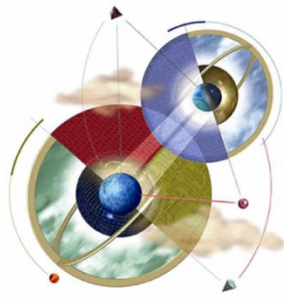


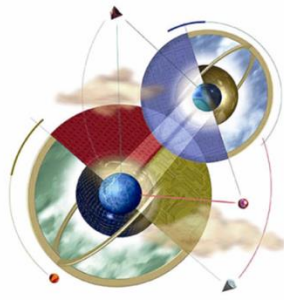
Introduction to Artificial Intelligence

智能技术/人工智能导论



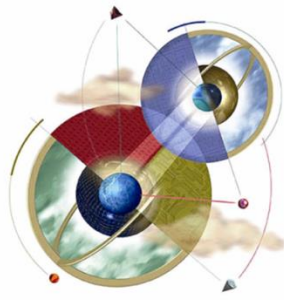
Introduction to AI

- ◆ **Lecturer: Huang Jinghua**
(huangjh@sem.tsinghua.edu.cn)(
Weilun 456A)
- ◆ **Assistant: Jin Yue**
(jiny.13@sem.tsinghua.edu.cn)
- ◆ **Office Hours: Thursday afternoon**
1:30-3:00



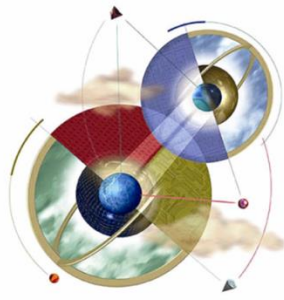
Syllabus

- ◆ **Course Objectives**
- ◆ **Prerequisites**
- ◆ **Attendance Policy and Courtesy**
- ◆ **Homework Policy**
- ◆ **Grading**
- ◆ **Textbook and References**
- ◆ **Course Overview**



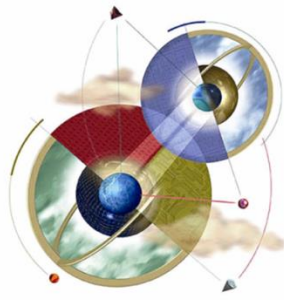
Course Objectives

- ◆ **This course is an introduction to AI, which is an integral part of the computer science curriculum.**
- ◆ **In this course, we learn how theory and applications complement each other. Both theory and application are presented.**



Course Objectives

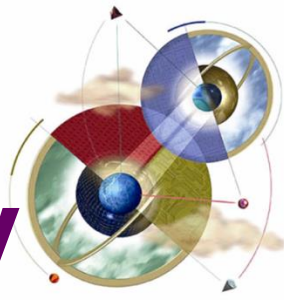
- ◆ **Students are provided with the Prolog and Matlab that can be used to develop systems and calculate.**
- ◆ **By integrating theory with a fully functional means of applying that theory to real-world situations, students will gain an appreciation for the role played by AI in today's world.**



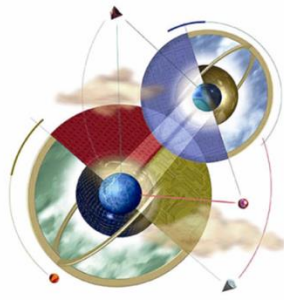
Prerequisites

- ◆ **Prior experience with at least one high-level programming language is expected.**
- ◆ **Familiarity with both procedural and object-oriented programming concepts is recommended.**

Attendance Policy and Courtesy

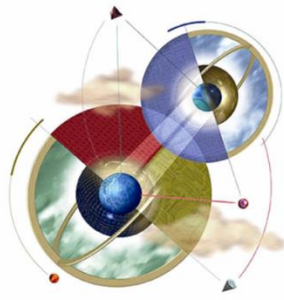


- ◆ **Students are expected to attend ALL lecture sessions. Failure to attend may affect your grade.**
- ◆ **Students are encouraged to actively participate in the class in a constructive manner.**
- ◆ **It is expected that students will conduct themselves in a courteous manner to the professor and fellow students.**
 - **No cell-phone calls, and no other actions that are disruptive to the class.**
 - **Make every effort to arrive on time to class.**



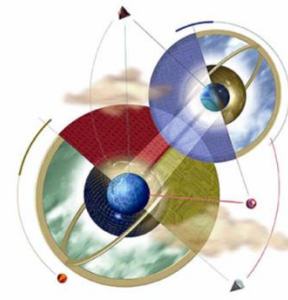
Homework Policy

- ◆ **Assignments will normally be due one week after they are assigned.**
- ◆ **Assignments can be submitted up to one week late for half credit.**
- ◆ **Assignments submitted later than one week past the due date will receive no credit.**



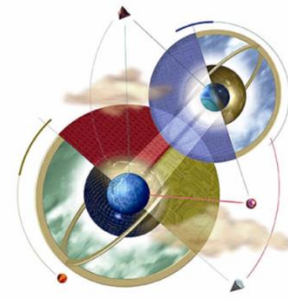
Grading

- ◆ **Assignment (20%)**
- ◆ **Group-work-report or case analysis, and Presentation (20%)**
- ◆ **Final exam(close-book) (60%)**



