ARTIFICIAL INTELLIGENCE

الذكاء الإصطناعي

Introduction: Chapter 1

□ How would you define "intelligence"?

□ What is the common definition of "AI"?

□ What are the AI sub-topics? Which topics failed? successful? Why?

□ Do you know any AI real application?

□ Should artificial intelligence simulate natural intelligence?

□ What is the relation between AI and logic?

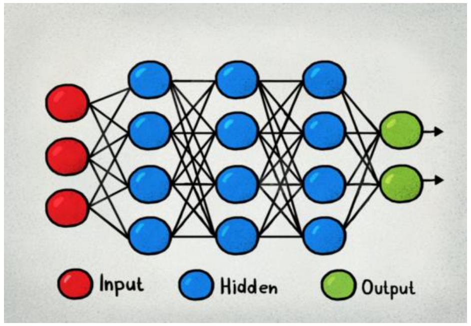
□ Do you think that computers or machines will ever be as intelligent as humans?

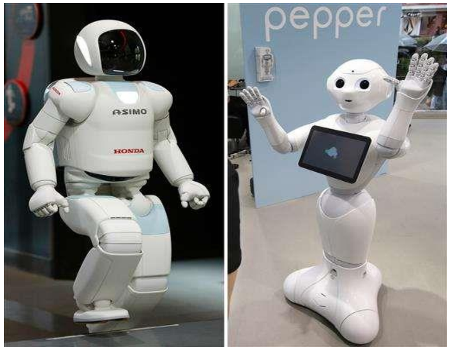
□ What is the main advantage of computers over people and vice versa?

□ How far is AI from reaching human-level intelligence? When will it happen.

□ Are computers fast enough to be intelligent?

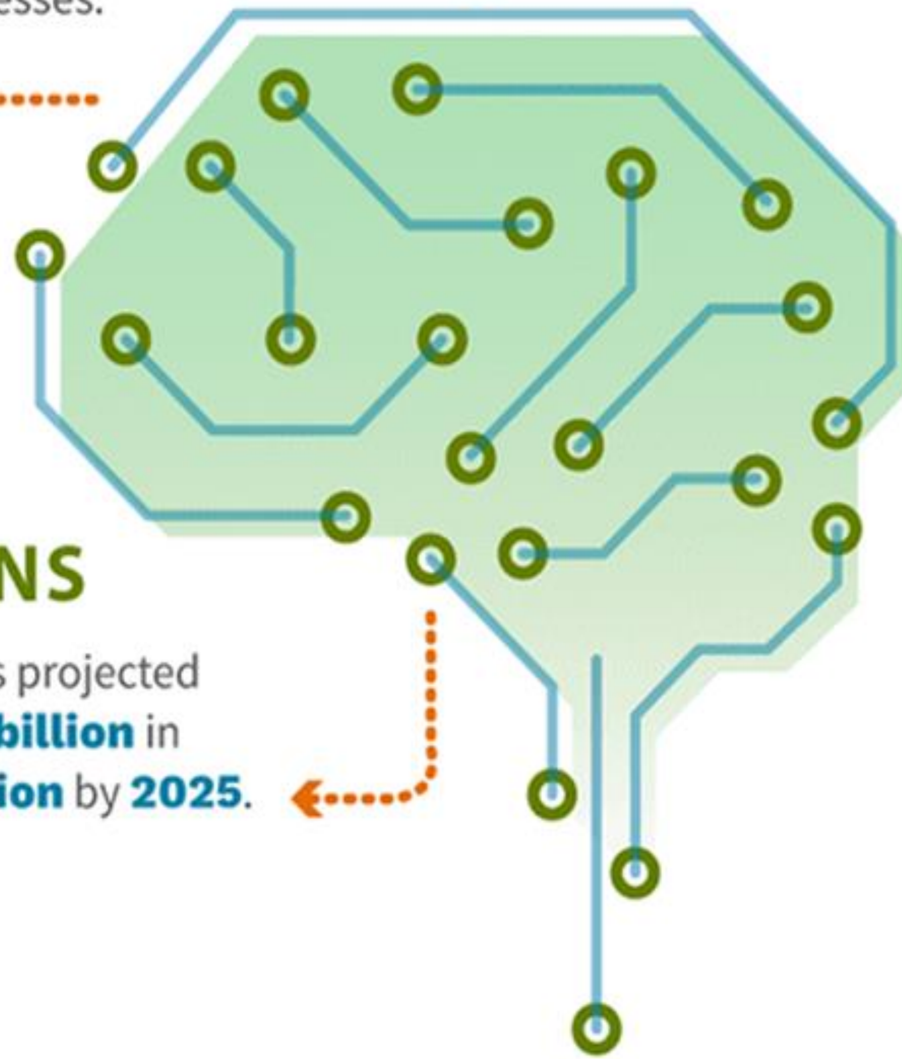
□ Do you definitely agree that AI augmenting human capability and capacity, or it will damage the human life?





AI

Technology designed to mimic the human cognitive processes.



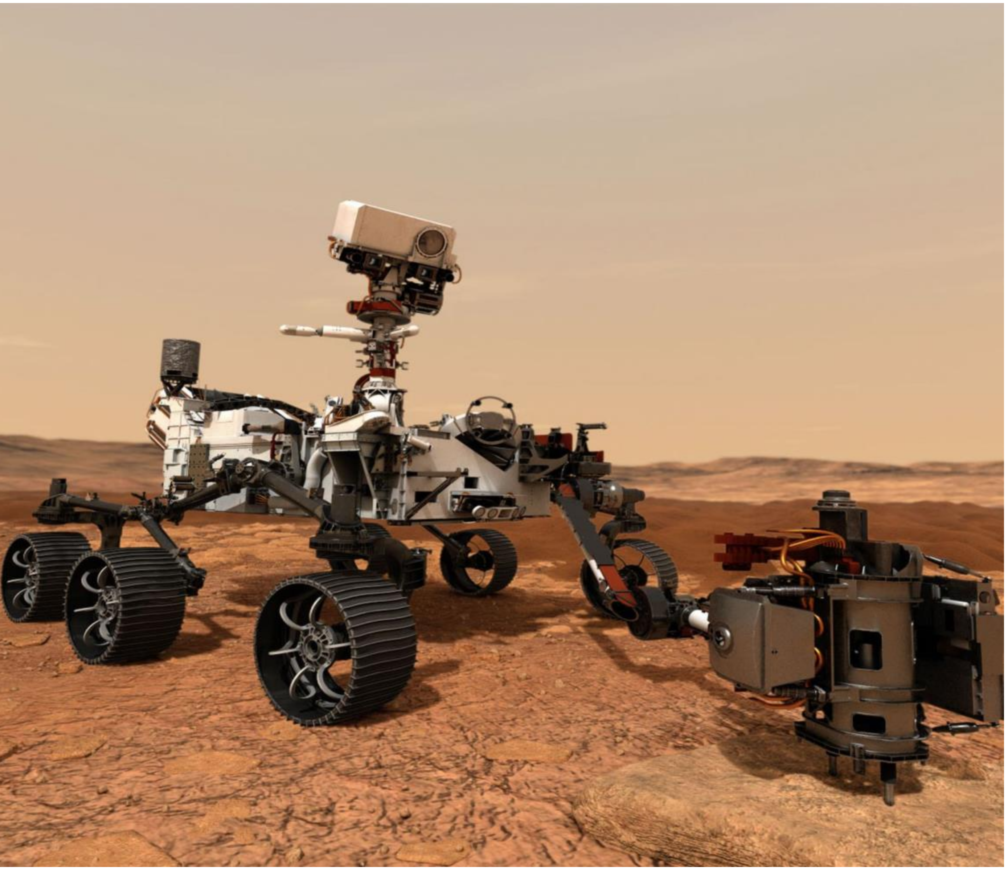
Deep learning utilizes neural networks with multiple layers which can analyze large volumes of complex data.

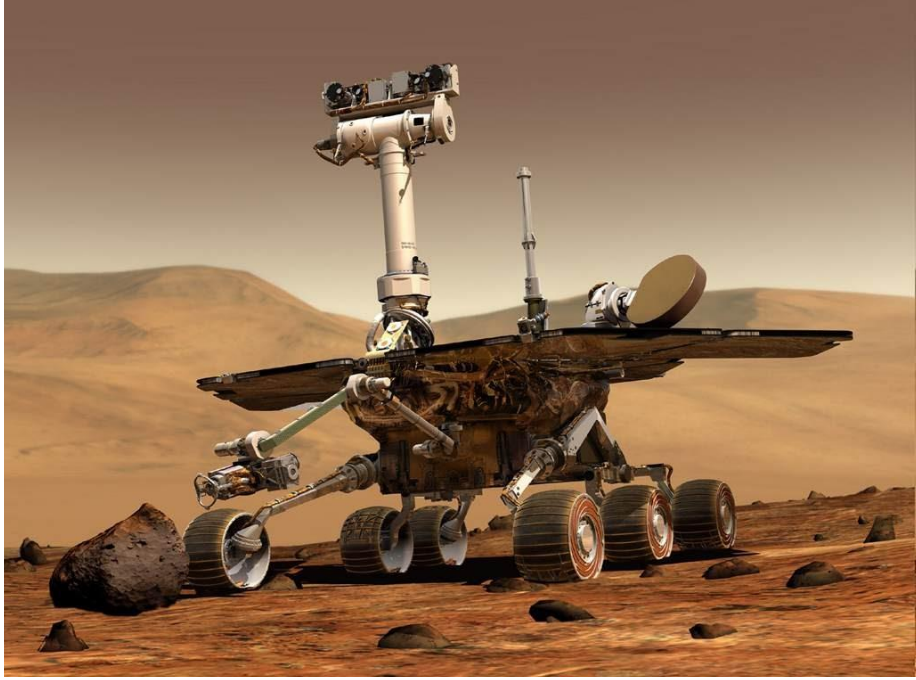
AI MARKET PROJECTIONS

The global AI market is projected to grow from **$21.46 billion** in **2018** to **$190.61 billion** by **2025**.

mars car

2021





2005

What is Intelligent

***There are many definitions of intelligence*.**

A person that learns fast or one that has a vast amount of experience, could be called "intelligent".

However for our purposes the most useful definition is: *systems comparative level of performance in reaching its objectives*

persons are not intelligent in all areas of knowledge, they are only intelligent in those areas where they had experiences.

AI Goals

- Artificial Intelligent is the part of computer science with designing intelligent computer systems, that is, systems that have characteristics associate with intelligence in human behaviour – understanding language, learning, reasoning, solving problems………………

- ***Scientific Goal*** To determine which ideas about knowledge representation, learning, rule systems, search, and so on, explain various sorts of real intelligence.

- ***Engineering Goal*** To solve real world problems using AI techniques such as..

  knowledge representation, learning, rule systems, search, and so on.

What is AI?

