Intelligent Systems

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Module Information

Assignments	Continuous Assessment – 40% End Semester Examination – 60%
References	• Russell and Norvig (2003), Artificial Intelligence – a Modern Approach, Prentice Hall • Tom Mitchell , Machine Learning, McGraw Hill, 1997 • Goldberg D. E. (1989), Genetic Algorithms, Pearson Education • Introduction to Artificial Intelligence by Philip C. Jackson
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Introduction
Artificial Intelligence

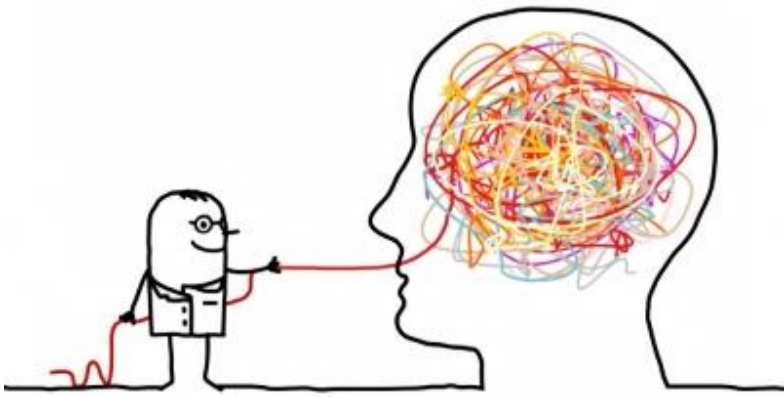
Overview

- Human Intelligence
- What is Intelligence and AI?
- Four Schools of thought
- Turing Test
- John Searle's argument
- History of AI
- Success Stories
- Can Computers beat Humans?
- Influential areas for AI
- More..

Machine vs Intelligent Machine

What is Intelligence?

- Intelligence:
  - "the capacity to learn and solve problems"
  - the ability to acquire and apply knowledge and skills.
  - in particular,
    - *the ability to solve novel problems*
    - *the ability to act rationally*
    - *the ability to act like humans*



What is Artificial Intelligence?

- Concerned with building smart machines capable of performing tasks that typically require human intelligence
- Build and understand intelligent entities or agents
- Studies and develops intelligent machines and software

Definitions

Artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals **(Wikipedia)**

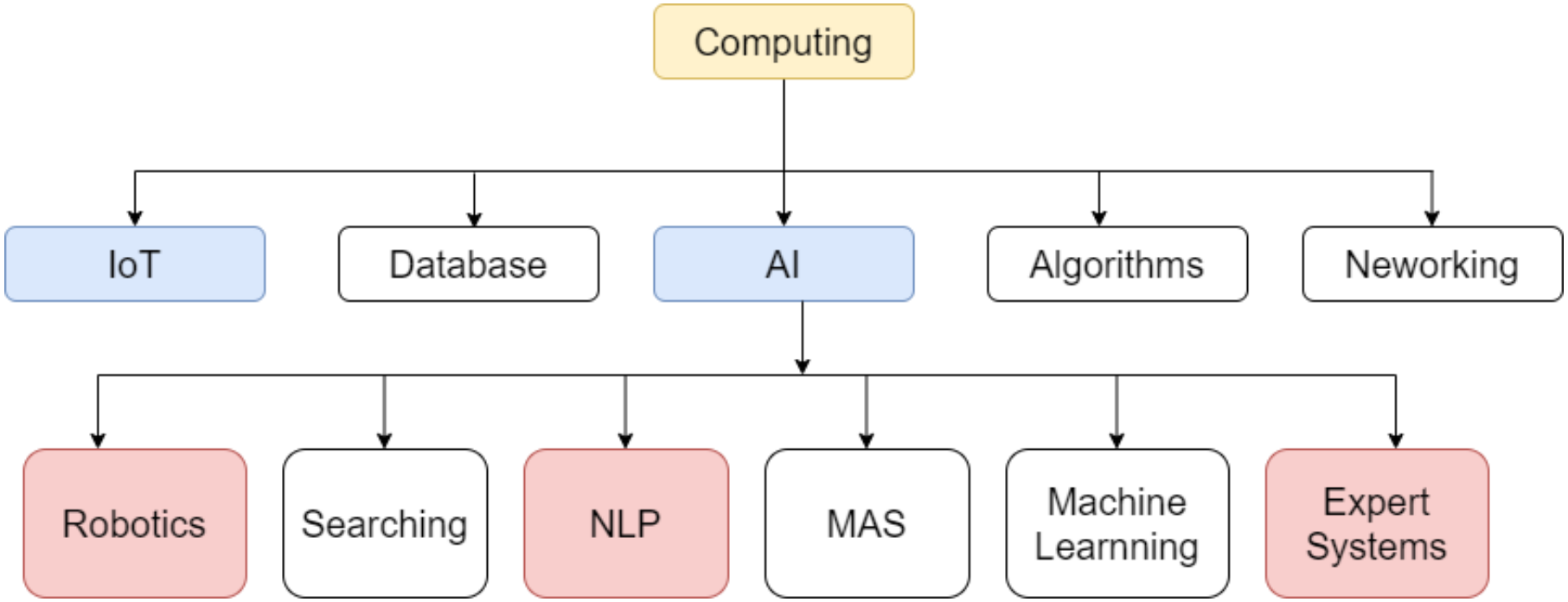
> The exciting new effort to make computers think …machines with minds, in the full literal sense. ***(Haugeland, 1985)***

The study of how to make computers do things at which, at the moment, people are better. ***(Rich & Knight, 1991)***

Goals of Artificial Intelligence

- **Scientific goal**: understand the mechanism behind human intelligence.
- **Engineering goal**: develop concepts and tools for building intelligent agents capable of solving real world problems. Examples:
  - **Knowledge-based systems**:
  - **Natural language understanding systems**.
  - **Intelligent robots.**
  - **Speech and vision recognition systems.**
  - **Game playing (IBM's Deep Blue)**

AI Taxonomy?