Textbook and References

- [1] George F.Luger. Artificial Intelligence: Structures and Strategies for Complex Problem Solving(6th edition). Addison Wesley, 2010
- [2] Joseph C. Giarratano, Gary D. Riley. Expert Systems: Principles and Programming (4th edition). Course Technology, 2005
- [3] Simon Haykin. Neural Networks and Learning Machine. (3rd edition). Pearson Edition and 机械工业出版社 , 2009
- [4] M. Mohri, A. Rostamizadeh A. Talwalkar. Foundations of Machine Learning. MIT Press, 2012
- [5] Appendix G of [2]
- [6] American Association for Artificial Intelligence
<http://www.aaai.org/aitopics/html/welcome.html>
- [7] AI Magazine



Course Overview

Ch.1 Introduction to AI (Ch1[1])

Ch.2 Predicate Calculus (Ch2,3,[2];Ch2,13 [1])

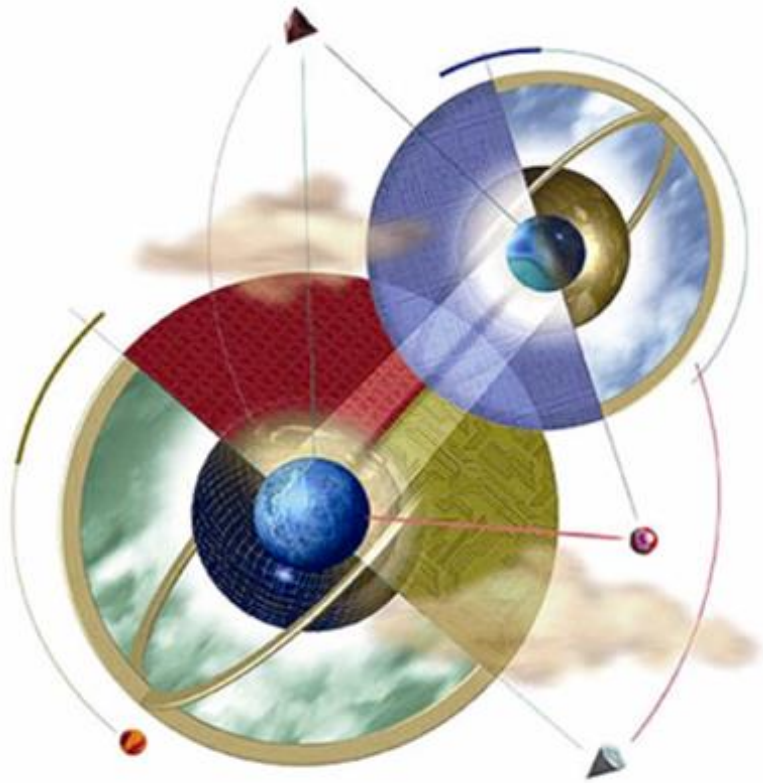
Ch.3 State Space Search(Ch3,4,[1])

Ch.4 Introduction to Prolog(Ch15,[1])

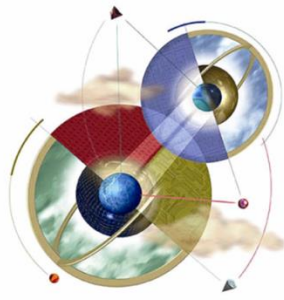
Ch.5 Other Knowledge Representation and Inference(Ch7,[1] ; Ch2,[2])

Ch.6 Reasoning in Uncertain Situation(Ch5,Ch9[1]; Ch4,5,[2])

Ch.7 Genetic Algorithm & Neural network(Ch11,12,[1])

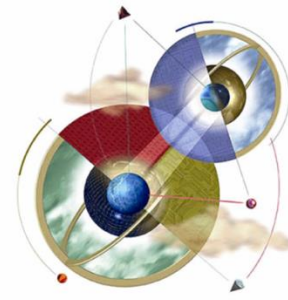


Chapter 1: Briefly Introduction to AI



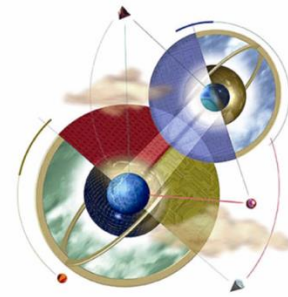
Outline

- ◆ **What is AI?**
- ◆ **Foundations of AI**
- ◆ **A Brief History**
- ◆ **Overview of AI Application Areas**
- ◆ **Common Important Features**



What is Artificial Intelligence

- ◆ **Origin after WWII**
- ◆ **Understand and BUILD intelligent entities**
- ◆ **Highly interdisciplinary**
- ◆ **Currently consist of huge variety of subfields**
 - **This course will discuss some of them**