Views of AI fall into four categories:

- Thinking humanly: systems that thinks like humans, (machine with mind). Activities as decision-making, problem solving, learning,……
- Thinking rationally: the study of thinking faculties.
- Acting humanly: systems that acting like humans, the study of how to make computers do things.
- Acting rationally: **The study of designing intelligent agents**

The textbook advocates “Acting Rationally"

منطقي

Turing test

Logic

منطق

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

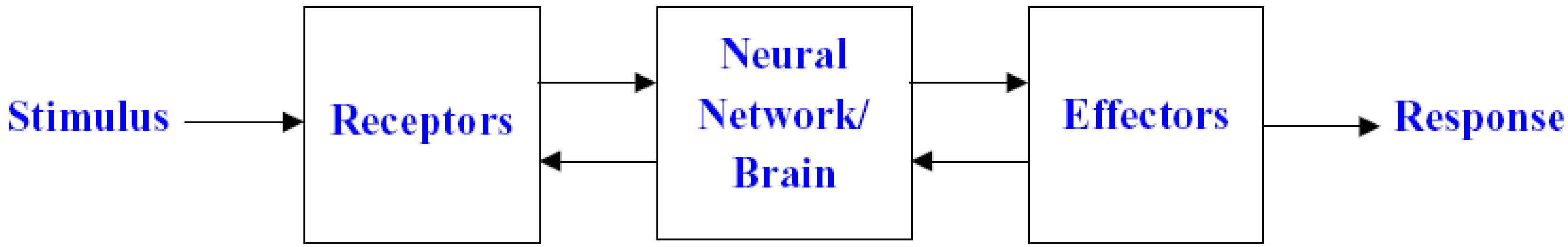
Cognitive science

علم الادراك علم التفكير

Agents

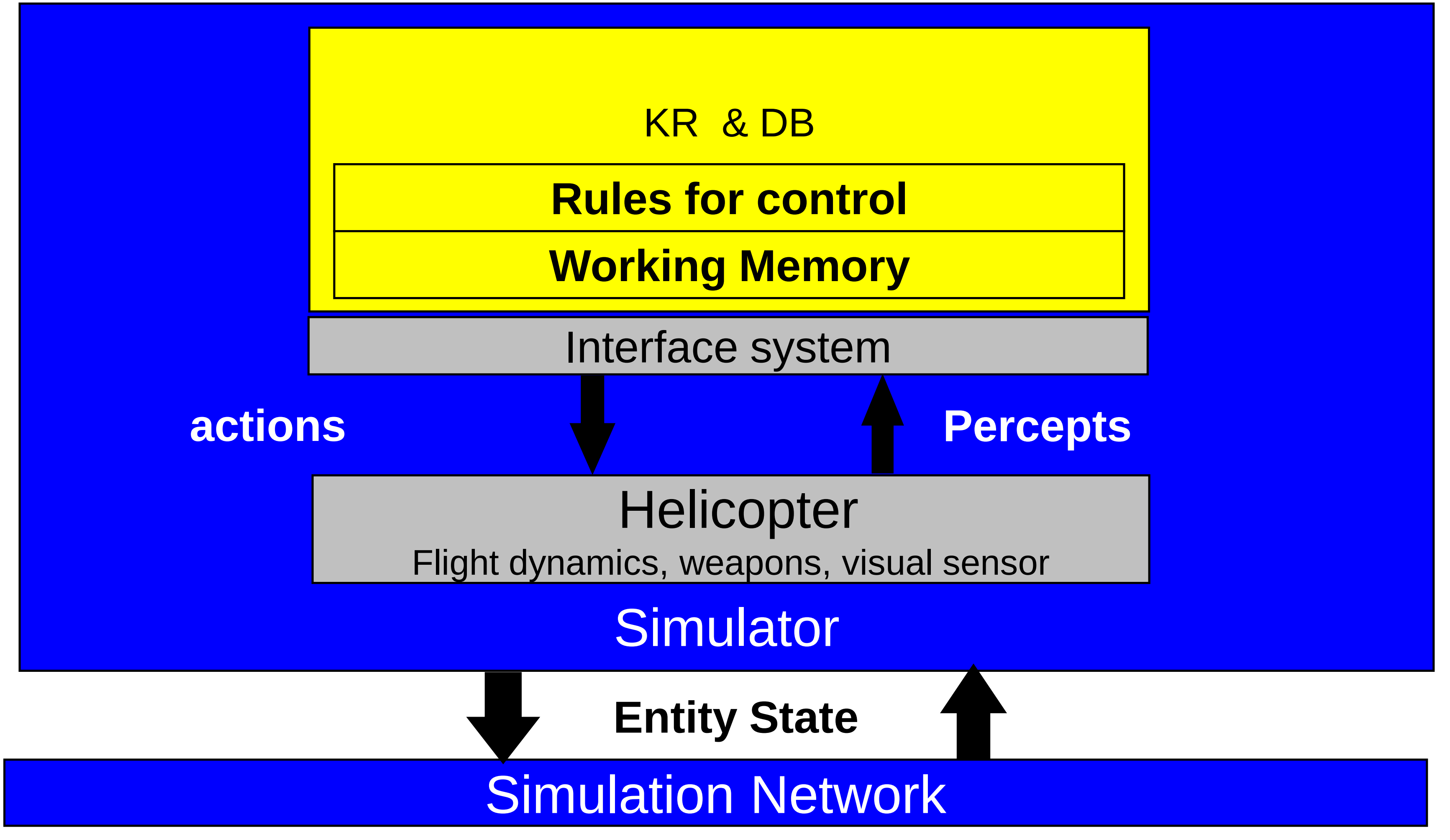
How do Humans do Intelligent Things?

- It seems natural to try to base our AI systems on the human nervous system. This can be broken down into three stages that may be represented in block diagram form as:



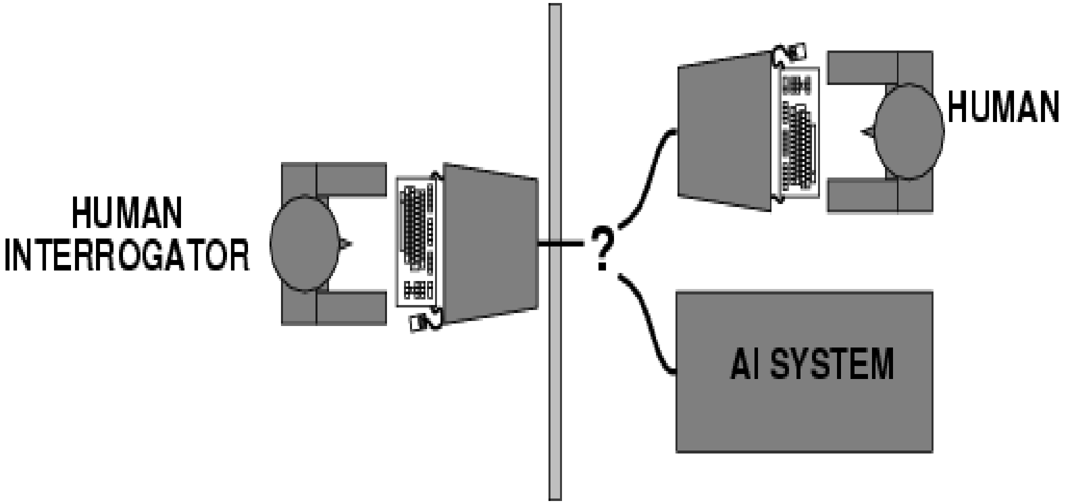
Receptors collect information from the environment, and effectors generate interactions with the environment. The flow of information between them is represented by arrows
– both forward and backward.
What we generally describe as "intelligence" is normally carried out in the central stage
– in the brain. The brain is known to consist of an interconnected network of neurons, and the study of ***neural networks*** is now a major sub-field of AI.

IS Pilot Architecture



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



Alan Turing's discussed conditions for considering a machine to be intelligent. He discuss that if the machine could successfully pretend to be human to a knowledgeable observer then you certainly should consider it intelligent. The observer could interact with the machine and a human by teletype, and the human would try to observe that it was human and the machine would try to fool the observer.

Sub-fields of Artificial Intelligence

AI now consists many sub-fields, using a variety of techniques, such as:

- **Neural Networks** – e.g. brain modeling, time series prediction, classification
- **Evolutionary Computation** – e.g. genetic algorithms, genetic programming
- **Computer Vision** – e.g. object recognition, image understanding
- ***Robotics*** – e.g. intelligent control, autonomous exploration
- **Expert Systems** – e.g. decision support systems, teaching systems
- **Speech Processing**– e.g. speech recognition and production
  Natural Language Processing – e.g. machine translation
- Machine Learning – e.g. decision tree learning, version space learning

Most of these have both engineering and scientific aspects.

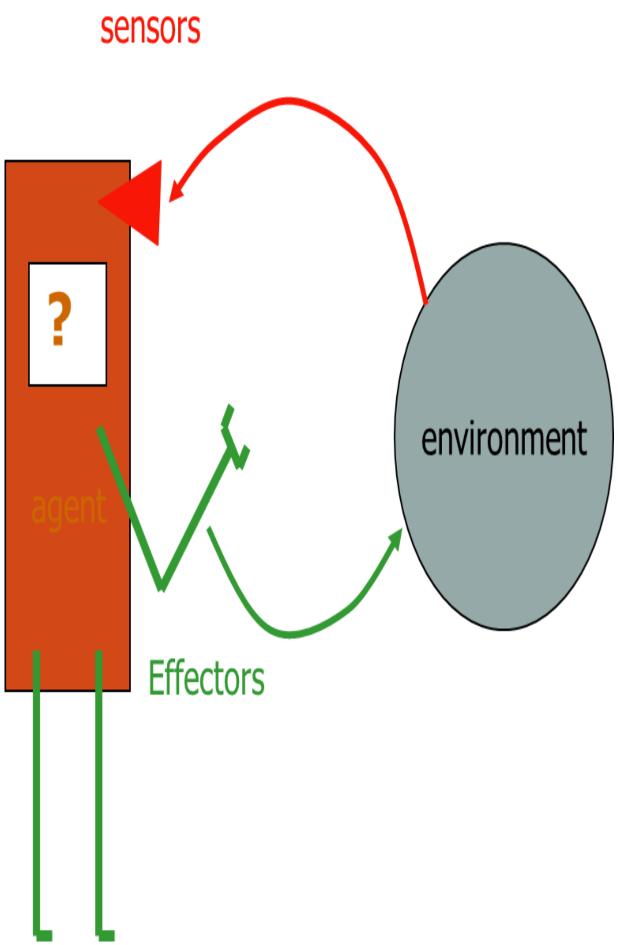
Rational agents

- An agent is an entity that perceives and acts
- This course is about designing rational agents
- an agent is a function from percept histories to actions:

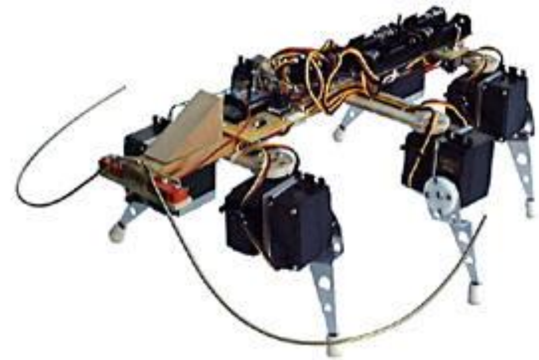
$$[\ f\ : P^* \rightarrow A]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Note: computational ***limitations*** make perfect rationality unachievable