Computing
IoT
Database
AI
Algorithms
Neworking
Robotics
Searching
NLP
MAS
Machine Learnning
Expert Systems

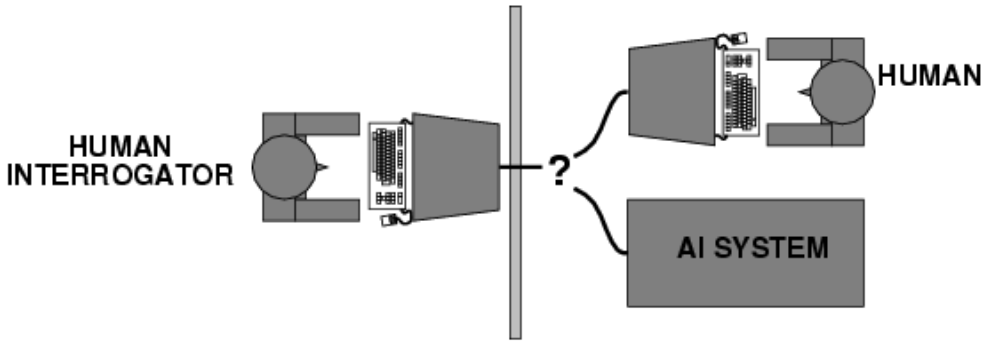
Artificial Intelligence

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Artificial Intelligence

Acting humanly: Turing test

- Turing (1950) "Computing machinery and intelligence“
- "Can machines think?" → "Can machines behave intelligently?“
- Operational test for intelligent behavior: the Imitation Game
- Suggests major components required for AI:
  - knowledge representation
  - reasoning,
  - language/image understanding,
  - learning



Turing test

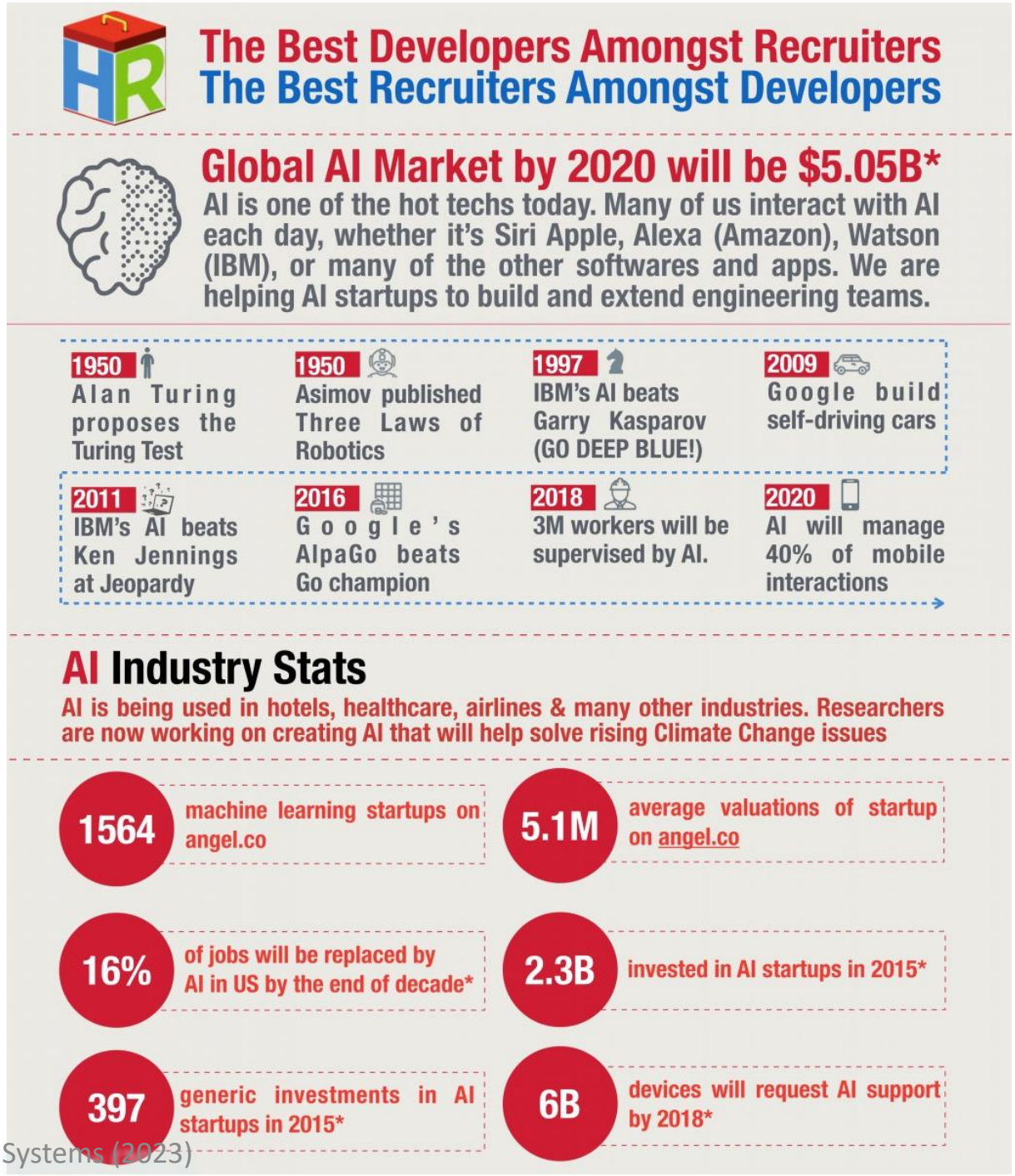
John Searle's argument

History of AI

- 1943: early beginnings
  - McCulloch & Pitts: Boolean circuit model of brain
- 1950: Turing
  - Turing's "Computing Machinery and Intelligence“
- 1956: birth of AI
  - Dartmouth meeting: "Artificial Intelligence“ name adopted
- 1950s: initial promise
  - Early AI programs, including
  - Samuel's checkers program
  - Newell & Simon's Logic Theorist
- 1955-65: “great enthusiasm”
  - Newell and Simon: GPS, general problem solver
  - Gelertner: Geometry Theorem Prover
  - McCarthy: invention of LISP

History of AI

- 1966—73: Reality dawns
  - Realization that many AI problems are intractable
  - Limitations of existing neural network methods identified
    - Neural network research almost disappears
- 1969—85: Adding domain knowledge
  - Development of knowledge-based systems
  - Success of rule-based expert systems,
    - E.g., DENDRAL, MYCIN
    - But were brittle and did not scale well in practice
- 1986-- Rise of machine learning
  - Neural networks return to popularity
  - Major advances in machine learning algorithms and applications
- 1990-- Role of uncertainty
  - Bayesian networks as a knowledge representation framework
- 1995-- AI as Science
  - Integration of learning, reasoning, knowledge representation
  - AI methods used in vision, language, data mining, etc