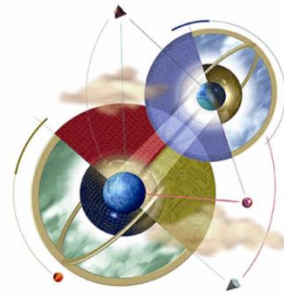


What is Artificial Intelligence

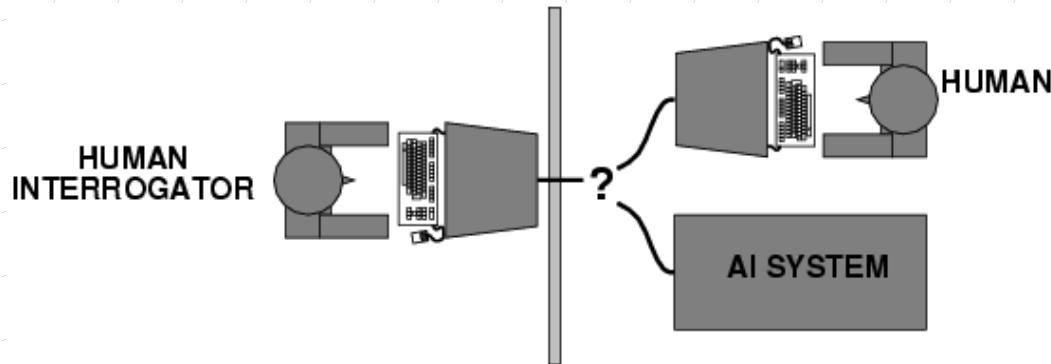
- ◆ Different definitions due to different criteria
 - Two dimensions:
 - ◆ Thought processes and reasoning vs. behavior/action
 - ◆ Success according to human standards vs. success according to an ideal concept of intelligence: rationality.

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

Systems that Act Like Humans

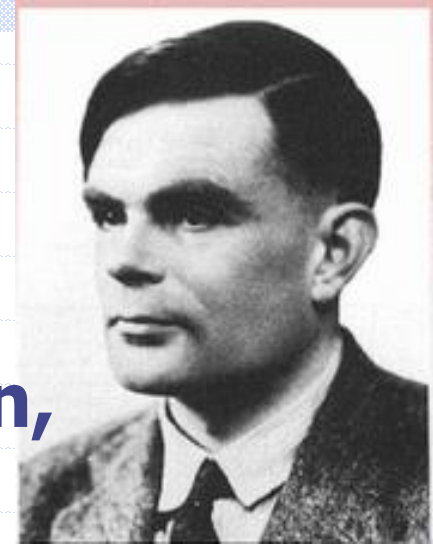


- ◆ When does a system behave intelligently?
 - Turing (1950) "Computing machinery and intelligence"
 - "Can machines think?" → "Can machines behave intelligently?"
 - Operational test for intelligent behavior: the Imitation Game



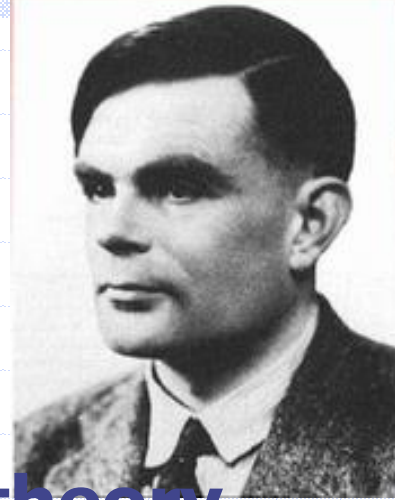
- Anticipated all major arguments against AI in following 50 years
- Suggested major components of AI: language understanding, knowledge representation, automated reasoning, machine learning, computer vision, robotics

Alan Turing



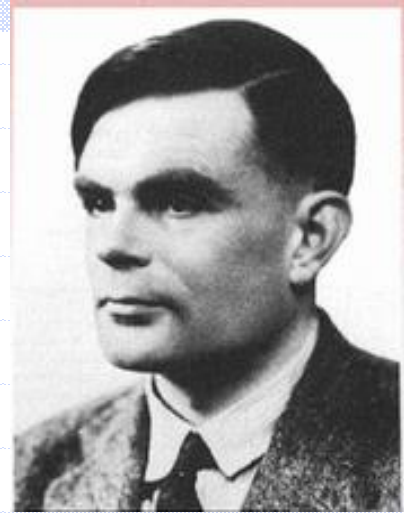
- ◆ **1912 (23 June): Birth, Paddington, London**
- ◆ **1931-34: Undergraduate at King's College, Cambridge University**
- ◆ **1936: “On computable numbers, with an application to the Entscheidungs problem.”**
 - **The Turing machine, computability, universal machine**
 - **Regarded as the foundation of computer science**

Alan Turing



- ◆ **1936-38: Ph.D. Princeton University, Logic, algebra, number theory**
- ◆ **1938-39: Return to Cambridge, Introduced to German Enigma cipher machine**
- ◆ **1945: National Physical Laboratory, London**
- ◆ **1948: Manchester University**

Alan Turing



- ◆ **1950: "Computing Machinery and Intelligence "**
 - **The Turing Test for machine intelligence**
 - **regarded as the foundation of the artificial intelligence program**
- ◆ **1952: Arrested as a homosexual**
- ◆ **1954 (7 June): Death (suicide) by cyanide poisoning, Wilmslow, Cheshire**
- ◆ **1966: Turing Awards set up by ACM in memory of Turing's contribution to the world**



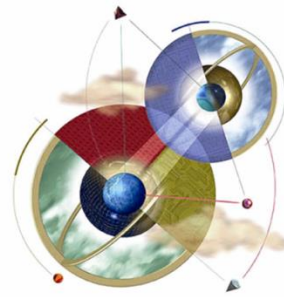
Systems that Think Like Humans

◆ How do humans think?