→ design best program for given machine resources



Examples of Agents



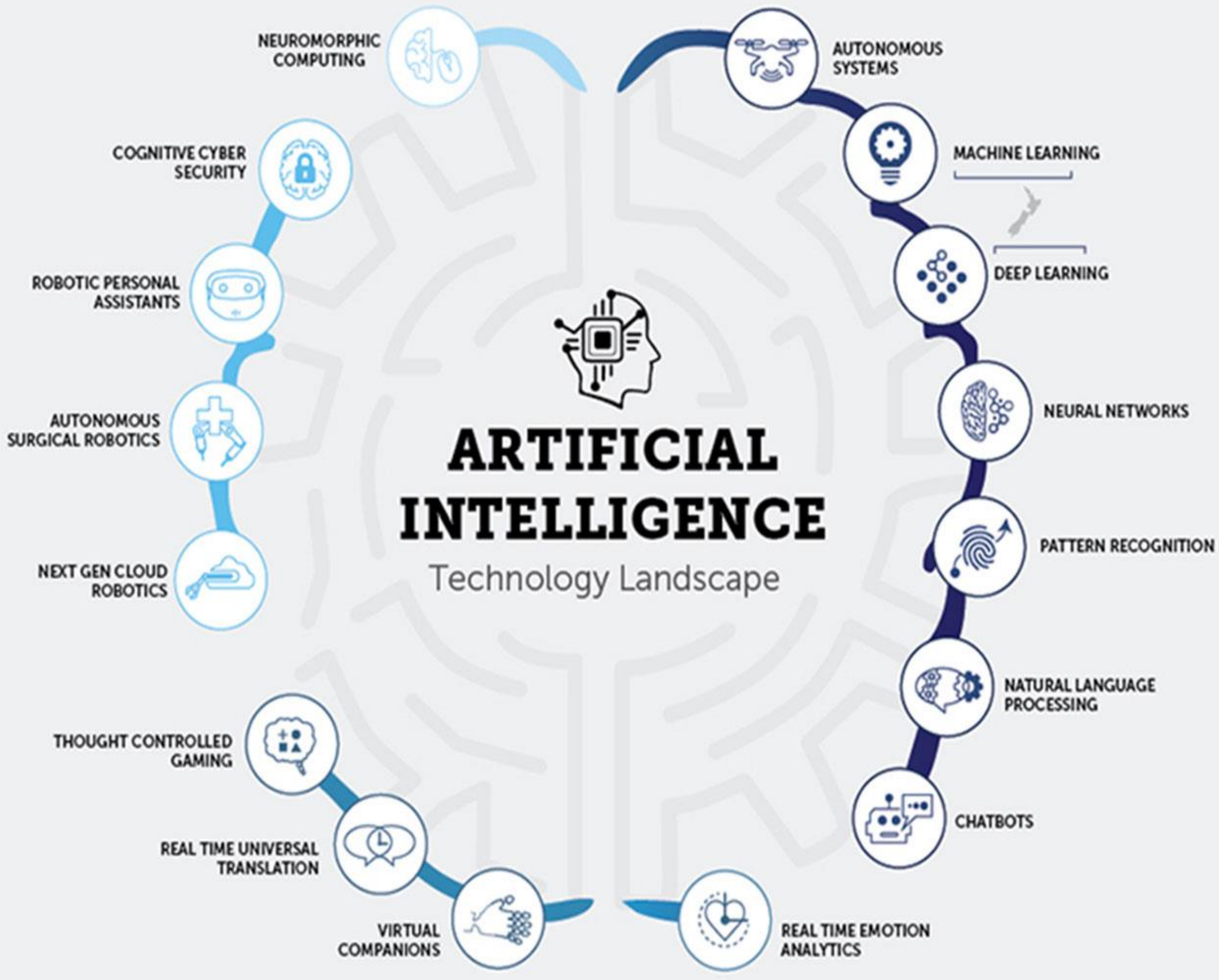
Humans	Programs	Robots
senses	keyboard, mouse, dataset	cameras, pads
body parts	monitor, speakers, files	motors, limbs

AI Complex?

complexity in AI tasks.

as computer scientists, should be familiar with, is **computational complexity**. We can solve useful problems in polynomial time, but most interesting AI problems — certainly the ones we looked at — are NP-hard. We will be constantly straddling the boundary between polynomial time and exponential time, or in many cases, going from exponential time with a bad exponent to exponential time with a less bad exponent.

Just as a simple example, in machine translation, we are given an input sentence (say, in Chinese) and need to output an translation (say, in English). Suppose our English vocabulary has size 10000 and we are considering English translations with 20 words. Then the total number of translations is $10000^{20} = 10^{80}$, which is completely ridiculous. One can be more clever and use the input sentence to prune down the number of words from 10000 to 10, but 10^{20} is still quite absurdly large.


ARTIFICIAL INTELLIGENCE
Technology Landscape
NEUROMORPHIC COMPUTING
COGNITIVE CYBER SECURITY
ROBOTIC PERSONAL ASSISTANTS
AUTONOMOUS SURGICAL ROBOTICS
NEXT GEN CLOUD ROBOTICS
THOUGHT CONTROLLED GAMING
REAL TIME UNIVERSAL TRANSLATION
VIRTUAL COMPANIONS
AUTONOMOUS SYSTEMS
MACHINE LEARNING
DEEP LEARNING
NEURAL NETWORKS
PATTERN RECOGNITION
NATURAL LANGUAGE PROCESSING
CHATBOTS
REAL TIME EMOTION ANALYTICS

Many more applications…

...
Web search
Speech recognition
Handwriting recognition
Machine translation
Information extraction
Document summarization
Question answering
Spelling correction
Image recognition
3D scene reconstruction
Human activity recognition
Autonomous driving
Music information retrieval
Automatic composition
Social network analysis
...

...
Product recommendation
Advertisement placement
Smart-grid energy optimization
Household robotics
Robotic surgery
Robot exploration
Spam filtering
Fraud detection
Fault diagnostics
AI for video games
Character animation
Financial trading
Protein folding
Medical diagnosis
Medical imaging
...

The Roots of AI

AI has roots in a number of older sciences , particularly:

- Philosophy
- Logic/Mathematics
- Computation
- Psychology/Cognitive Science
- Biology/Neuroscience
- Evolution

- By looking at each of these in turn, we can gain a better understanding of their role in AI, and how these underlying the developed to play that role.

History of AI: 1952- 1969

- **Great successes!**
  - Solving hard math problems
  - game playing
  - LISP was invented by McCarthy (1958)
  - McCarthy went to MIT and Marvin Minsky started lab at Stanford *(Both powerhouses in AI to this day)*

History of AI: 1966 - 1973

- **Reality**
  - Systems fail to play chess and translate Russian
  - neural networks was exposed *(neural networks did not return to appear until late 1980s)*

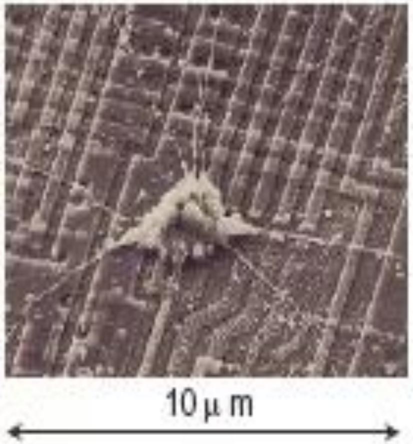
AI History: 1969 - 1979

- **Knowledge-based Systems (Expert systems)**
  - Problem: General logical algorithms could not be applied to realistic problems
  - Solution: accumulate specific logical algorithms
    - DENDRAL – **infer chemical structure**

- AI History: 1987 - present
- **AI becomes a science**
  - More repeatability of experiments
  - More development
- Intelligent Agents (1994)
  - AI systems exist in real environments with real sensory inputs

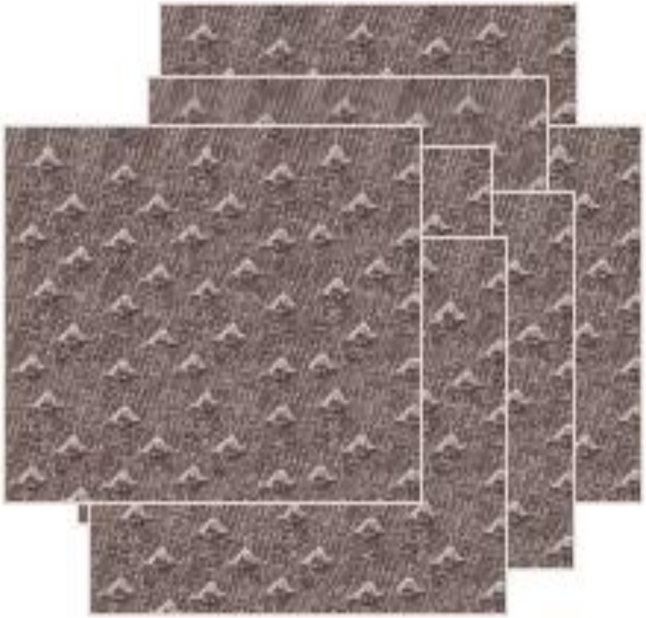
AI History: Where are We Now?

- Autonomous planning: scheduling operations aboard a robot
- Game playing: Kasparov lost to IBM's Big Blue in chess
- Autonomous Control: CMU's NAVLAB drove from Pittsburgh to San Francisco under computer control 98% of time
- *Stanford vehicle wins 2006 DARPA Grand Challenge CMU's 2005 vehicle falls crashes at starting line*
- Logistics: organized the time tables for any task.
- Robotics: remote heart operations.
- human genome, protein folding, drug discovery.
- stock market ……………………….etc.

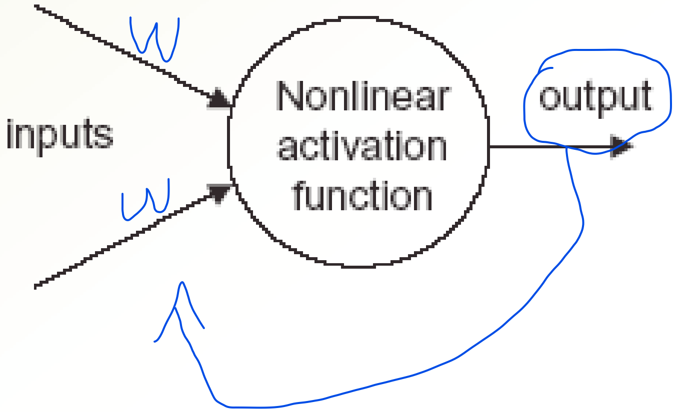


a) An isolated neuron under a microscope with a magnification of about 10^6

b) Looking at slices of live neurons under microscope, one can observe chemical causing electrical activities among the neurons.



