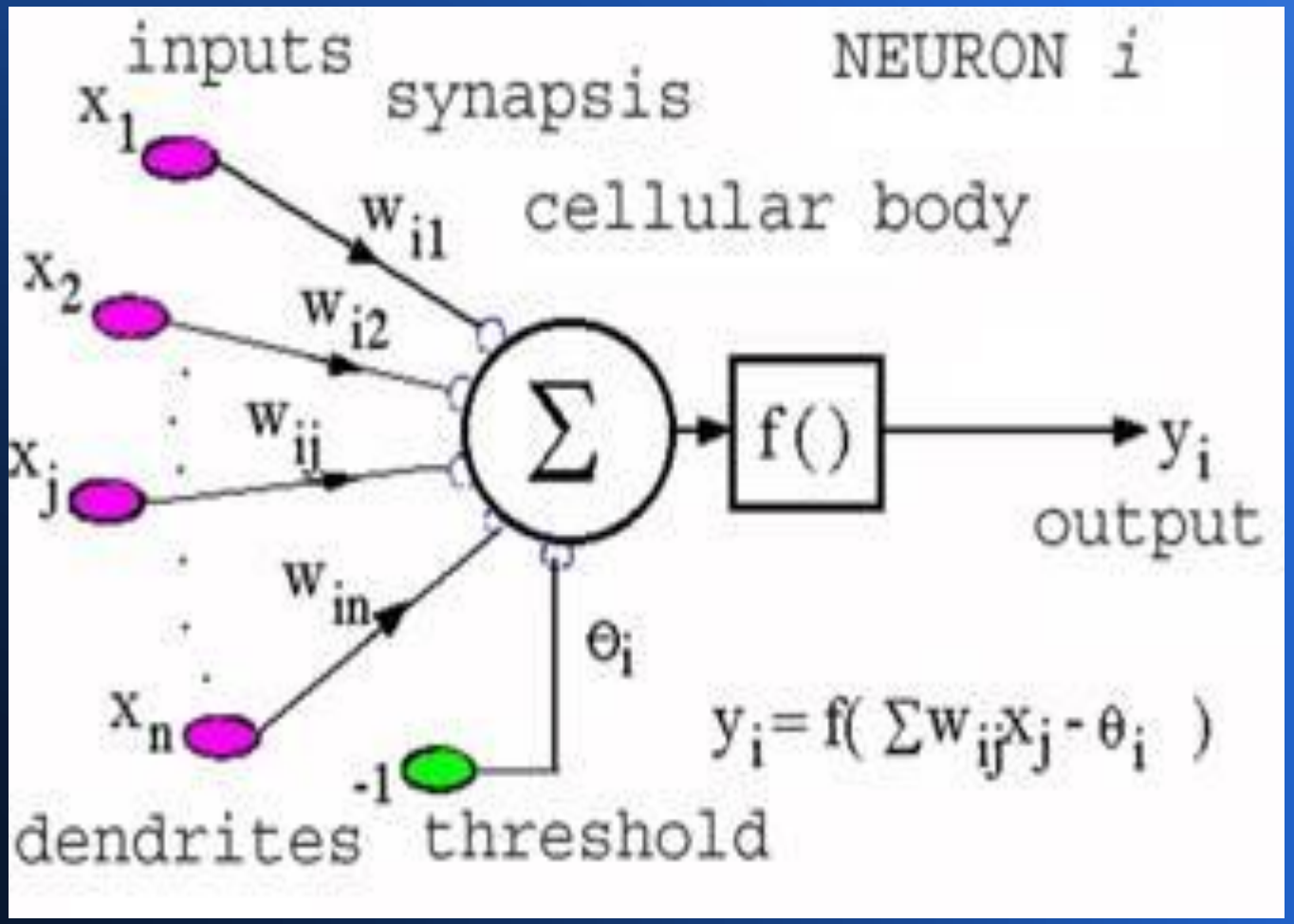
Neural Net



http://t1.gstatic.co

Machine Learning

Neuron



http://www.bradley.edu/campusorg/aipo/372_files/image002.jpg

Communication and Perception

Communication and Perception

Communication with machine in natural language (e.g., English) gained notoriety for difficulties and troubles.