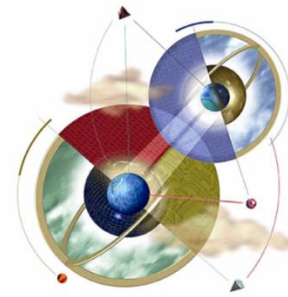
- Requires scientific theories of internal brain activities (cognitive model)
- -- How to validate? Requires
 - ◆ 1) Predicting and testing human behavior of human subjects
 - ◆ or 2) Direct identification from neurological data
- Cognitive Science vs. Cognitive neuroscience

◆ Both approaches are now distinct from AI

Systems that Think Rationally

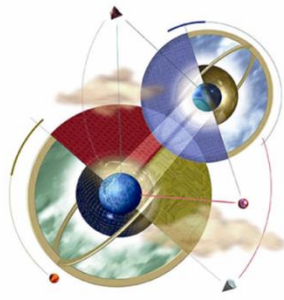


- ◆ **What are correct argument /thought processes? -- the laws of thought**
 - **Correctness depends on irrefutability of reasoning processes--- by Aristotle**
- ◆ **This study initiated the field of logic**
 - **The logicist tradition in AI hopes to create intelligent systems using logic programming**



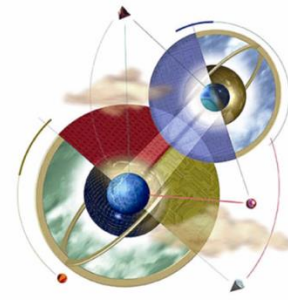
Systems that Act Rationally

- ◆ **Rational behavior: “doing the right thing”**
 - **The “right thing” is that what is expected to maximize goal achievement given the available information**
- ◆ **Making correct inferences is sometimes part of rational act**
- ◆ **Some rational action without thinking**
- ◆ **An agent is an entity that perceives and acts**
 - **Search agent, price-comparative agent**



Outline

- ◆ **What is AI?**
- ◆ **Foundations of AI**
- ◆ **A Brief History**
- ◆ **Overview of AI Application Areas**
- ◆ **Common Important Features**



Foundations of AI

◆ Different fields have contributed to AI in the form of ideas, viewpoints and techniques

◆ *Philosophy:*

- Concerned questions

- ◆ Can formal rules be used to draw valid conclusion?
- ◆ How does the mental mind arise from a physical brain?
- ◆ Where does knowledge come from?
- ◆ How does knowledge lead to action?

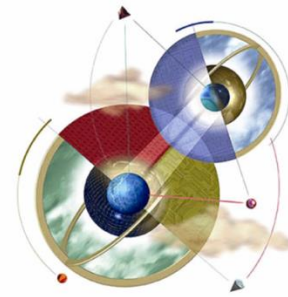
- Logic, reasoning, foundations of learning, language and rationality.

◆ *Mathematics:*

- Concerned questions

- ◆ What are the formal rules to draw valid conclusion?
- ◆ What can be computed?
- ◆ How do we reason with uncertain information?

- Formal representation and proof algorithms, computation, (un)decidability, probability



Foundations of AI

◆ *Psychology:*

■ Questions

- ◆ How do humans and animals think and act?
- adaptation, phenomena of perception, experimental techniques

◆ *Economics and Operations Research:*

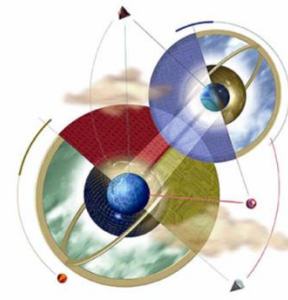
■ Questions

- ◆ How should we make decisions so as to maximize payoff?
- ◆ How should we do this when others may not go along?
- ◆ How should we do this when the payoff may be far in the future?
- theory of rational decisions, game theory

◆ *Computer engineering*

■ Questions

- ◆ How can we build efficient computers



Foundations of AI

◆ *Linguistics:*

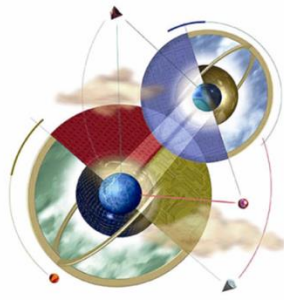
- Questions
 - ◆ How does language relate to thought?
- Natural language processing, knowledge representation, grammar

◆ *Neuroscience:*

- Questions
 - ◆ How do brains process information?
- physical substrate for mental activities

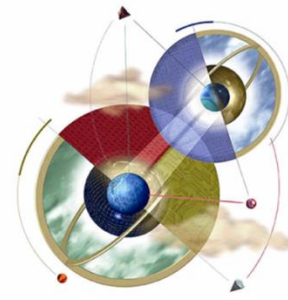
◆ *Control theory:*

- Questions
 - ◆ How can artifacts operate under their own control
- Homeostatic systems, stability, optimal agent design



Outline

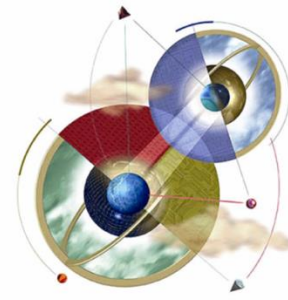
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A Brief History(1)