The Best Developers Amongst Recruiters
The Best Recruiters Amongst Developers
Global AI Market by 2020 will be $5.05B*
AI is one of the hot techs today. Many of us interact with AI each day, whether it's Siri Apple, Alexa (Amazon), Watson (IBM), or many of the other softwares and apps. We are helping AI startups to build and extend engineering teams.
1950 Alan Turing proposes the Turing Test
1950 Asimov published Three Laws of Robotics
1997 IBM's AI beats Garry Kasparov (GO DEEP BLUE!)
2009 Google build self-driving cars
2011 IBM's AI beats Ken Jennings at Jeopardy
2016 Google's AlpaGo beats Go champion
2018 3M workers will be supervised by AI.
2020 AI will manage 40% of mobile interactions
AI Industry Stats
AI is being used in hotels, healthcare, airlines & many other industries. Researchers are now working on creating AI that will help solve rising Climate Change issues
1564 machine learning startups on angel.co
5.1M average valuations of startup on angel.co
16% of jobs will be replaced by AI in US by the end of decade*
2.3B invested in AI startups in 2015*
397 generic investments in AI startups in 2015*
6B devices will request AI support by 2018*

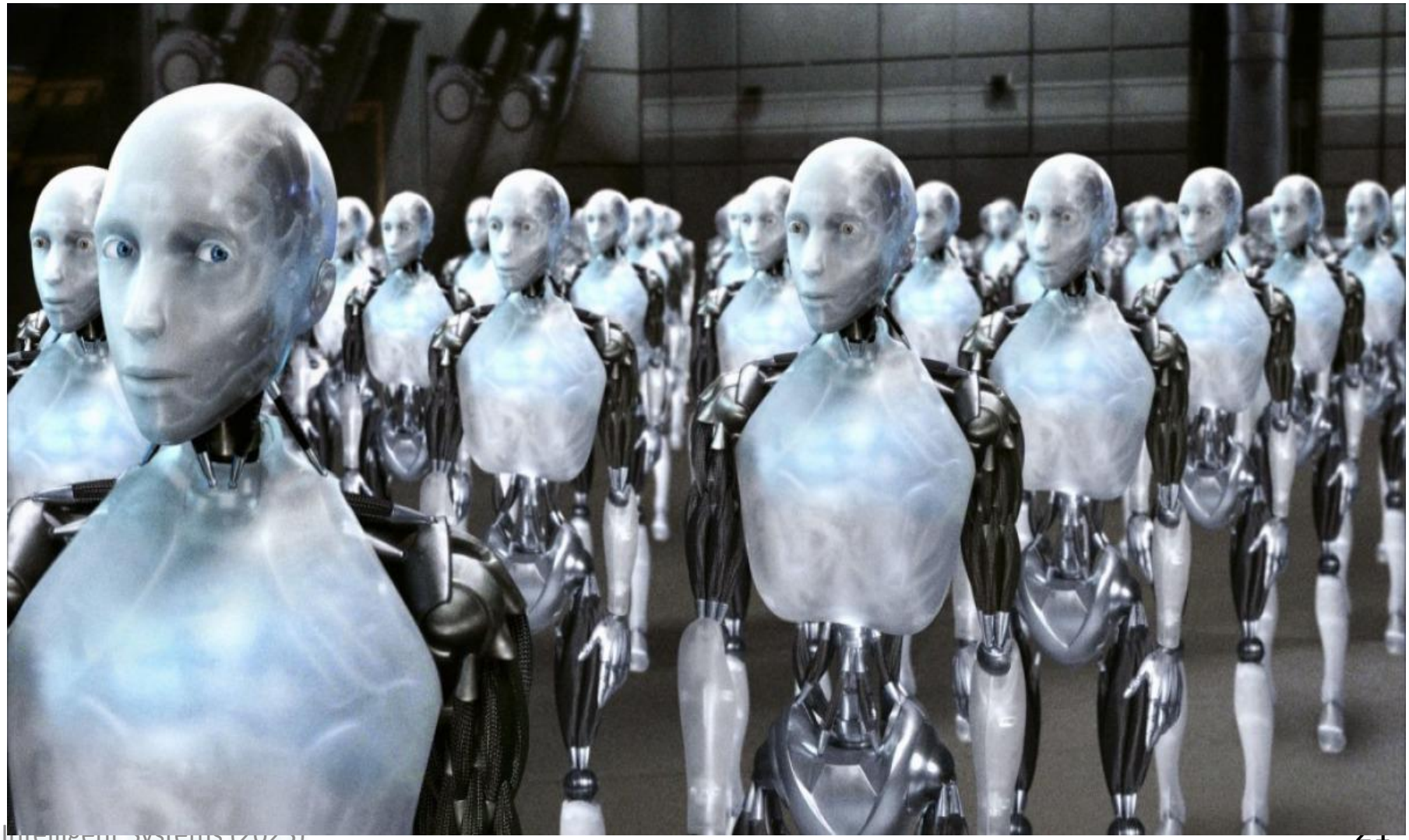
Success Stories

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- AI program proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- 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

Success Stories

- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- Proverb solves crossword puzzles better than most humans
- Robot driving: DARPA grand challenge 2003-2007
- 2006: face recognition software available in consumer cameras

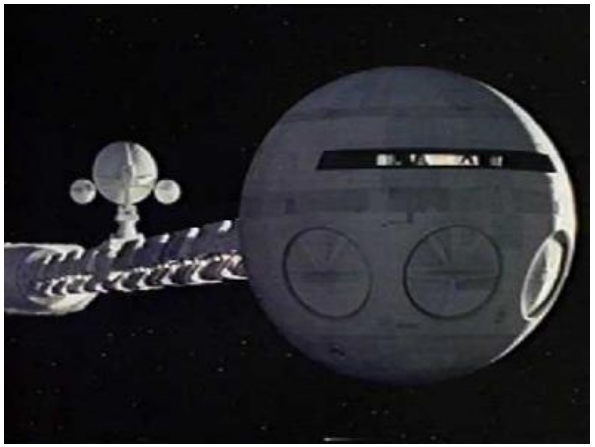
Dreams: iRobot,



HAL: from the movie 2001

- 2001: A Space Odyssey
  - classic science fiction movie from 1969

- Part of the story centers around an intelligent computer called HAL
- HAL is the “brains” of an intelligent spaceship
- in the movie, HAL can
  - speak easily with the crew
  - see and understand the emotions of the crew
  - navigate the ship automatically
  - diagnose on-board problems
  - make life-and-death decisions
  - display emotions



Consider what might be involved in building a computer like Hal….