c) A human brain has about a massive network of 10^{11} to 10^{12} neurons, connected in a random-like parallel pattern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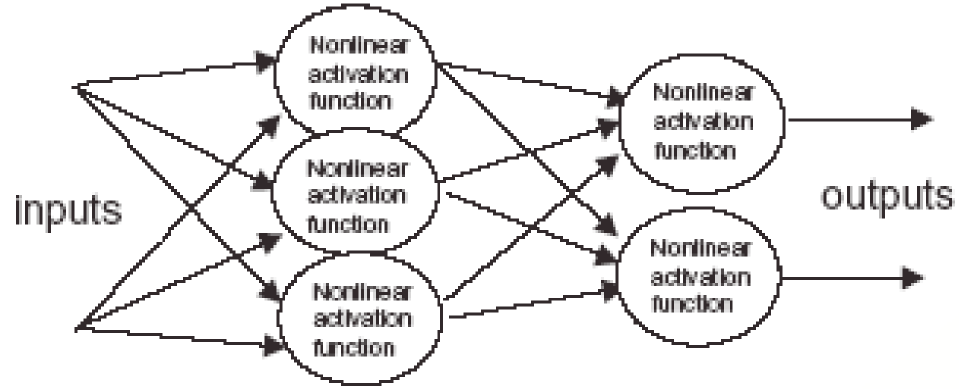
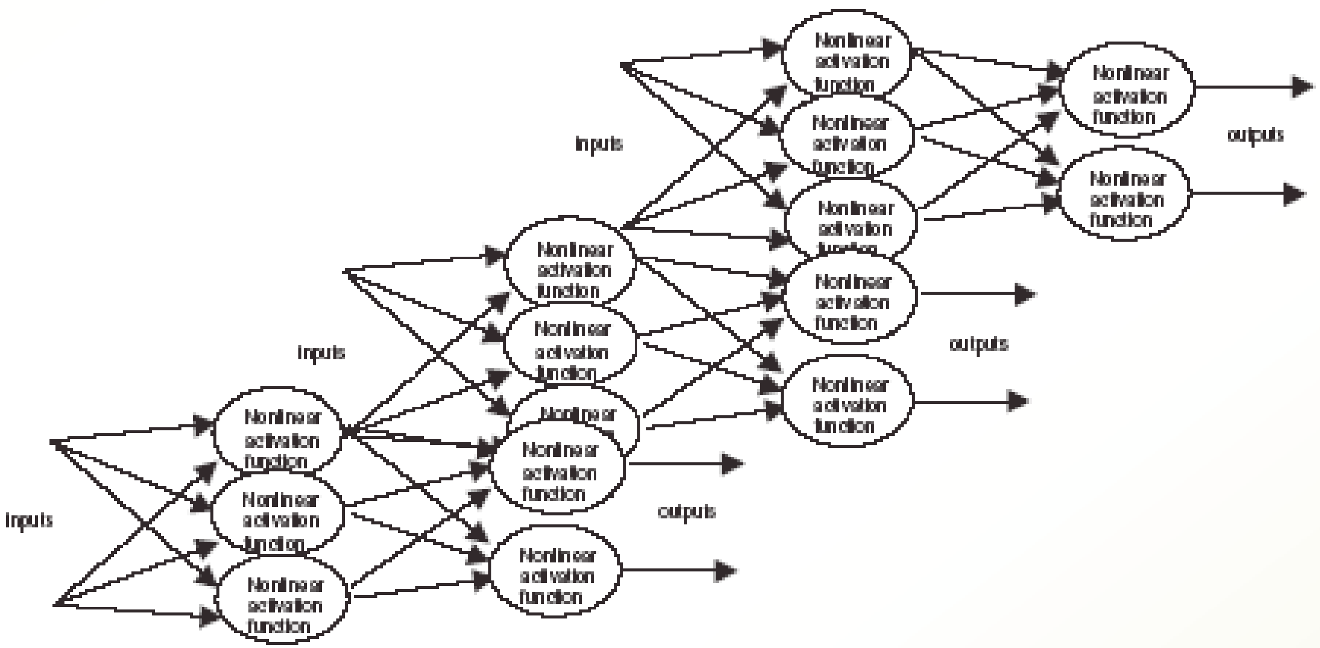
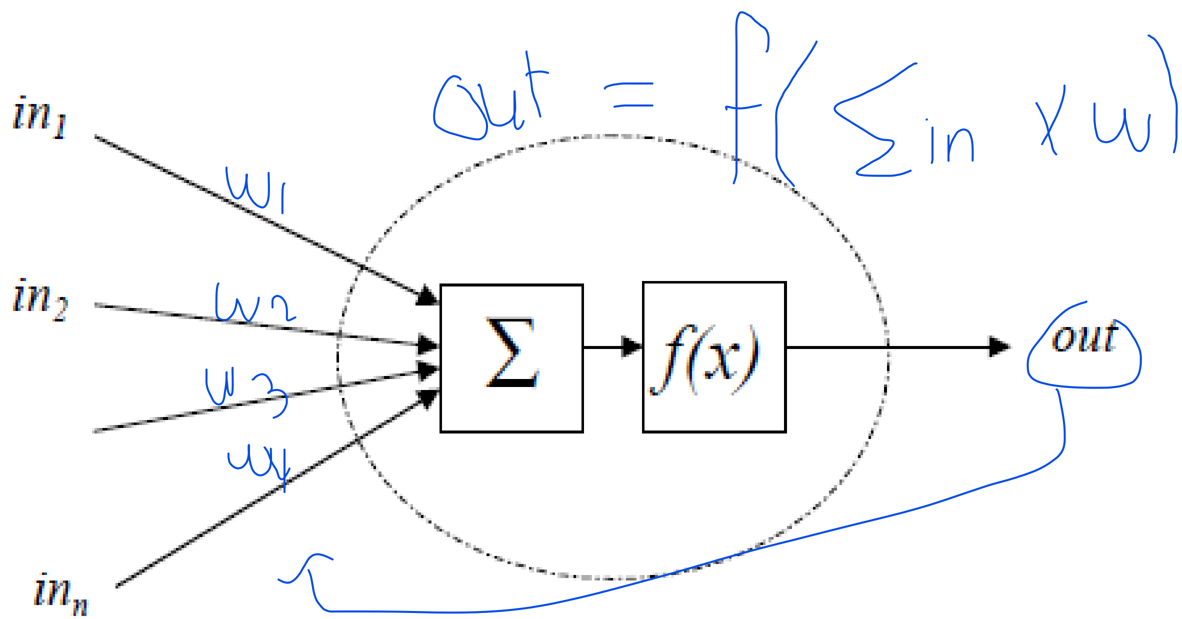
w
inputs
Nonlinear activation function
output


inputs
Nonlinear activation function
Nonlinear activation function
Nonlinear activation function
Nonlinear activation function
Nonlinear activation function
outputs


inputs
outputs
inputs
outputs
inputs
outputs
Nonlinear activation function

The Basic Artificial Neuron

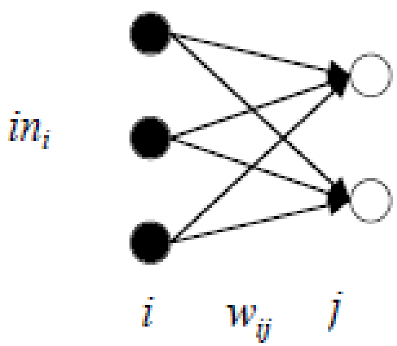
The basic artificial neuron is the following simplified model of a biological neuron:



1. A set of synapses (i.e. connections) brings in activations from other neurons.
2. The processing unit sums the inputs, and then applies a non-linear activation/ squashing/transfer/threshold function *f(x)*.
3. An output line transmits the result to other neurons.

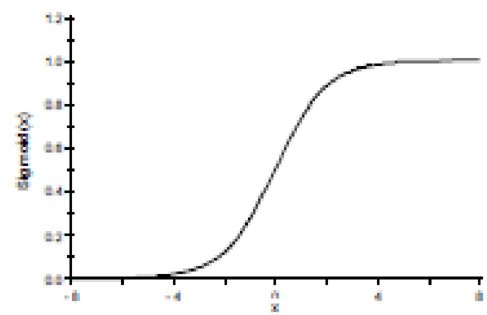
Artificial Neural Networks

The inputs into each neuron j are the outputs of each connected neuron i multiplied by the corresponding connection strength/weight w_{ij}. Any pattern of connectivity is allowed, but one usually takes a simplified ***architecture*** (i.e. layout) for the network, e.g. two or three layers of neurons with full connectivity between layers and no connections within layers. The activations of the first layer are the network inputs.



$$out_j = \mathrm{Sig\,moid}(\sum in_i w_{ij})$$

$$\frac{1}{1+e^{-x}}$$

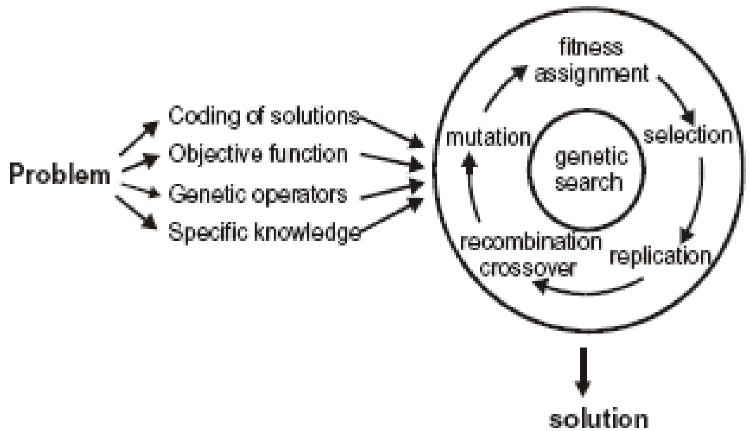


We usually start the network with random initial connection weights w_{ij} and use a ***training algorithm*** to update them iteratively so that the correct outputs are produced for each input pattern in a set of ***training data***. In this way the networks ***learn*** how to perform appropriately.

Genetic algorithms

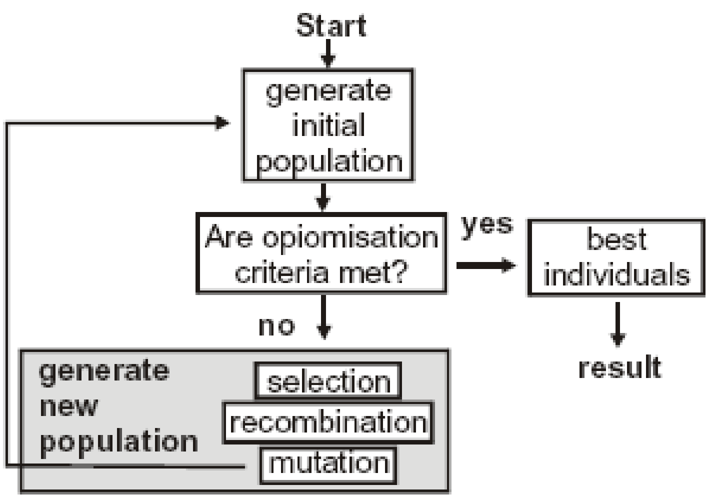
evaluotion algo

- Basic scheme
  - (1)Initialize population
  - (2)evaluate fitness of each member
  - (3)reproduce with fittest members
  - (4)introduce random mutations in new generation
  - Continue (2)-(3)-(4) until prespecified number of generations are complete



Structure of the simple GA

- A successor state is generated by combining two parent states
- Start with *k* randomly generated states (population)
- A state is represented as a string over a finite alphabet (often a string of 0s and 1s)
- Evaluation function (fitness function). Higher values for better states.
- Produce the next generation of states by selection, crossover, and mutation



Basic structure of GA

A Simple Example

The Traveling Salesman Problem:

Find a tour of a given set of cities so that

- each city is visited only once
- the total distance traveled is minimized

Representation

Representation is an ordered list of city numbers known as an *order-based* GA.

1) London	3) Dunedin	5) Beijing	7) Tokyo
2) Venice	4) Singapore	6) Phoenix	8) Victoria

CityList1 (3 5 7 2 1 6 4 8)

CityList2 (2 5 7 6 8 1 3 4)

Crossover

Crossover combines inversion and recombination:

* *

Parent1 (3 5 7 2 1 6 4 8)

Parent2 (2 5 7 6 8 1 3 4)

Child (5 8 7 2 1 6 3 4)

This operator is called the *Order1* crossover.

Mutation

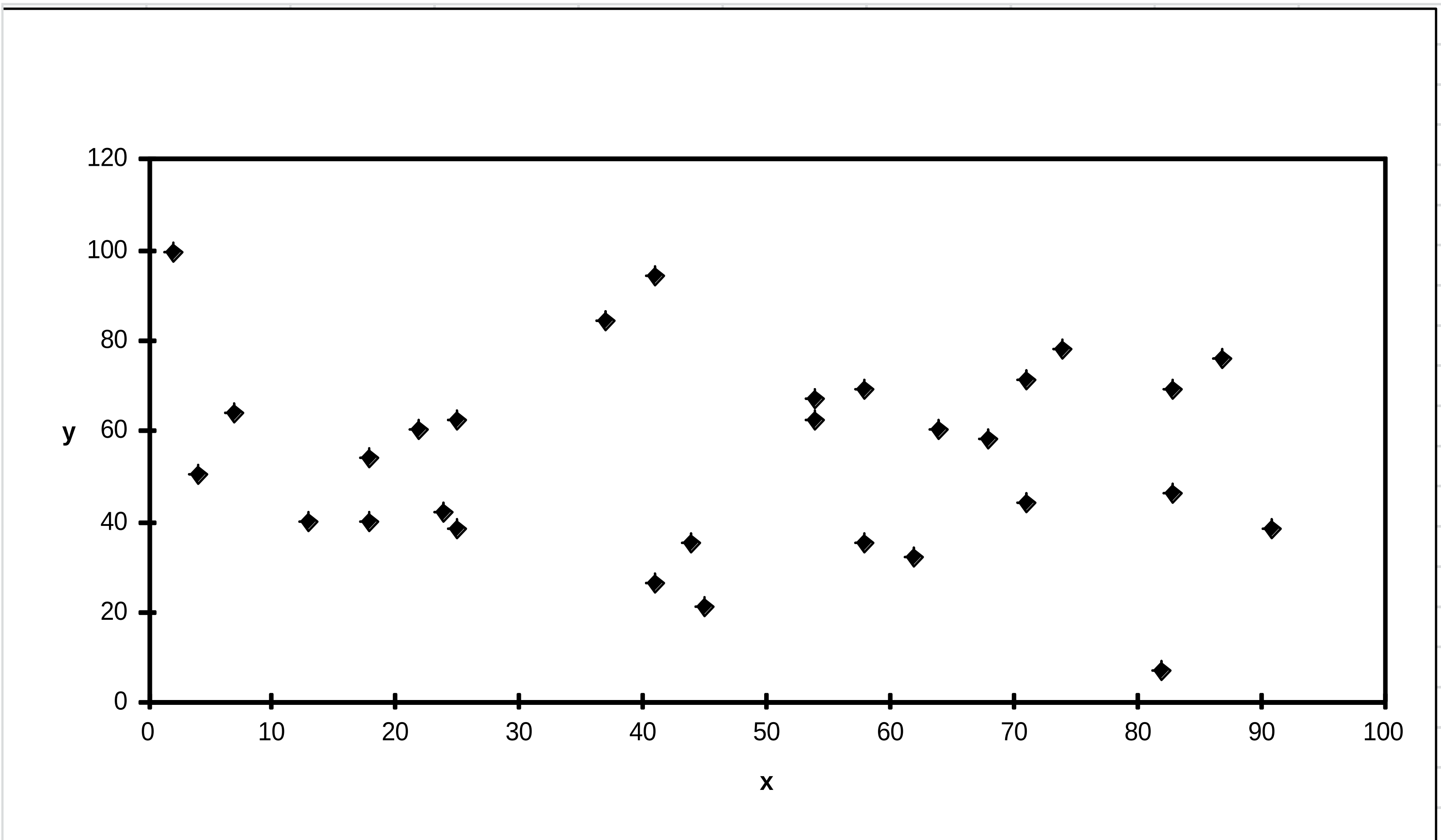
Mutation involves reordering of the list:

* *

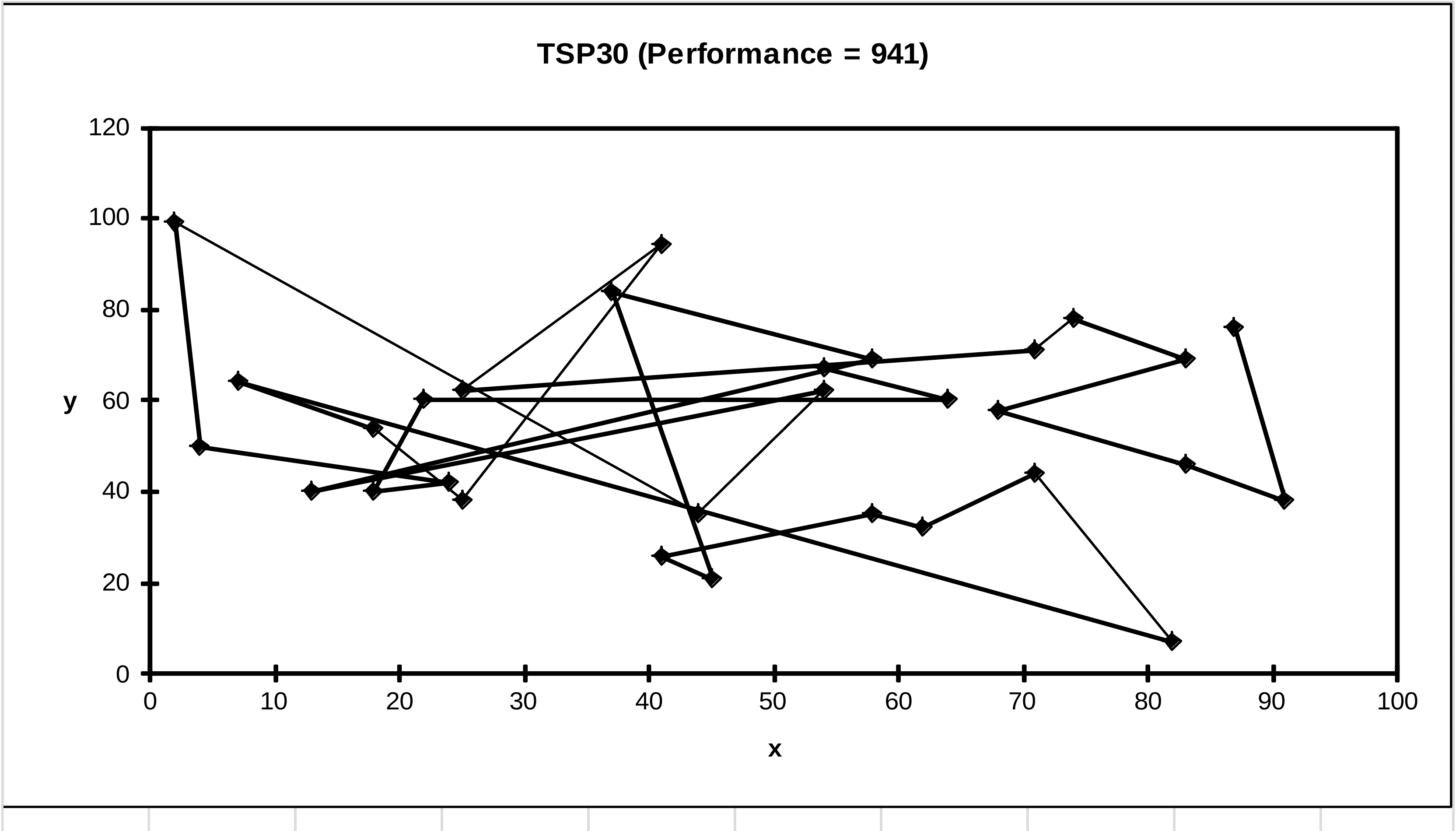
Before: (5 8 7 2 1 6 3 4)

After: (5 8 6 2 1 7 3 4)

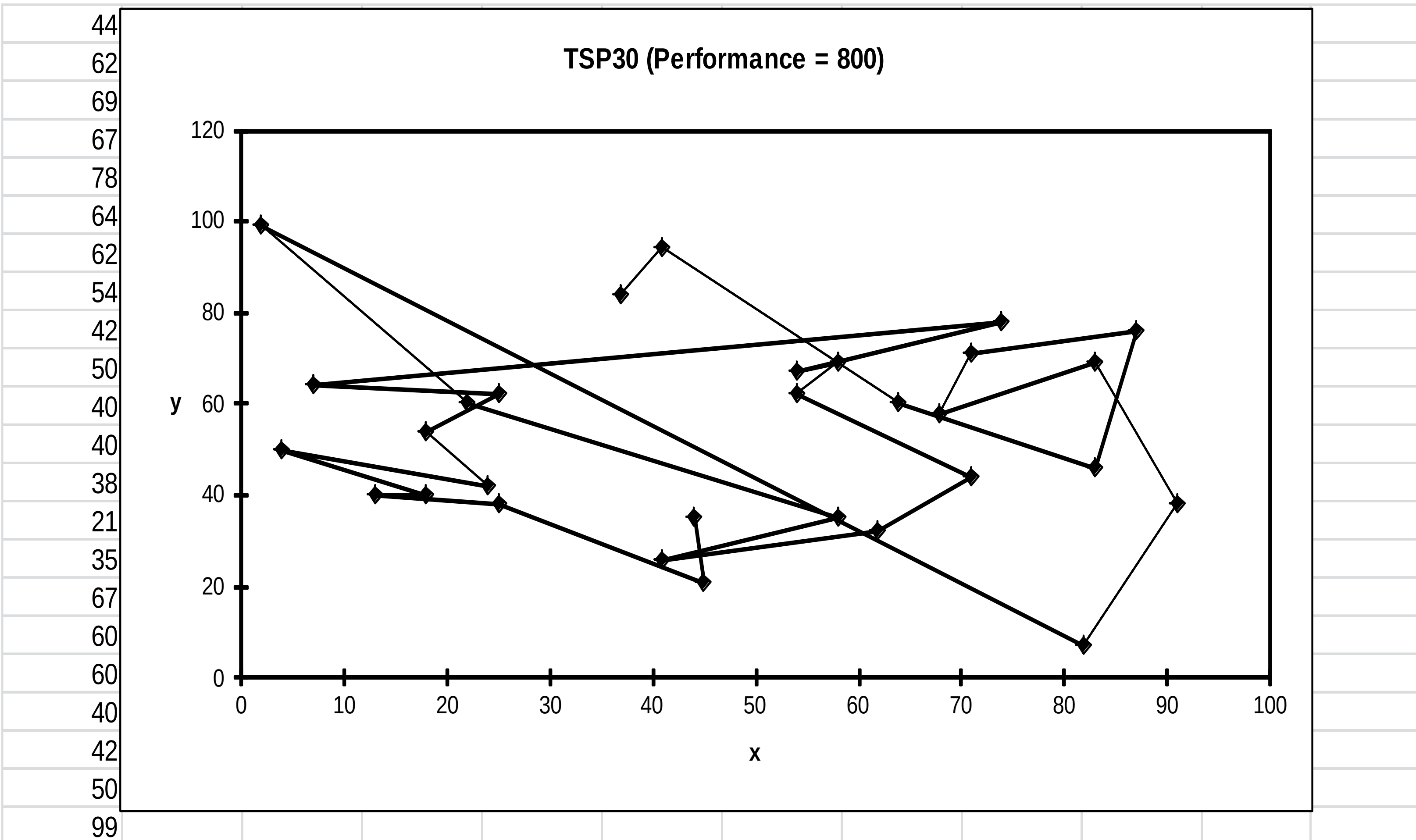
TSP Example: 30 Cities



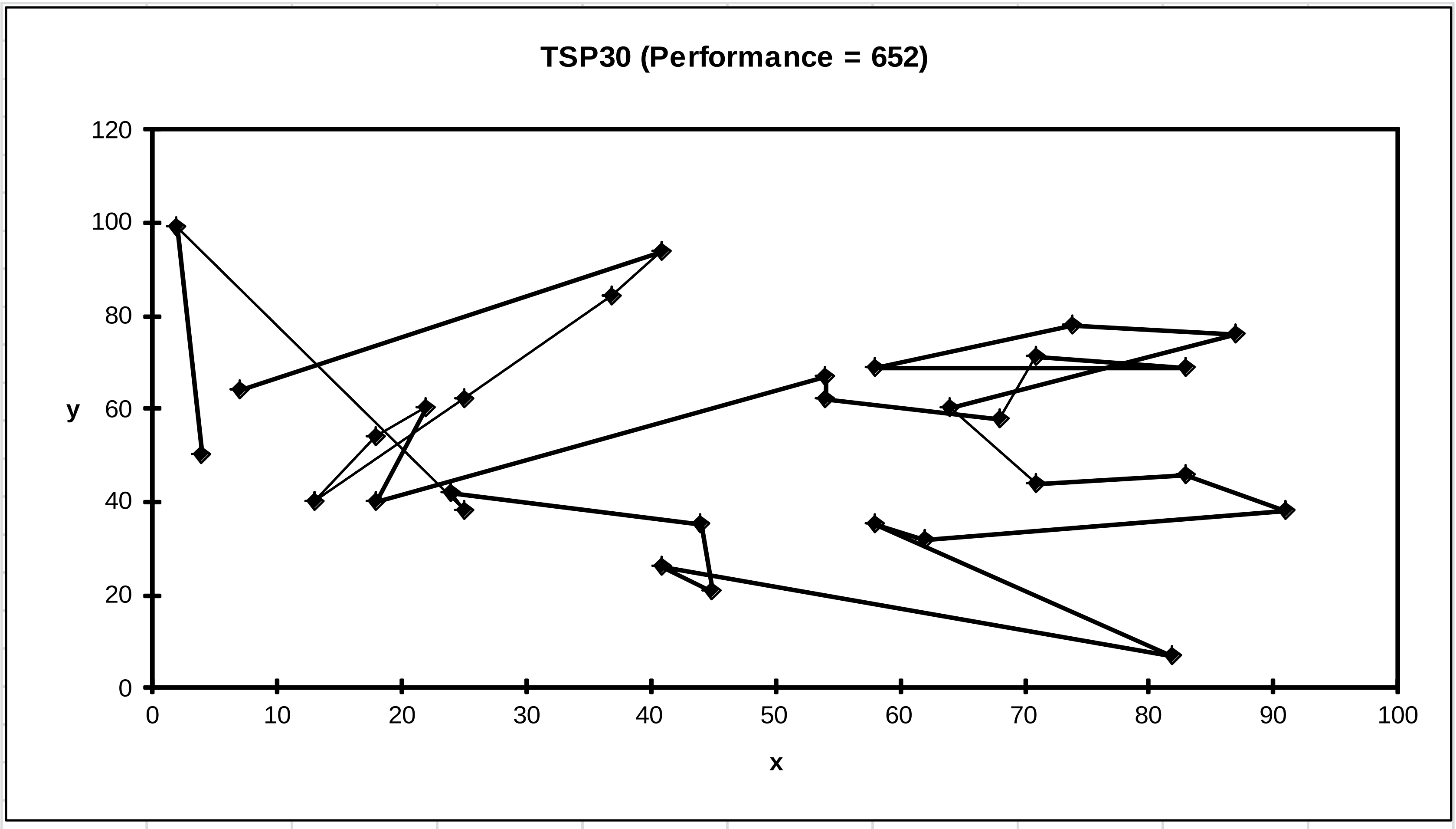
Solution ¡ (Distance = 941)