◆ The gestation of AI(43-55)

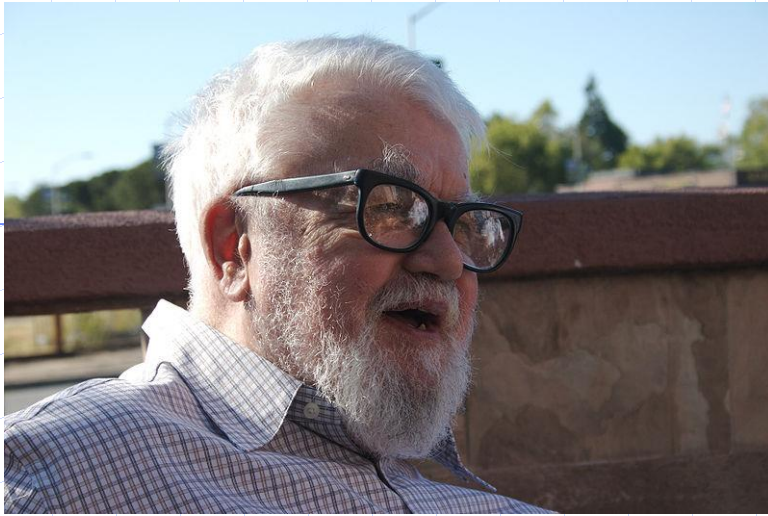
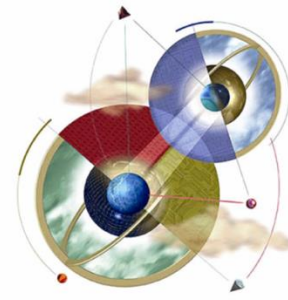
- **1943: Warren McCulloch and Walter Pitts: a model of artificial boolean neurons to perform computations**
- **1949: Donald Habb: first steps toward connectionist computation and learning (Hebbian learning)**
- **1951: Marvin Minsky and Dann Edmonds : constructed the first neural network computer**
- **1950: Alan Turing's "Computing Machinery and Intelligence"**



A Brief History (2)

◆ The birth of AI and great expectations (52-69)

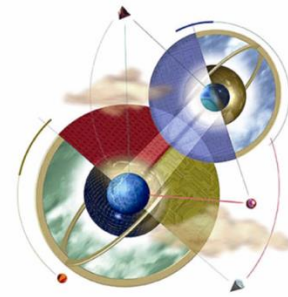
- **1956:Dartmouth Workshop bringing together top minds on automata theory, neural nets and the study of intelligence**
 - ◆ **Allen Newell and Herbert Simon: The logic theorist (first nonnumerical thinking program used for theorem proving)**
 - ◆ **For the next 20 years the field was dominated by these participants**
 - ◆ **“Artificial Intelligence” (suggested by McCarthy) adopted**
 - ◆ **Discipline was definitely started**



John McCarthy



Herbert Simon and Allen Newell

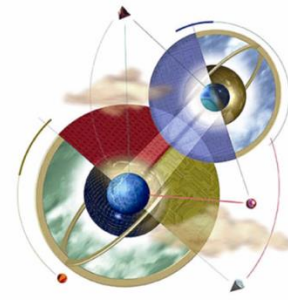


A Brief History (2)

◆ The birth of AI and great expectations (1952-1969) Continue

■ Great expectations (1952-1969)

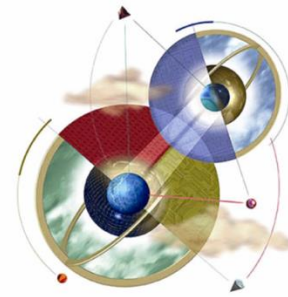
- ◆ Newell and Simon introduced the General Problem Solver
 - Imitation of human problem-solving
- ◆ Arthur Samuel (1952) investigated game playing (checkers) with great success
- ◆ John McCarthy(1958) :
 - Inventor of Lisp (second-oldest high-level language)
 - Logic oriented, Advice Taker (separation between knowledge and reasoning)
- ◆ Marvin Minsky (1958)
 - Introduction of microworlds that appear to require intelligence to solve: e.g. blocks-world
 - Anti-logic orientation



A Brief History (3)

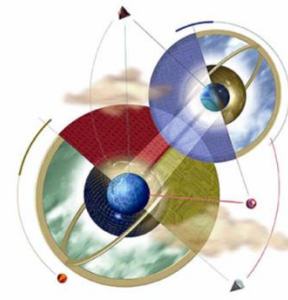
◆ A Dose of Reality (1966 - 1973)

- Progress was slower than expected
 - ◆ Unrealistic predictions
- Difficulties come from the following three ways
 - ◆ Most early programs contained little or no knowledge of the subject
 - Machine translation
 - ◆ Some systems lacked scalability
 - Combinatorial explosion in search
 - ◆ Fundamental limitations on techniques and representations
 - Minsky and Papert (1969) Perceptrons



A Brief History (4)