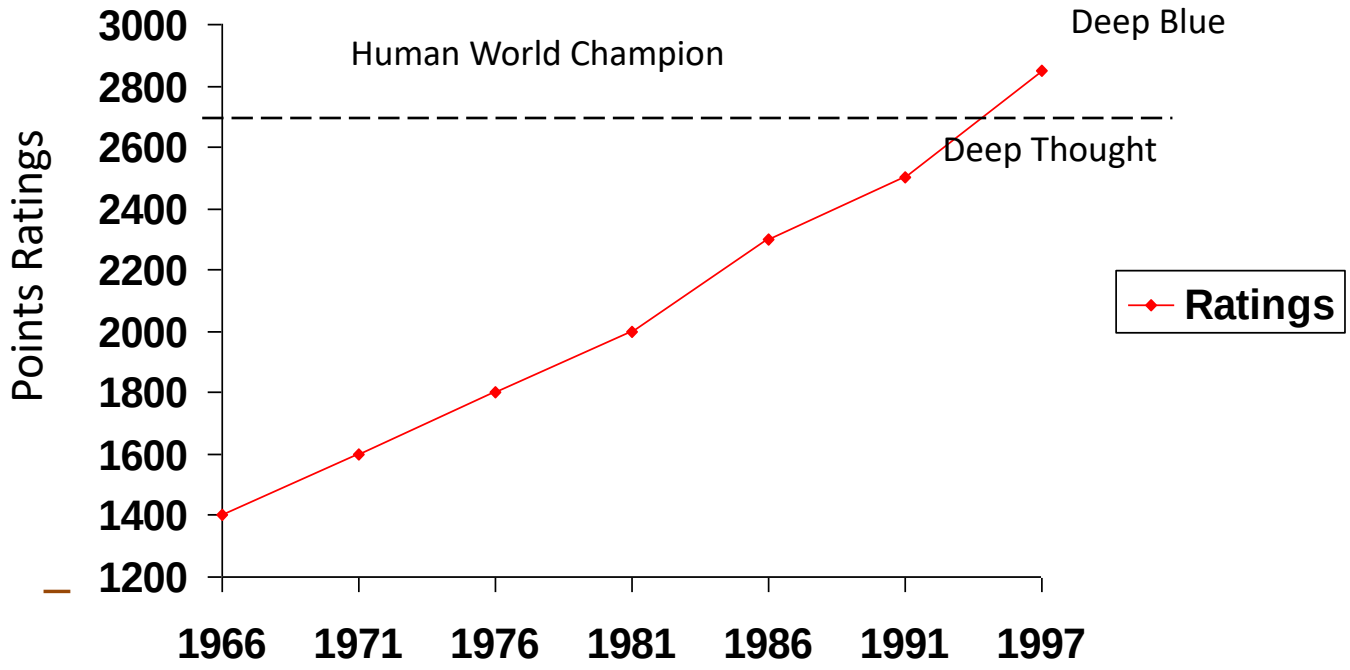
- What are the components that might be useful?
  - Fast hardware?
  - Chess-playing at grandmaster level?
  - Speech interaction?
    - speech synthesis
    - speech recognition
    - speech understanding
  - Image recognition and understanding ?
  - Learning?
  - Planning and decision-making?

Can we build hardware as complex as the brain?

- How complicated is our brain?
  - A neuron, or nerve cell, is the basic information processing unit
  - estimated to be on the order of 10^{12} neurons in a human brain
  - many more synapses (10^{14}) connecting these neurons
  - cycle time: 10^{-3} seconds (1 millisecond)
- How complex can we make computers?
  - 10^8 or more transistors per CPU
  - supercomputer: hundreds of CPUs, 10^{12} bits of RAM
  - cycle times: order of 10^{-9} seconds
- Conclusion
  - **YES**: in the near future we can have computers with as many basic processing elements as our brain, but with
    - far fewer interconnections (wires or synapses) than the brain
    - much faster updates than the brain
  - But building hardware is very different from making a computer behave like a brain!

Can Computers beat Humans at Chess?

- Chess Playing is a classic AI problem
  - well-defined problem
  - very complex: difficult for humans to play well



- Conclusion:
  - YES: today's computers can beat even the best human

Can Computers Talk?

- This is known as “speech synthesis”
  - translate text to phonetic form
    - e.g., “fictitious” -> fik-tish-es
  - use pronunciation rules to map phonemes to actual sound
    - e.g., “tish” -> sequence of basic audio sounds
- Difficulties
  - sounds made by this “lookup” approach sound unnatural
  - sounds are not independent
    - e.g., “act” and “action”
    - modern systems (e.g., at AT&T) can handle this pretty well
  - a harder problem is emphasis, emotion, etc
    - humans understand what they are saying
    - machines don’t: so they sound unnatural
- Conclusion:
  - NO, for complete sentences
  - YES, for individual words

A.L.I.C.E

- The A.L.I.C.E. AI Foundation promotes the adoption of the A.L.I.C.E.
- Free open source software for
  - chatrobots,
  - chat robots
  - Chatterbots
  - Chatterboxes
- **http://alice**.pandorabots.com

Can Computers Recognize Speech?

- Speech Recognition:
  - mapping sounds from a microphone into a list of words
  - classic problem in AI, very difficult
    - "Lets talk about how to wreck a nice beach"
    - (I really said "_____")
- Recognizing single words from a small vocabulary
  - systems can do this with high accuracy (order of 99%)
  - e.g., directory inquiries
    - limited vocabulary (area codes, city names)
    - computer tries to recognize you first, if unsuccessful hands you over to a human operator
    - saves millions of dollars a year for the phone companies

Can Computers Understand speech?

- Understanding is different to recognition:
  - "Time flies like an arrow"
    - assume the computer can recognize all the words
    - how many different interpretations are there?
      - 1. time passes quickly like an arrow?
      - 2. command: time the flies the way an arrow times the flies
      - 3. command: only time those flies which are like an arrow
      - 4. "time-flies" are fond of arrows

Can Computers Understand speech?