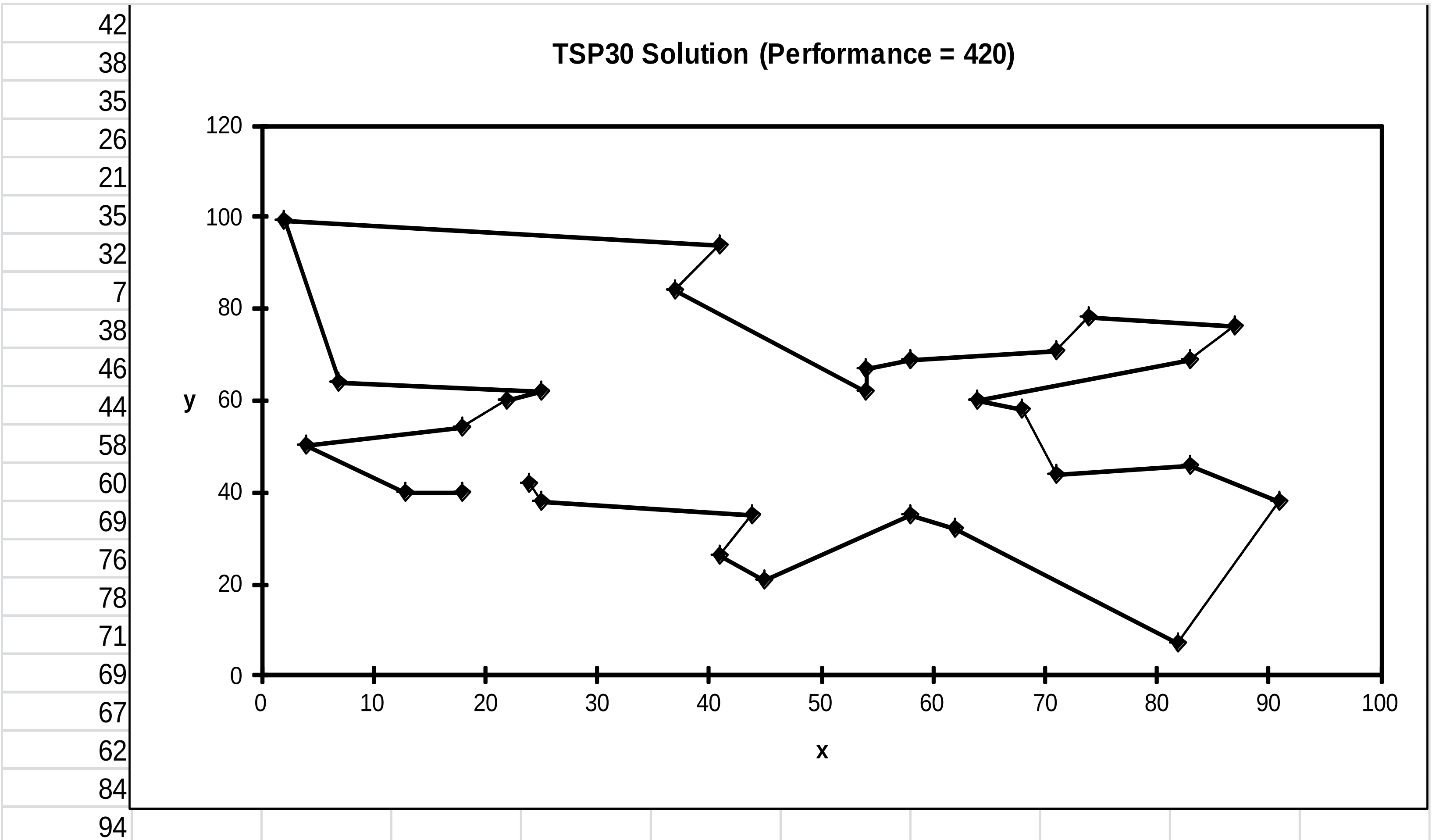
Solution $_j$(Distance = 800)



Solution $_k$(Distance = 652)



Best Solution (Distance = 420)



Computer vision : The world is composed of three-dimensional objects, but the inputs to the human eye and computers' TV cameras are two dimensional.

Some useful programs can work in two dimensions, but full computer vision requires partial three-dimensional information that is not just a set of two-dimensional views.

At present there are only limited ways of representing three-dimensional information directly, and they are not as good as what humans evidently use.

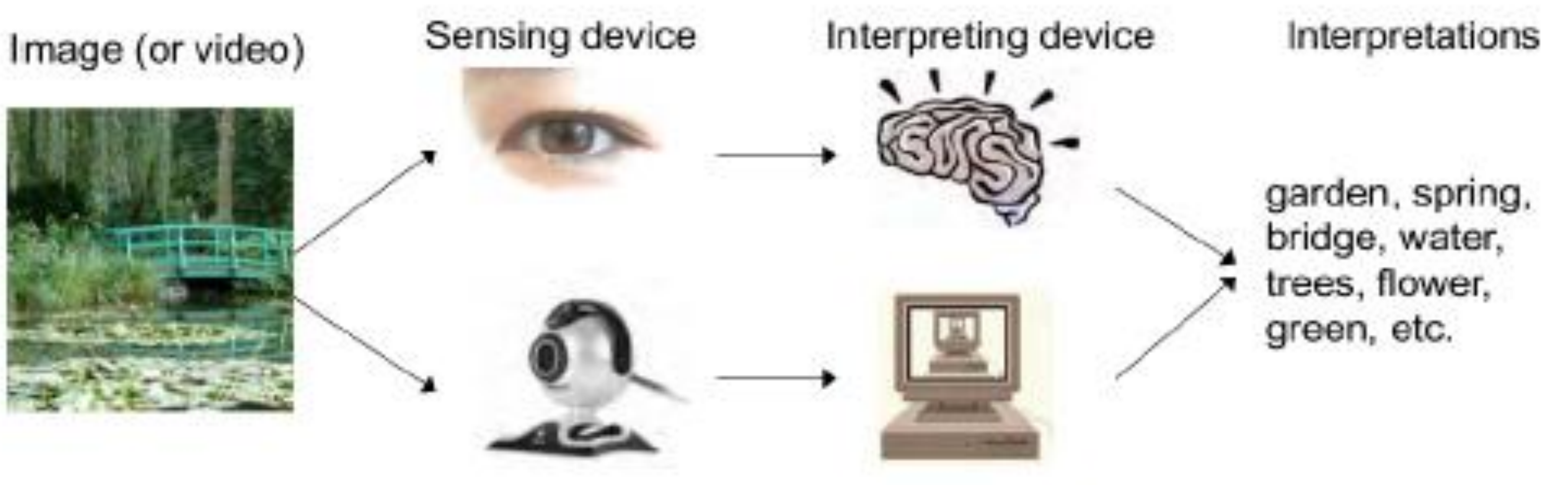
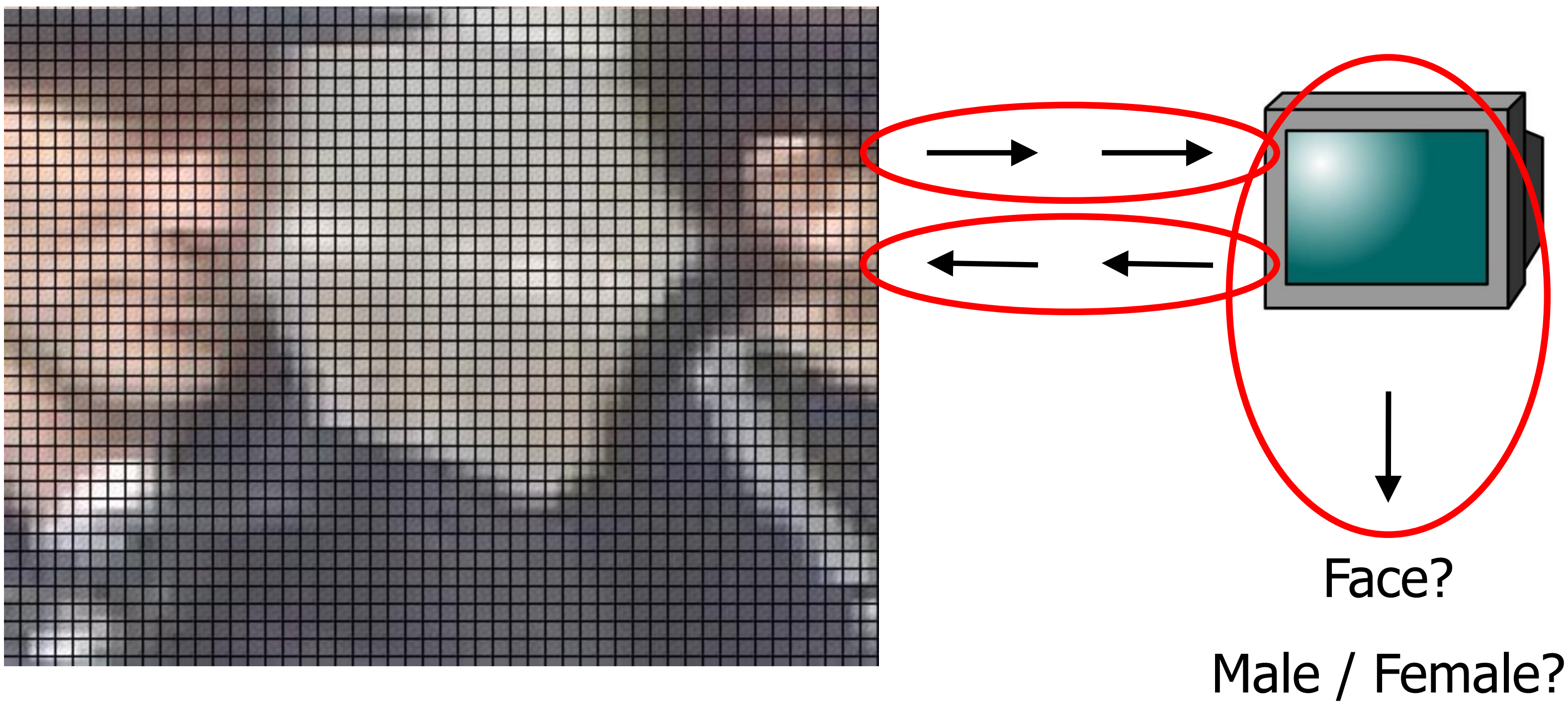
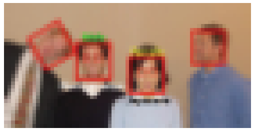


Image Recognition

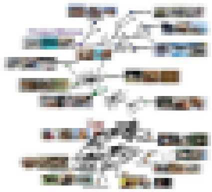


Computer vision

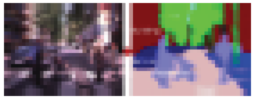
Check reading: automatic tellers widespread



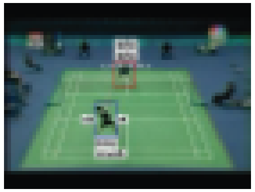
Face detection/recognition: widespread on digital cameras