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Spoken and hand-written communications magnified these difficulties.

Communication and Perception

Speech synthesis proved relatively easy, though.

Communication and Perception

Speech synthesis proved relatively easy, though.

A system can recite virtually anything you can type.

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A system can recite virtually anything you can type.

Recognition of printed text with OCR technology has been successful as well.

Communication and Perception

- Speech recognition

Communication and Perception

- Speech recognition
  - syntactic analysis (parsing)

Communication and Perception

- Speech recognition
  - syntactic analysis (parsing)
  - semantic interpretation

Communication and Perception

- Speech recognition
  - syntactic analysis (parsing)
  - semantic interpretation
  - resolving ambiguities

Communication and Perception

- Speech recognition
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- Speaker Independence

Communication and Perception

- Speech recognition
  - syntactic analysis (parsing)
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  - domain of discourse
- Speaker Independence
- Speech synthesis

Communication and Perception

- Computer vision

Communication and Perception

- Computer vision
  - pattern recognition

Communication and Perception

- Computer vision
  - pattern recognition
  - 3D images

Communication and Perception

- Computer vision
  - pattern recognition
  - 3D images
  - motion

Communication and Perception

- Computer vision
  - pattern recognition
  - 3D images
  - motion
- Image processing

Communication and Perception

- Computer vision
  - pattern recognition
  - 3D images
  - motion
- Image processing
- Manipulation and navigation

Robotics

Robotics

Human-like robots

http://upload.wikimedia.org/wikipedia/commons/thumb/c/c5/Shadow_Hand_Bulb_large.jpg/

Robotics

Industrial robots

http://www.rstech.com/zimages/industrial-robotics.gif

Robotics

Tasks specific for robots:

http://www.rstech.com/zimages/industrial-robotics.gif

Robotics

Tasks specific for robots:

- Planning

http://www.rstech.com/zimages/industrial-robotics.gif

Robotics

Tasks specific for robots:

- Planning
- Moving

http://www.rstech.com/zimages/industrial-robotics.gif

Limitations

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Mr. Beekman cannot prove this sentence without contradicting himself.

Limitations

Mr. Beekman cannot prove this sentence without contradicting himself.

But ...

Limitations

Mr. Beekman cannot prove this sentence without contradicting himself.

But ...

Every math major can prove it!

Limitations

A machine that can correctly determine if a software program ever properly terminates cannot exist.

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A machine that can correctly determine if a software program ever properly terminates cannot exist.

Not now, not a thousand years form now, never.

Limitations

A machine that can correctly determine if a software program ever properly terminates cannot exist.

Not now, not a thousand years form now, never.

[Alan Turing, 1936]

Modern History of AI 1950 - 2000

Excerpts from
http://www.aaai.org/AITopics/pmwiki/pmwiki.php/AITopics/BriefHistory with corrections by Marek A. Suchenek

Modern History of AI 1950 - 2000

1950

“The Turing Test” is proposed by Alan Turing (University of Manchester) in his book "Computing Machinery and Intelligence" as a way of dealing with the question whether machines can think.

Modern History of AI 1950 - 2000

1951

Marvin Minsky and Dean Edmonds (at Princeton) built SNARC, the first neural network computer.

Modern History of AI 1950 - 2000

1956

John McCarthy (at Darthmouth College) coined the term "artificial intelligence" at the first conference devoted to the subject (in Dartmouth).

Modern History of AI 1950 - 2000

1956

The first running AI program, the Logic Theorist (LT) written by Allen Newell, J.C. Shaw and Herbert Simon (Carnegie Institute of Technology, now Carnegie Mellon University).

Modern History of AI 1950 - 2000

1957

The General Problem Solver (GPS)
demonstrated by Newell, Shaw & Simon.

Modern History of AI 1950 - 2000

1952-62

Arthur Samuel (IBM) wrote the first game-playing program, for checkers, to challenge a world champion.

Modern History of AI 1950 - 2000

1961

James Slagle (PhD dissertation, MIT) wrote the first symbolic integration program, SAINT, which solved calculus problems at the college freshman level.

Modern History of AI 1950 - 2000

1962

First industrial robot company, Unimation, founded.