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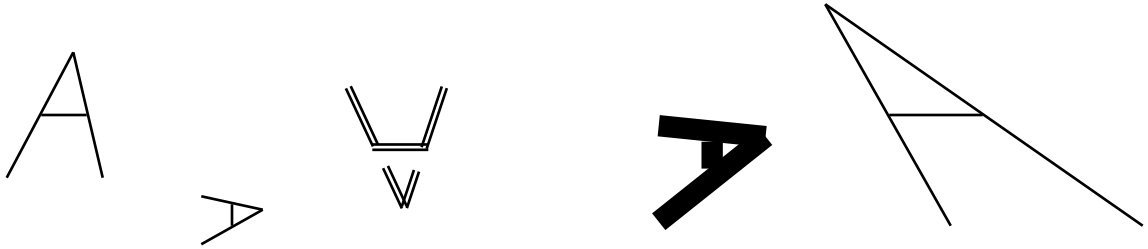
      - 4. "time-flies" are fond of arrows
    - only 1. makes any sense,
      - but how could a computer figure this out?
      - clearly humans use a lot of implicit commonsense knowledge in communication

- **Conclusion**: NO, much of what we say is beyond the capabilities of a computer to understand at present

Can Computers "see"?

- Recognition v. Understanding (like Speech)
  - Recognition and Understanding of Objects in a scene
    - look around this room
    - you can effortlessly recognize objects
    - human brain can map 2d visual image to 3d "map"
- Why is visual recognition a hard problem?



- Conclusion:
  - mostly NO: computers can only "see" certain types of objects under limited circumstances
  - YES for certain constrained problems (e.g., face recognition)

Types of Learning in AI

- **Supervised Learning:** The machine has a "teacher" who guides it by providing sample inputs along with the desired output. The machine then maps the inputs and the outputs. This is similar to how we teach very young children with picture books.
- All of the AI machines we have today have used this form of learning (from speech recognition to self-driving cars).

Types of Learning in AI

- **Reinforcement Learning**: this plays a relatively minor role in training AI and is similar to training an animal. When the animal displays a desired behavior it is given a reward.
- According to the Wikipedia entry on Machine Learning, reinforcement learning is defined as "a computer program interacts with a dynamic environment in which it must perform a certain goal (such as driving a vehicle), without a teacher explicitly telling it whether it has come close to its goal. "

Types of Learning in AI

- **Unsupervised Learning**: This is the most important and most difficult type of learning and would be better titled Predictive Learning. In this case the machine is not given any labels for its inputs and needs to "figure out" the structure on its own. This is similar to how babies learn early in life. For example they learn that if an object in space is not supported it will fall

Modern Classification in AI

Reactive machines

Performing basic operations for the existing conditions. These machines are programmed with a predictable output based on the input it receives.

Therefore, machines will respond to identical situations in an exact way every time.

Spam filters and Deep Blue, the supercomputer created by IBM are notable examples of reactive machines.

Modern Classification in AI

Limited memory machines

Ability to store the previous date and use that for better predictions.

These machines are characterized by the ability to absorb learning data and improve over time based on their experience similar to the way the human brain's neurons connect.

In addition to that, those machines can complete complex classification tasks and uses historical data to make predictions.

Ex: Self-driving cars

Modern Classification in AI

Theory of Mind

Is a competency, which comprises both social and cognitive skills. This competency enables us to think about our own as well as others' mental states and emotions. Such as, machines would have the capability to understand and remember emotions and adjust behavior based on those emotions just as humans can in social interactions. Thus, these machines should have decision-making capabilities equal to humans.

Ex: Robots Kismet and Sophia

Modern Classification in AI

Self-aware is the final type of AI where the machines are aware of themselves and perceive their internal states and others' emotions, behaviors, and acumen.

This AI is yet to develop, and if it is incarnated, we will surely witness a robot with human-level consciousness and intelligence.

Some-day, artificial superintelligence makes it possible for machines to take over the world.

Top Countries with AI talent

The Top 6 countries are mentioned below. China, Sweden, Finland & Poland also make it to top 10

US 102K	IN 27K	UK 16K	CA 10K	FR 10K	DE 9K

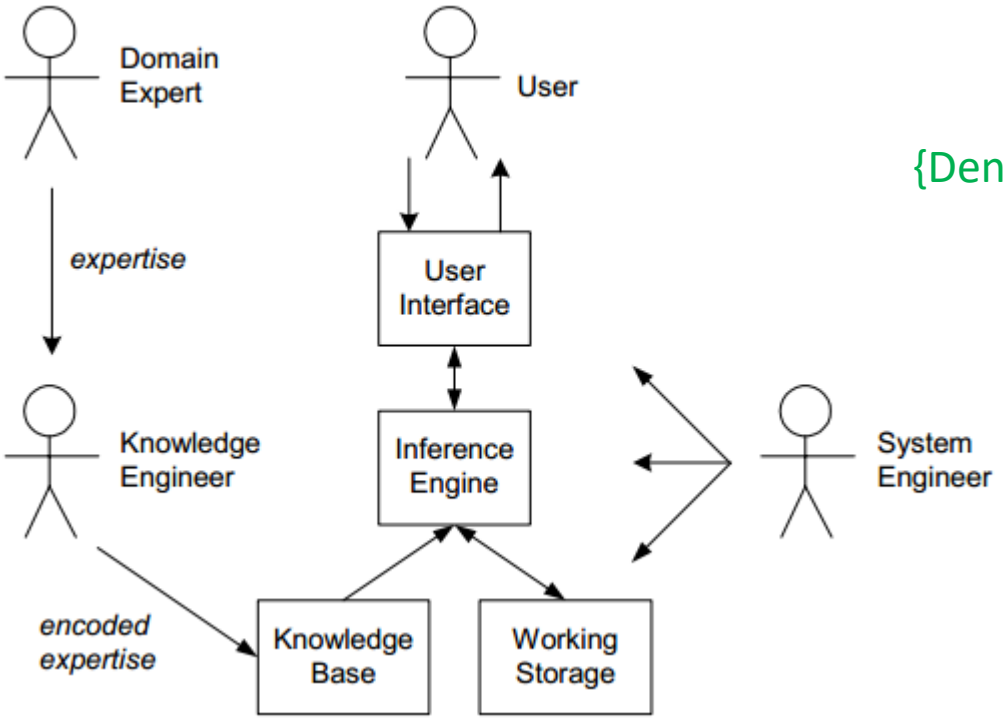
Top Countries with AI Tech Talent by language