Object recognition: 10 million labeled images, 100,000 object categories



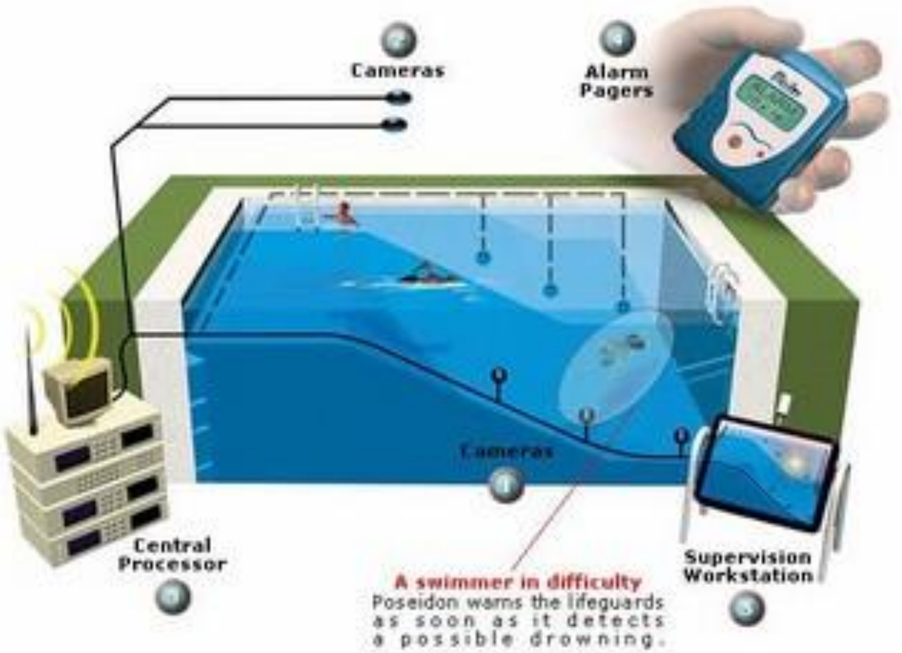
Scene understanding: partition image and label regions with building, sky, road, etc.



Activity recognition: infer high-level concept from low-level data (UIUC)

The <u>Poseidon system</u> is based on a network of overhead and underwater cameras installed in a public pool.

all linked to a computer system which is going to acquire video signals in real-time, filter them, extract human body shapes from images, and assess the movement of these bodies.

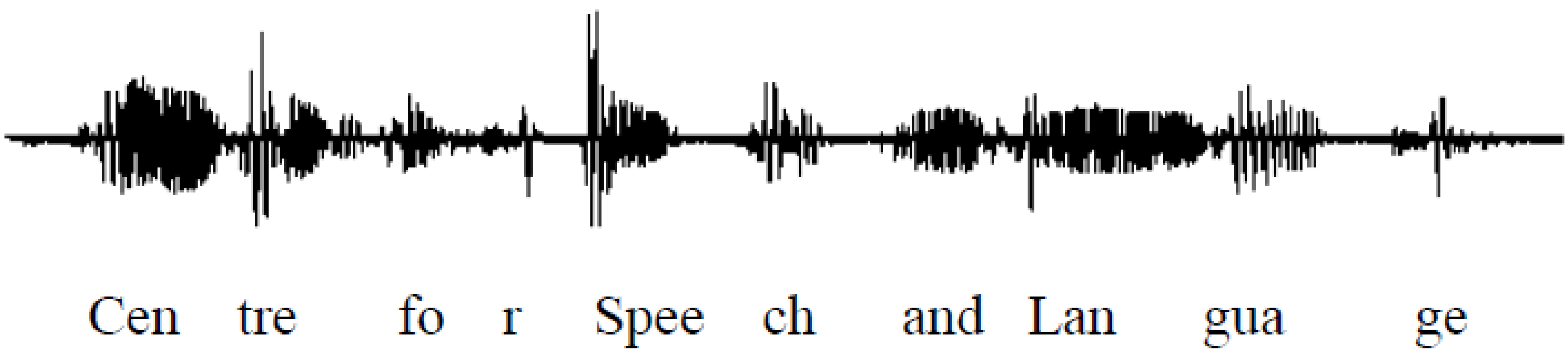


Whenever the system detects that a body movement pattern (or lack thereof) resembles one of a drowning swimmer, it sends an alerts to lifeguards through pagers that indicate the location of the endangered person.

Speech Processing

As well as trying to understand human systems, there are also numerous real world applications: speech recognition for dictation systems and voice activated control; speech production for automated announcements and computer interfaces.

How do we get from sound waves to text streams and vice-versa?

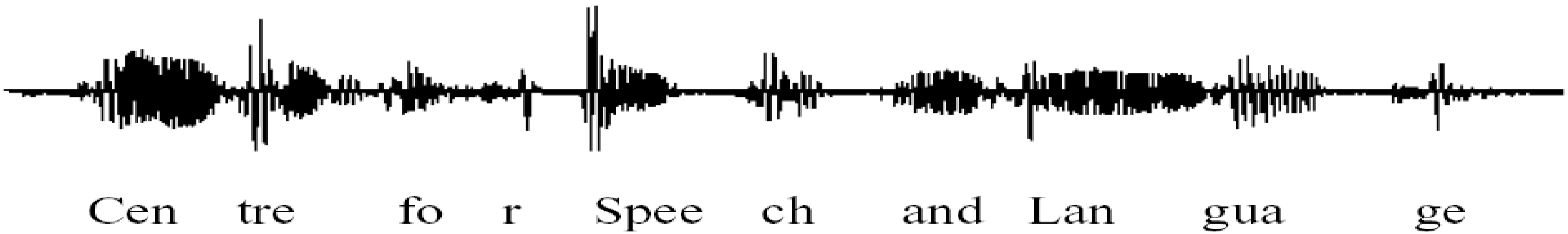


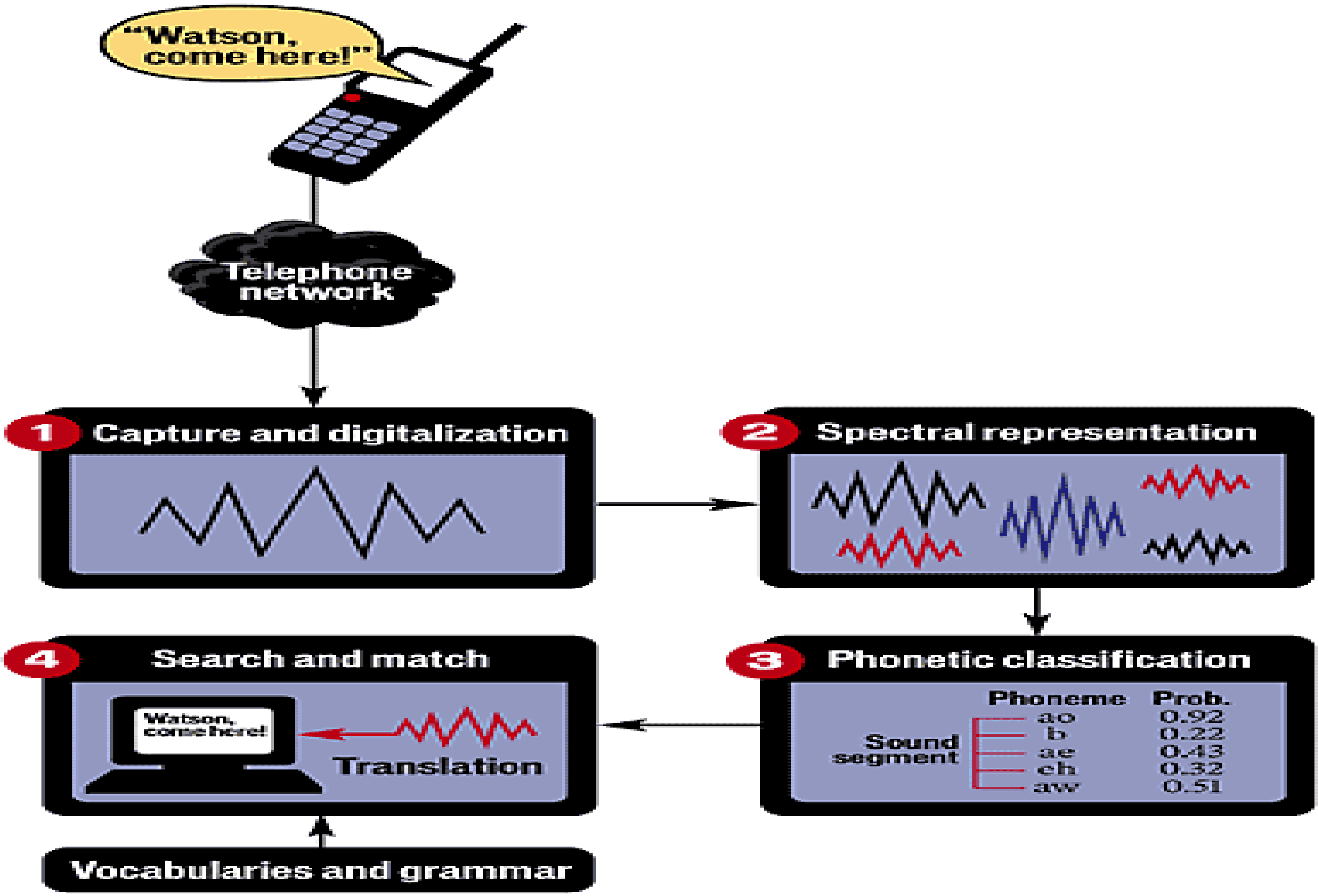
How should we go about segmenting the stream into words? How can we distinguish between "Recognise speech" and "Wreck a nice beach"?

- In the 1990s, computer speech recognition reached a practical level for limited purposes. Thus United Airlines has replaced its keyboard tree for flight information by a system using speech recognition of flight numbers and city names. It is quite convenient.

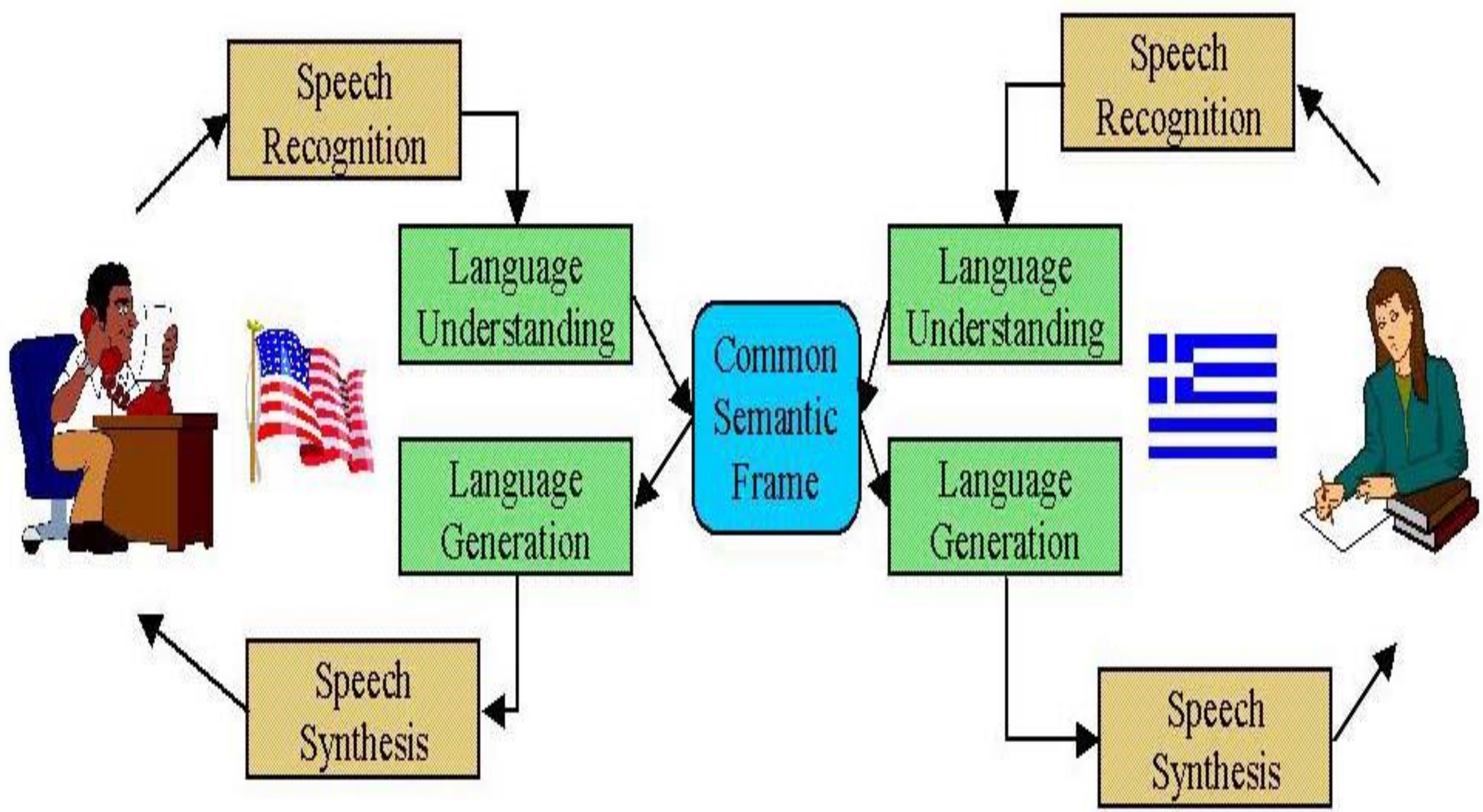
Speech recognition application

- Telephone-based Information (directions, air travel, banking, etc)
- Hands-free (in car)
- Second language ('L2') (accent reduction)
- Audio archive searching