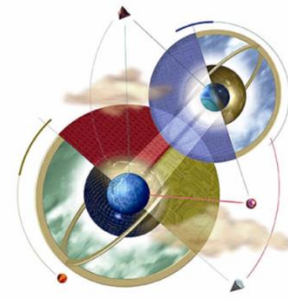
- ◆ **AI revival through knowledge-based systems (1969-1979)**
 - **General-purpose vs. domain specific**
 - ◆ **E.g. the DENDRAL project (Buchanan et al. 1969)**
 - **First successful knowledge intensive system**
 - **Expert systems**
 - ◆ **MYCIN to diagnose blood infections (Feigenbaum et al.)**
 - **Introduction of uncertainty in reasoning**
 - **Increase in knowledge representation research**
 - ◆ **Logic, frames, semantic nets, ...**



A Brief History (5)

- ◆ **AI becomes an industry (1980 - present)**
 - **R1 at DEC (1982)**
 - **Fifth generation project in Japan (1981)**
 - **American response ...**
- ◆ **Puts an end to the AI winter**

- ◆ **Connectionist revival (1986 - present)**
 - **Parallel distributed processing (Rumelhart and McClelland, 1986); backprop.**



A Brief History (6)

◆ 90's: Major advances in all areas of AI

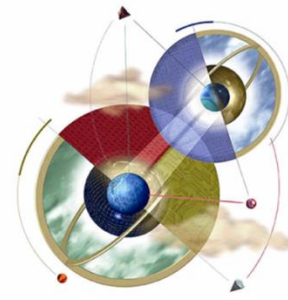
- machine learning
- case-based reasoning
- multi-agent planning
- scheduling
- uncertain reasoning
- data mining
- natural language understanding and translation
- vision
- virtual reality

◆ Late 90's:

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

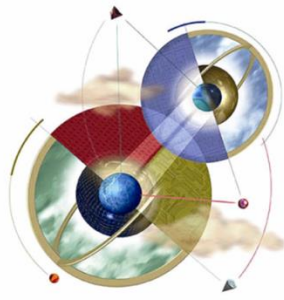
◆ 2000's:

- Interactive robot pets (a.k.a. "smart toys") become commercially available



Abridged history of AI

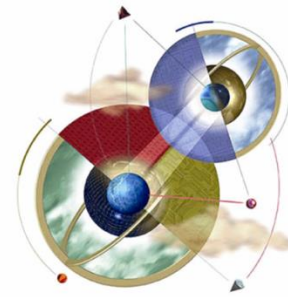
- ◆ 1943 McCulloch & Pitts: Boolean circuit model of brain
- ◆ 1950 Turing's "Computing Machinery and Intelligence"
- ◆ **1956** Dartmouth meeting: "Artificial Intelligence" adopted
- ◆ 1950s Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist
- ◆ 1965 Robinson's complete algorithm for logical reasoning
- ◆ 1966--73 AI discovers computational complexity
Neural network research almost disappears
- ◆ 1969--79 Early development of knowledge-based systems
- ◆ 1980--88 Expert systems industry booms (AI becomes an industry)
- ◆ 1988--93 Expert systems industry busts: "AI Winter"
- ◆ 1986-- Neural networks return to popularity



Outline

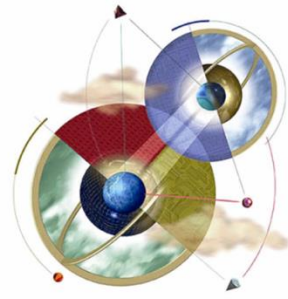
- ◆ **What is AI?**
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Important Research and Application Areas



- ◆ **Automated reasoning and theorem proving**
 - **Oldest and the most fruitful branch of AI**
 - **Responsible for formalizing search algorithm and developing formal representation language , such as predicate calculus and Prolog**
 - **Automated theorem proving lies in logic which leads itself to automation**
 - **Automated reasoning is based on formal mathematical logic**

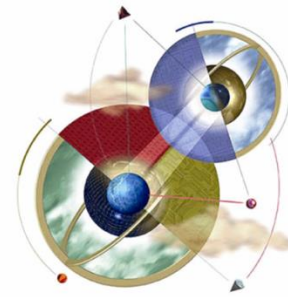
Important Research and Application Areas



◆ Expert Systems

“An expert system is a computer system that emulates, or acts in all respects, with the decision-making capabilities of a human expert.”

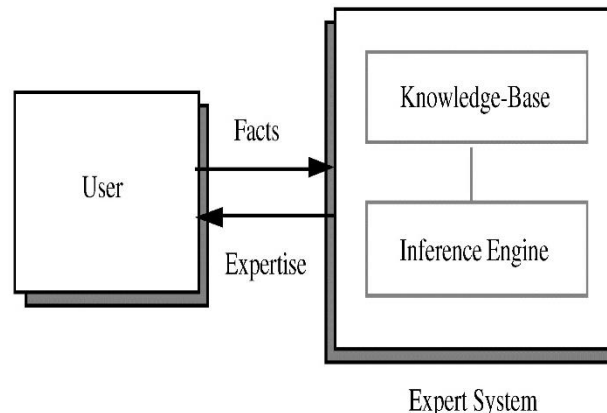
Professor Edward Feigenbaum
Stanford University