Some areas of AI

- Expert systems
- **Machine Learnning**
- Fuzzy Logic
- **Genetic Algorithms**
- Case-base reasoning
- Natural Language Processing
- Computer Vision
- Robotics
- **Agents and Multi agent systems**

Expert System

- Computer applications which embody some non-algorithmic expertise for solving certain types of problems



{Dennis Merritt}

Advantages

- Easy to develop and modify
- The use of satisficing (accepting satisfactory solution rather than the optimal one)
- The use of heuristics
- Development by knowledge engineers and users
- Goal driven reasoning or backward chaining
- Coping with uncertainty
- Data driven reasoning or forward chaining
- Data representation
- User interface
- Explanations

Limitations of Expert Systems

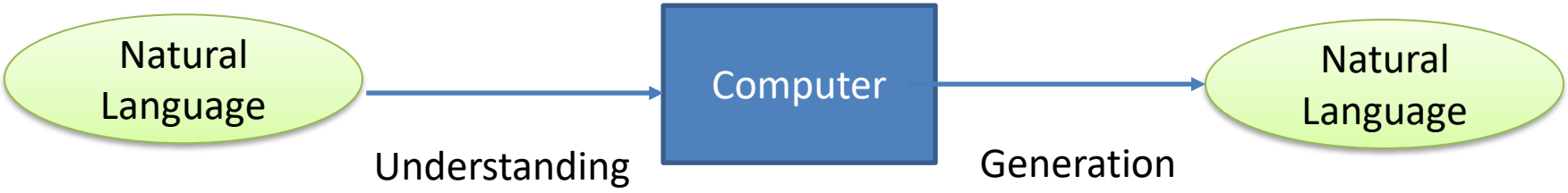
- Limited to relatively narrow problems
- Cannot readily deal with “mixed” knowledge
- Possibility of error
- Cannot refine own knowledge base
- Difficult to maintain
- May have high development costs
- Raise legal and ethical concerns

Applications of Expert Systems

- Credit granting
- Information management and retrieval
- AI and expert systems embedded in products
- Plant layout
- Hospitals and medical facilities
- Help desks and assistance
- Employee performance evaluation
- Loan analysis
- Virus detection
- Repair and maintenance
- Shipping
- Marketing
- Warehouse optimization

What is Natural Language Processing?

- Natural Language Processing (NLP) is a computational treatment of the Natural (human) Languages
  - Natural Language Understanding
  - Natural Language Generation
- Pipeline



Why Study NLP?

- A hallmark of human intelligence.
- Text is the largest repository of human knowledge and is growing quickly.
  - emails, news articles, web pages, scientific articles, insurance claims, customer complaint letters, transcripts of phone calls, technical documents, government documents, patent portfolios, court decisions, contracts, ……
- Are we reading any faster than before?

Why are language technologies needed?

- Many companies would make a lot of money if they could use computer programmes that understood text or speech. Just imagine if a computer could be used for:
  - Answering the phone, and replying to a question
  - Understanding the text on a Web page to decide who it might be of interest to
  - Translating a daily newspaper from Japanese to English (an attempt is made to do this already)
  - Understanding text in journals / books and building an expert systems based on that understanding

Dreams??

- NLP Applications
  - Show me Star Trek..?? (Talk to your TV set)
  - Will my computer talk to me like another human ??
  - Will the search engine get me exactly what I am looking for??
  - Can my PC read the whole newspaper and tell me the important news only..??
  - Can my palmtop translate what that Japanese lady is telling me.. ??
  - Can my PC do my English homework ??

Application areas

- Text-to-Speech & Speech recognition
- Natural Language Dialogue Interfaces to Databases
- Information Retrieval
- Information Extraction
- Document Classification
- Document Image Analysis
- Automatic Summarization
- Text Proofreading – Spelling & Grammar
- Machine Translation
- Story understanding systems
- Plagiarism detection
- Can u think of anything else ??

NLP Applications

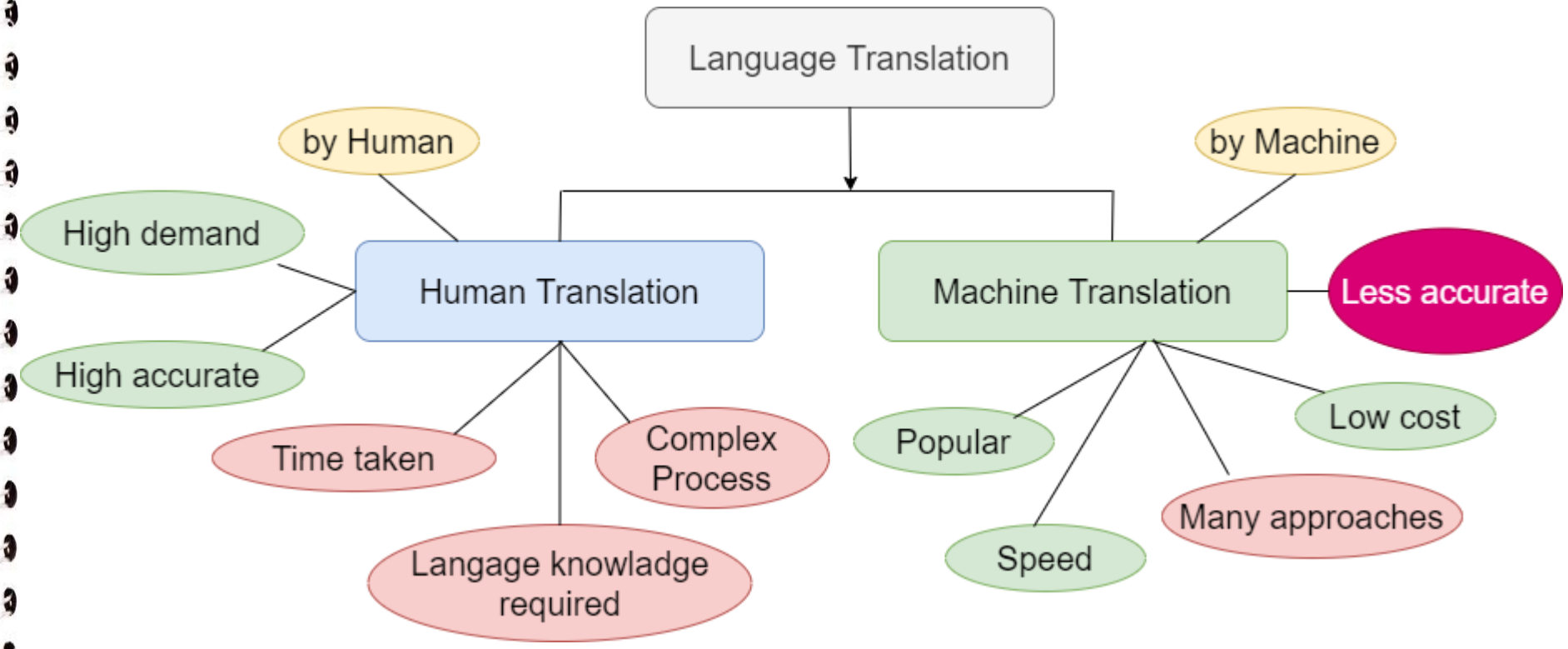
- Question answering
  - Who is the first Taiwanese president?
- Text Categorization/Routing
  - e.g., customer e-mails.
- Text Mining
  - Find everything that interacts with BRCA1.
- Machine Translation
- Language Teaching/Learning
  - Usage checking
- Spelling correction
  - Is that just dictionary lookup?