Modern History of AI 1950 - 2000

1963

Thomas Evans' program, ANALOGY, written at MIT, demonstrated that computers can solve problems on IQ tests.

Modern History of AI 1950 - 2000

1964

Danny Bobrow's dissertation at MIT shows that computers can understand natural language well enough to solve algebra word problems correctly.

Modern History of AI 1950 - 2000

1965

J. Alan Robinson at Rice University and Argonne National Laboratory invented a mechanical proof procedure, the Resolution Method, which allowed programs to work efficiently with formal logic as a representation language.

Modern History of AI 1950 - 2000

1965

Joseph Weizenbaum (MIT) built ELIZA, an interactive program that carries on a dialogue in English on any topic.

Modern History of AI 1950 - 2000

1967

Dendral program (Edward Feigenbaum, Joshua Lederberg, Bruce Buchanan, Georgia Sutherland at Stanford): first successful knowledge-based program for scientific reasoning.

Modern History of AI 1950 - 2000

1969

SRI robot, Shakey, demonstrated combining locomotion, perception and problem solving.

Modern History of AI 1950 - 2000

1970

Jaime Carbonell (Sr.) developed SCHOLAR, an interactive program for computer-aided instruction based on semantic nets as the representation of knowledge.

Modern History of AI 1950 - 2000

1971

Robert S. Boyer and J Strother Moore at University of Edinburgh begun their work on Nqthm, a fully-automatic, logic-based theorem prover.

Modern History of AI 1950 - 2000

1974

Ted Shortliffe's PhD dissertation on MYCIN (Stanford): rule-based system for knowledge representation and inference in the domain of medical diagnosis and therapy. Sometimes called the first expert system.

Modern History of AI 1950 - 2000

1975

The Meta-Dendral learning program produced new results in chemistry (some rules of mass spectrometry) the first scientific discoveries by a computer to be published in a refereed journal.

Modern History of AI 1950 - 2000

1978

Herb Simon wins the Nobel Prize in Economics for his theory of bounded rationality, one of the cornerstones of AI known as "satisficing".

Modern History of AI 1950 - 2000

1979

Drew McDermott & Jon Doyle at MIT, John McCarthy at Stanford, and Raymond Reiter at University of Toronto, published works on non-monotonic logic.

Modern History of AI 1950 - 2000

1983

Ryszard S. Michalski at University of Illinois at Urbana-Champaign, Jaime G. Carbonell at Carnegie Mellon University, and Tom M. Mitchell at Rutgers University, publish book "Machine Learning: An Artificial Intelligence Approach"

Modern History of AI 1950 - 2000

Mid 80's

Neural Networks become widely used .

Modern History of AI 1950 - 2000

1988

Jack Minker at University of Maryland, College Park, edits book Foundations of Deductive Databases and Logic Programming

Modern History of AI 1950 - 2000

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Go to http://www.bing.com

and search for deductive data bases

Modern History of AI 1950 - 2000

1989

Dean Pomerleau at CMU creates ALVINN (An Autonomous Land Vehicle in a Neural Network), which grew into the system that drove a car coast-to-coast under computer control for all but about 50 of the 2850 miles.

Modern History of AI 1950 - 2000

1990's

Major advances in all areas of AI with significant demonstrations in:

machine learning,

intelligent tutoring,

case-based reasoning,

multi-agent planning,

Modern History of AI 1950 - 2000

scheduling,

uncertain reasoning,

data mining,

natural language understanding and translation,

vision,

virtual reality,

games,

and other topics.

Modern History of AI 1950 - 2000

1997

The Deep Blue chess program beats the current world chess champion, Garry Kasparov, in a widely followed match.

Modern History of AI 1950 - 2000

1997

First official Robo-Cup soccer match featuring table-top matches with 40 teams of interacting robots and over 5000 spectators.

Modern History of AI 1950 - 2000

Late 90's

Web crawlers and other AI-based information extraction programs become essential in widespread use of the world-wide-web.

Modern History of AI 1950 - 2000

2000

Interactive robot pets (a.k.a. "smart toys") become commercially available, realizing the vision of the 18th century novelty toy makers.

Modern History of AI 1950 - 2000

2000

The Nomad robot explores remote regions of Antarctica looking for meteorite samples.

Now you know Computers 101