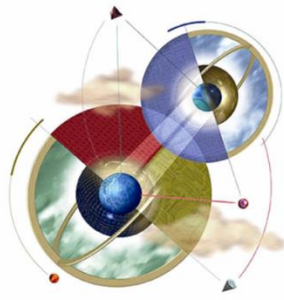


General Concepts of ES

◆ ES Main Components

- **Knowledge base – obtainable from books, magazines, knowledgeable persons, etc.**
- **Inference engine – draws conclusions from the knowledge base**





商用专家系统

- ◆ <http://www.exsys.com/>
- ◆ <http://www.exsys.com/Demos/Dogs/DogSelectorDemoPage.html>
- ◆ http://www.exsys.com/app_crm.html

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[NaturalMedsForum.com](#)

Symptoms & Signs Available:

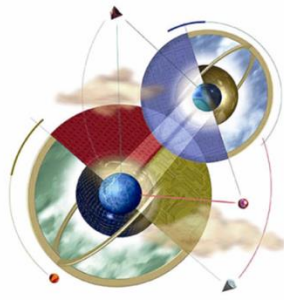
- CHEST PAIN** [info](#)
- CHEST PAIN (Pro Version)** [info](#)
- CONSTIPATION** [info](#)
- COUGH** [info](#)
- FAINTING (SYNCOPE)** [info](#)
- FATIGUE** [info](#)
- HEADACHE** [info](#)
- LOW BACK PAIN** [info](#)
- VERTIGO (DIZZINESS)** [info](#)
- UPPER ABDOMINAL SYMPTOMS** [info](#)

Conditions Available:

- ALCOHOLISM** [info](#)
- ATTENTION DEFICIT DISORDERS** [info](#)
- DEPRESSION** [info](#)
- GALL BLADDER DISEASE** [info](#)
- HEARING LOSS** [info](#)

Our **FREE** newsletter, "[Second Opinions](#)" discusses current medical issues and controversies and comes out once every few weeks.

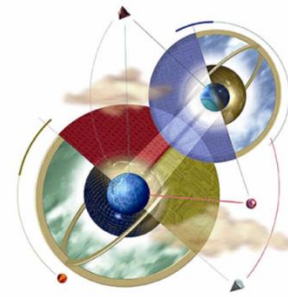
Enter email address here



医疗诊断专家系统demo

- ◆ <http://easydiagnosis.com/>
- ◆ <http://www.easydiagnosis.com/cgi-bin/expert/start.cgi?mod=Chronic+Fatigue>

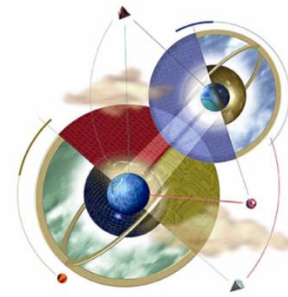
Important Research and Application Areas



◆ Natural Language Understanding

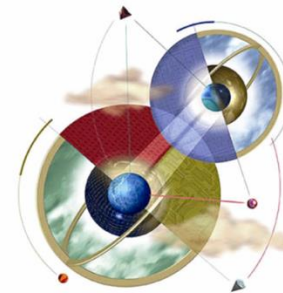
- Long-standing goal of AI: to create program capable of understanding and generating human language
- Examples:
 - ◆ conversation with computer
 - ◆ http://v.youku.com/v_show/id_XMjk5Njk0MDY4.html
- Some techniques
 - ◆ Parsing sentences into individual parts of speech and looking them up in a dictionary
 - ◆ Having extensive background knowledge about the discourse
 - ◆ Having idioms used in that domain
 - ◆ Applying contextual knowledge to resolve the omissions and ambiguities
 - ◆ Structuring semantic meaning

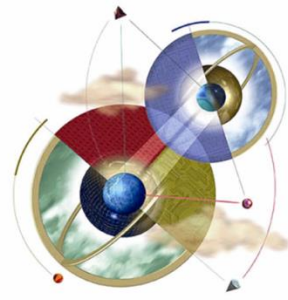
Important Research and Application Areas



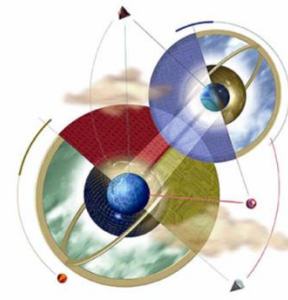
◆ Planning and Robotics

- During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people
- Bill Gates "A Robot in Every Home", Scientific American, 2007, 1

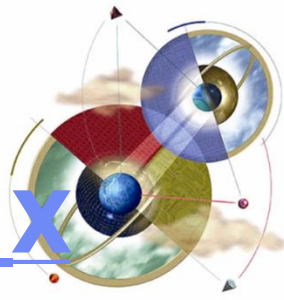




iRobot, a company based in Burlington, Mass., manufactures the Packbot EOD, which assists with bomb disposal in Iraq



Stanley, an autonomous vehicle built by the Stanford Racing Team won the 2005 DARPA Grand Challenge, traversing more than 130 miles of desert without the aid of a human driver.