NLP Applications: Machine Translation

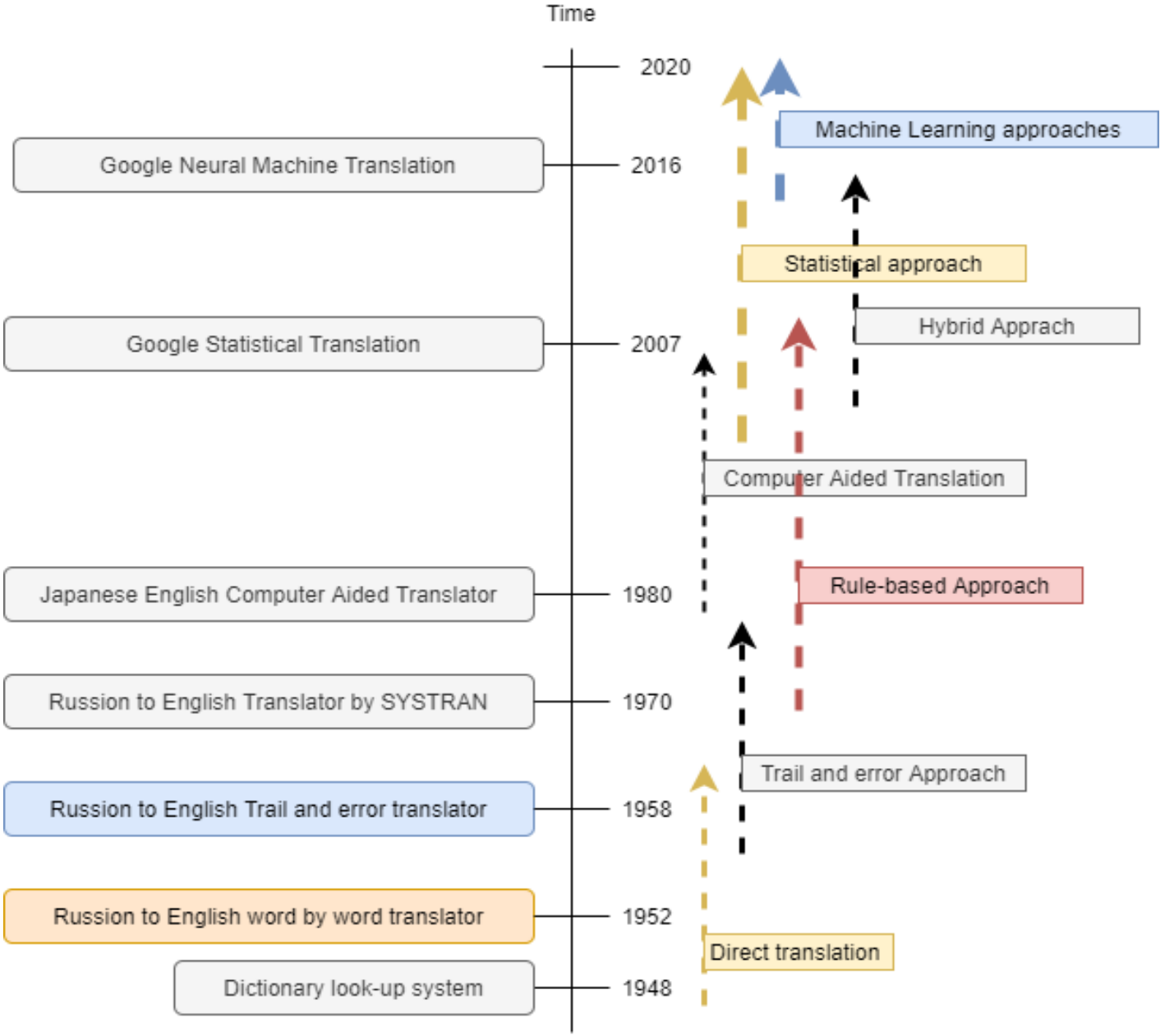
- Language problems in international business
  - E.g., at a meeting of Japanese, Korean, Vietnamese and Swedish investors, no common language
  - Or: you are shipping your software manuals to 127 countries
  - Solution; hire translators to translate
  - Would be much cheaper if a machine could do this
- How hard is automated translation
  - Very difficult! e.g., English to Sinhala
  - Not only must the words be translated, but their meaning also!
  - Is this problem “AI-complete”?

Language translation

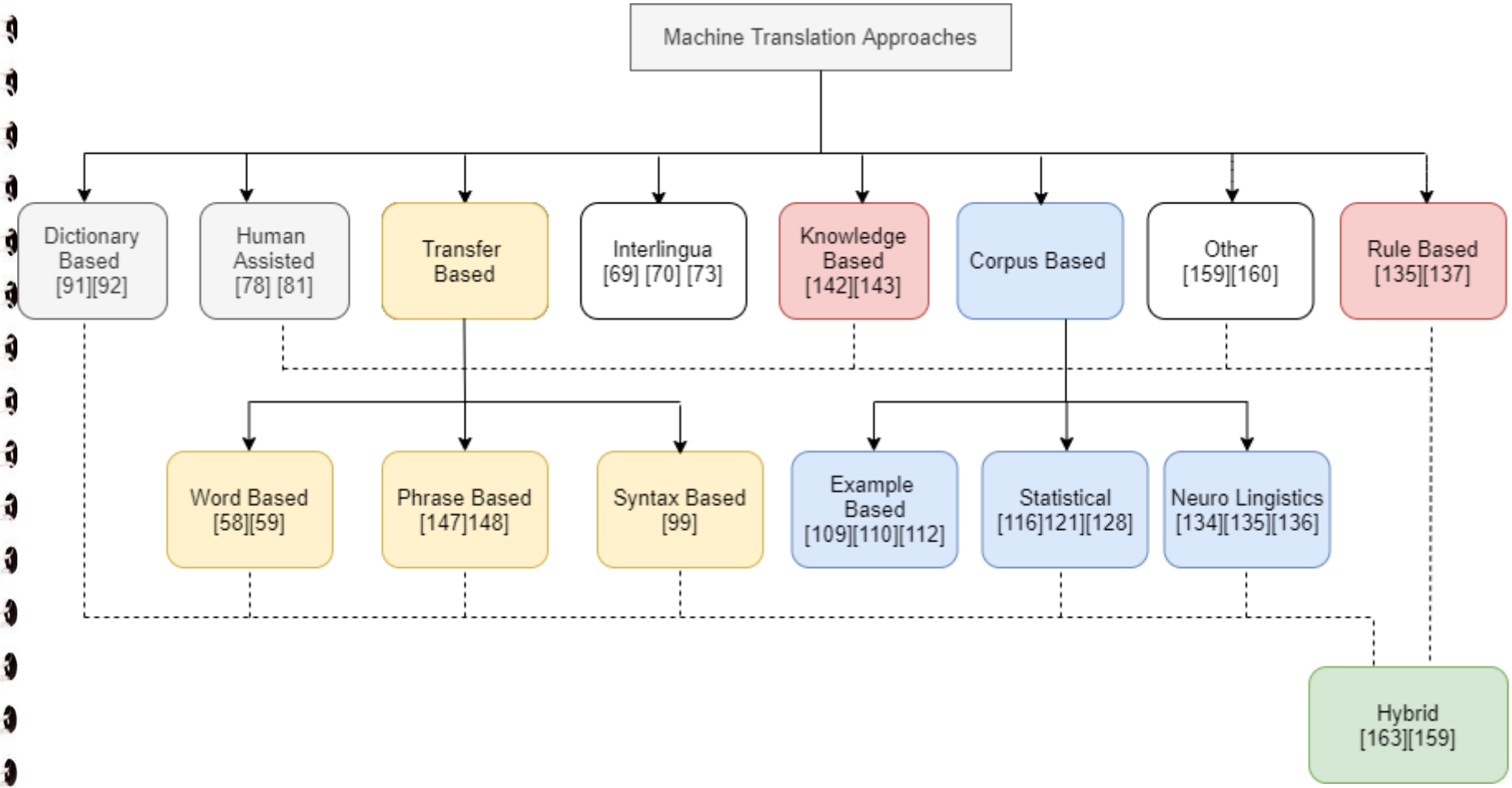
The process of converting the **meaning** of a source language text into an equivalent target language text by a **human** or a **machine**



TimeLine: Key points only



Approaches: Machine Translation



MT Systems

#	Approach	Example	Features	Limitations
1	Dictionary-based	Pali to Sinhala MT Czech and Russian	Only required a bilingual dictionary	Success only for related languages
2	Human-assisted	Anusaaraka (Among Indian Languages) OmegaT	humans and machines co-operate	Semi-automated
3	Rule-Based	BEES Toshiba	Provides grammatically correct translation	More rules than more complex
4	Interlingua	ICENT, UNITRAN English-Hindi interlingua-based machine translation, Sanskrit to English MT	Easy to introduce new language	An analysis is more complex (All the levels of analysis is required)
5	Example-based	English-Japanese English-Arabic	Easily to update	Without examples translation is difficult

MT Sysrems

#	Approach	Example	Features	Limitations
6	Knowledge-based	KBMT-89 KANT	A bit closer to human translation	Knowledgebase creation is difficult
7	Statistical	Moses Si-Ta Google Translator	Most used approach with high accuracy	Sometimes result has some grammatical issues
8	Phrase-based	SWAN Joshus	More accurate than word-based	More rules than more complex
9	Agent-based	No complete MAS system for MT. Some systems take agents support for the translation	Handle complexity in Natural languages	Difficult to implement and model
10	Neural Machine Translation	OpenNMT Stanford NLP Sinhala-Tamil	More accurate	More training and parallel corpus required
11	Hybrid	Moses Hindi-English data-driven MT	Provide better accuracy	Difficult to implement

Summary

- What is Intelligence?
- Four Schools of thought
- Turing Test and John Searle's argument
- History of AI
- Success Stories
- Can Computers beat Humans?
- Influential areas for AI
- AI Applications
  - Machine Translation
  - Expert Systems
- Take more on Machine Learning later

Questions

1. What is Artificial Intelligence?
2. Does AI aim to put the human mind into the computer?
3. Does AI aim at human-level intelligence?
4. Don't some people say that AI is a bad idea?
5. Explain why ML is more popular?

Questions

(a)Answer the following questions.

(a) "Intelligence is the capacity to learn and solve problems", Do you agree with this statement? Justify your answer

(b) Compare and contrast Thinking Humanly and Acting Rationally.

(c) With an example, briefly explain the POSITIVE and NEGATIVE test to a measure of intelligence.

(b) Identify which of the following is/are true? In each case, justify your answer.

i. In 1943 McCulloch and Pitts's introduced the Boolean circuit model for the human brain

ii. In 1990 Bayesian networks were used as a knowledge representation framework.

iii. In 1950 Asimov published the three laws of robotics.

(c) The famous films "Knight Rider" gives several AI techniques and applications, some of them now appear as real. Briefly explain two techniques or tools which are now available as real applications.