◆ 佳佳机器人:

http://v.youku.com/v_show/id_XMTUzNjE5ODAzNg==.html?from=s1.8-1-1.2

◆ 波士顿动力新一代阿特拉斯机器人

http://v.youku.com/v_show/id_XMTQ4MDU4ODAxMg==.html?from=s1.8-1-1.2

◆ 无人驾驶汽车

http://v.youku.com/v_show/id_XMTUzODM0ODA0OA==.html?from=s1.8-1-1.2

http://v.youku.com/v_show/id_XMTUzMjczMjg2MA==.html?from=s1.8-1-1.2

Important Research and Application Areas

◆ Game playing

- State space search
- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997 by the score of 3.5 to 2.5



1963年
国际象棋AI(深蓝)
首次与人类大师对抗

1996年
国际象棋AI
首次挑战
人类世界冠军,
但以2-4落败

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国际象棋AI
以1胜2负3平
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2006年
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顶尖的国际象棋AI

2015年
Alpha Go以
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2016年3月
Alpha Go与
世界顶尖棋手
李世石对弈



Important Research and Application Areas



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谷歌AlphaGo背后团队DeepMind发迹史



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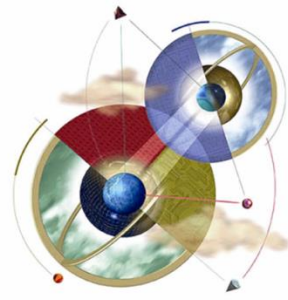
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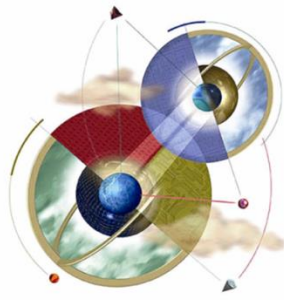


Important Research and Application Areas



“Mastering the Game of Go with Deep Neural Networks and Tree Search” . Nature, 2016,1

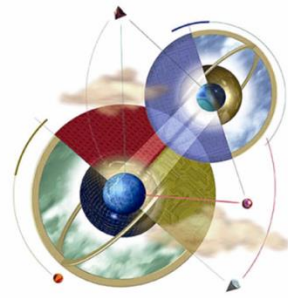
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Outline

- ◆ **What is AI?**
- ◆ **Foundations of AI**
- ◆ **A Brief History**
- ◆ **Overview of AI Application Areas**
- ◆ **Common Important Features**

Important Features Common to all Divisions of AI



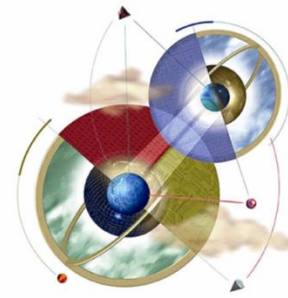
1. The use of computers to do reasoning, pattern recognition, learning.

pattern recognition is the assignment of a label to a given input value.

An example of pattern recognition is classification, which attempts to assign each input value to one of a given set of *classes* (for example, determine whether a given email is "spam" or "non-spam").

- 语音识别
- 手写识别
- 生物特征识别
- 人脸识别
- 指纹识别
- 虹膜识别

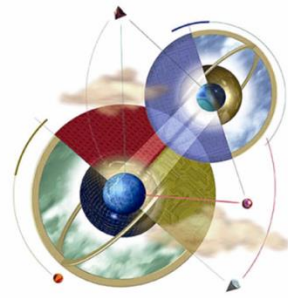
Important Features Common to all Divisions of AI



◆ Machine Learning

- Machine Learning seeks to answer the question "How can we build computer systems that automatically improve with experience, and what are the fundamental laws that govern all learning processes?"
- Concerns the construction and study of systems that can learn from data
- Design and develop of algorithms that allow computers to evolve behaviours based on empirical data

Important Features Common to all Divisions of AI

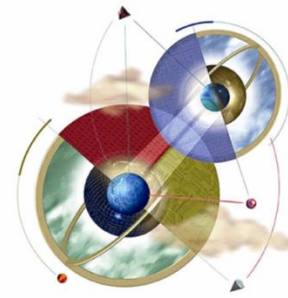


◆ Machine Learning

■ Application area

- ◆ Credit card, spam email, Airfare price prediction
- ◆ Nature language processing
 - IBM Watson Jeopardy
http://v.youku.com/v_show/id_XMjYwODkxNDA4.html
- ◆ Design autonomous mobile robots that learn to navigate from their own experience
- ◆ Data mine historical medical records to learn which future patients will respond best to which treatments
- ◆ Search engines that automatically customize to their user's interests.
- ◆ Recommendation
 - 推荐广告：使用海量数据提升广告点击率准确度

Important Features Common to all Divisions of AI

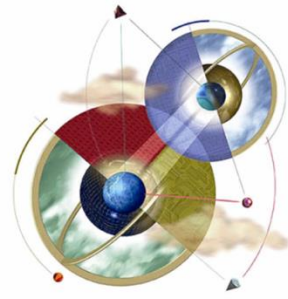


2. A focus on problems that do not respond to algorithmic solutions. This underlies the reliance on heuristic search as an AI problem-solving technique.

3. A concern with problem-solving using inexact, missing, or poorly defined information and the use of representational formalisms that enable the programmer to compensate for these problems.

4. Reasoning about the significant qualitative features of a situation.

Important Features Common to all Divisions of AI



5. An attempt to deal with issues of semantic meaning as well as syntactic form.
6. The use of large amounts of domain-specific knowledge in solving problems.