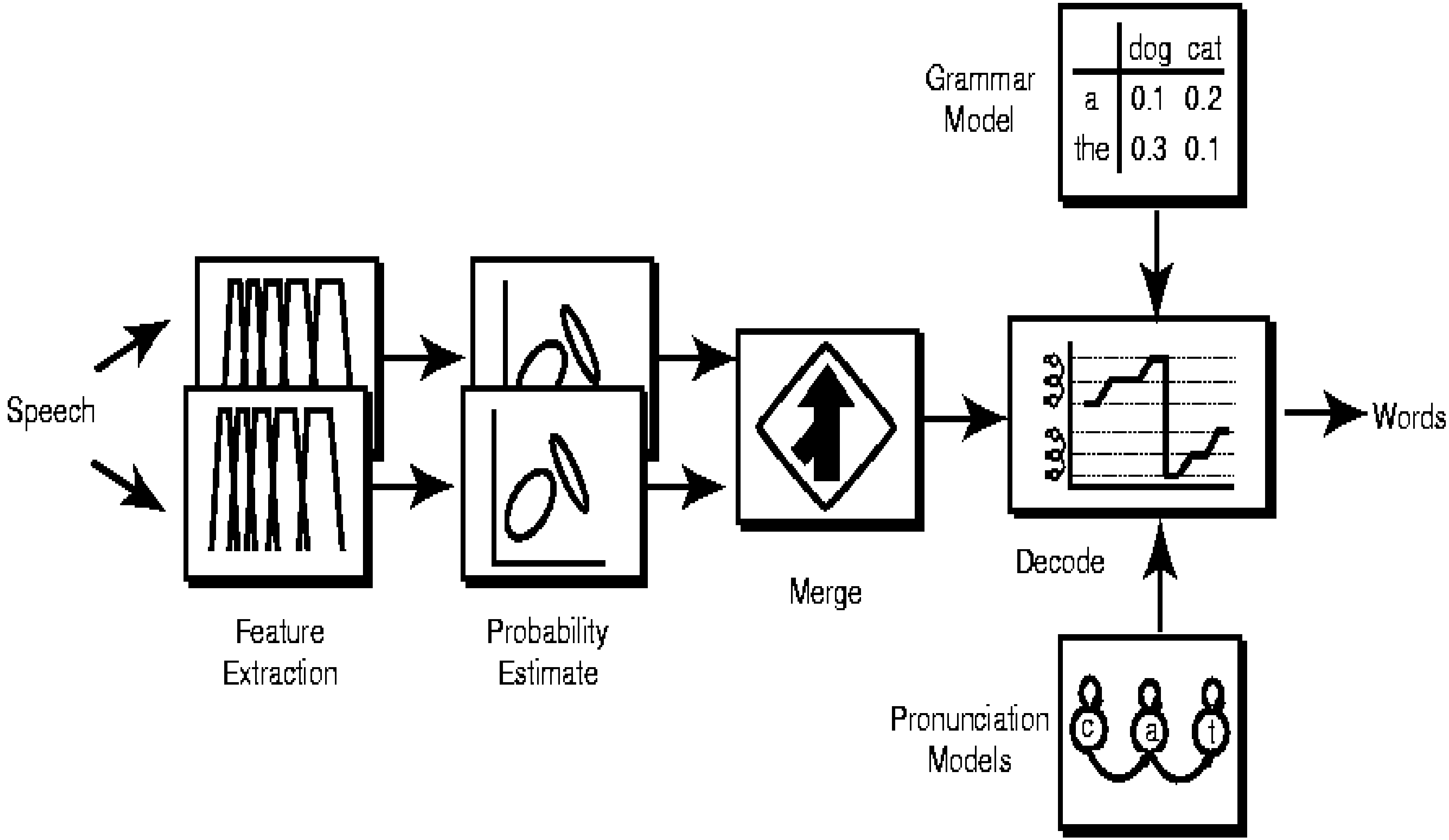

Cen tre fo r Spee ch and Lan gua ge


"Watson, come here!"
Telephone network
1 Capture and digitalization
2 Spectral representation
3 Phonetic classification
Phoneme Prob.
Sound segment
ao 0.92
b 0.22
ae 0.43
ch 0.32
aw 0.51
4 Search and match
Watson, come here!
Translation
Vocabularies and grammar

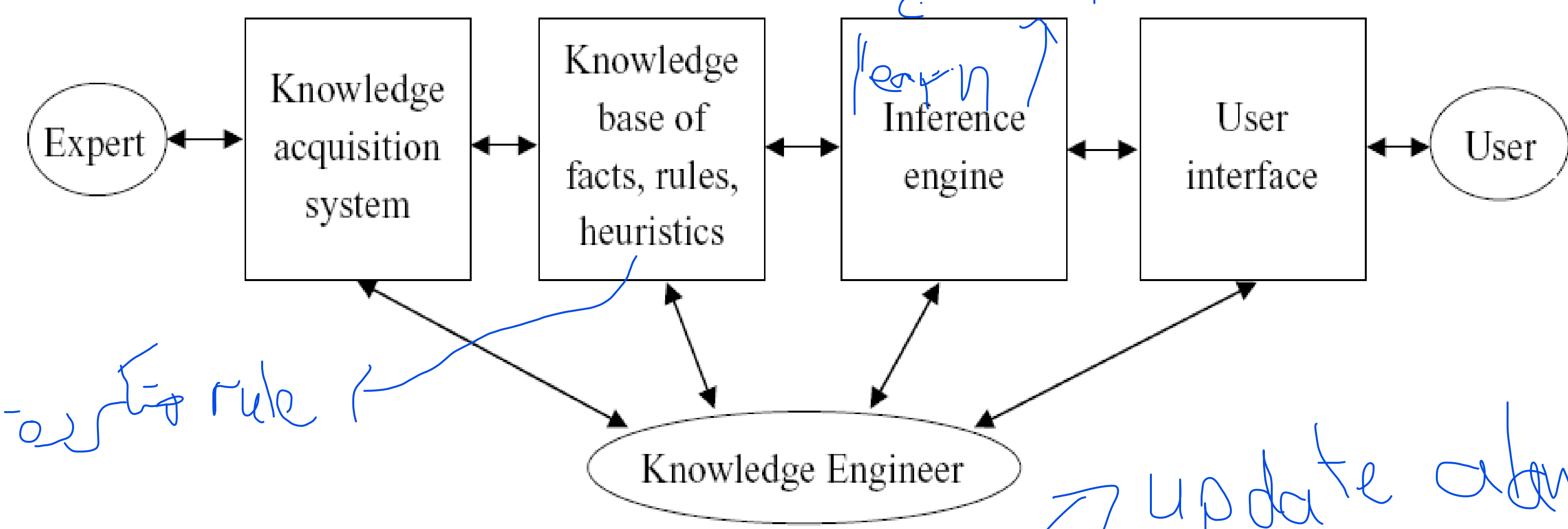
Complex example used speech recognition



Feature Selection for Automatic Speech Recognition



- The process of building expert systems is often called ***knowledge engineering***. The ***knowledge engineer*** is involved with all components of an expert system:



update always

Building expert systems is generally an iterative process. The components and their interaction will be refined over the course of numerous meetings of the knowledge engineer with the experts and users. We shall look in turn at the various components.

Understanding natural language

Goal: To create *computational models* of language in enough detail that you could write computer programs to perform various tasks involving natural language.

scientific: to explore the nature of linguistic communication
practical: to enable effective human-machine communication

إعراب

Just getting a sequence of words into a computer is not enough.
Parsing sentences is not enough either.
The computer has to be provided with an understanding of the domain the text is about, and this is presently possible only for very limited domains.

فكرة الدرس

Is this system intelligent?

- Mohammed : I am Mohammed .
- ALICE: I am very pleased to meet you Mohammed.
- Mohammed : How can I help you?
- ALICE: Just keep talking to me as long as you can.
- Mohammed : Do you wish to as long as me?
- ALICE: OK, I will as long as you.
- Mohammed : Do you wish to will as long as me?
- ALICE: OK, I will will as long as you.
- Mohammed : Do you wish to will will as long as me?
- ALICE: OK, I will will will as long as you.
- Mohammed : Do you wish to will will will as long as me?
- ALICE: OK, I will will will will as long as you.
- Mohammed : Do you wish to will will will will as long as me?
- ALICE: OK, I will will will will will as long as you.
- Mohammed : Do you wish to will will will will will as long as me?
- ……………………

not efficent

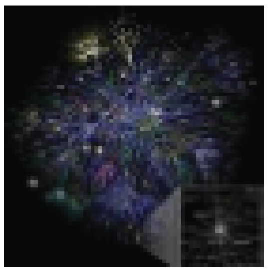
Understanding Natural Language

Natural language processing (NLP) does automated generation and understanding of natural human languages.

- **Natural language generation system**
  Converts information from computer databases into normal-sounding human language
- **Natural language understanding system**
  Converts samples of human language into more formal representations that are easier for computer programs to manipulate.
- **Some major tasks in NLP**
  - Text-to-Speech (TTS) system :
    converts normal language text into speech.
  - Speech recognition (SR) system :
    process of converting a speech signal to a sequence of words;
  - Machine translation (MT) system :
    translate text or speech from one natural language to another.
  - Information retrieval (IR) system :
    search for information from databases such as Internet or World Wide Web or Intranets.

Natural language processing

Spam filtering: 80-90% of all messages are spam; adversarial



Information retrieval: rank web pages based on relevance to query

Machine translation: Google Translate handles 64 languages

Speech recognition: personal assistants (Siri, Google Now)

Even apparently radically different AI systems *(such as rule based expert systems and neural networks*) have many common techniques. Four important ones are:

Representation Knowledge needs to be represented somehow – perhaps as a series of **if-then rules**, as a **frame based system**, as a **semantic network**, or in the **connection weights of an artificial neural network**.

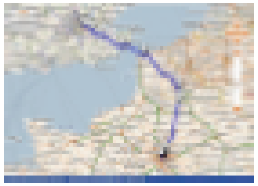
Learning Automatically building up knowledge from the environment – such as acquiring the rules for a rule based expert system, or determining the appropriate connection weights in an artificial neural network.

(Detailed in next chapters)

Rules These could be explicitly built into an expert system by a knowledge engineer, or implicit in the connection weights learnt by a neural network.

Search This can take many forms – perhaps searching for a sequence of states that leads quickly to a problem solution, or searching for a good set of connection weights for a neural network by minimizing a fitness function.

Search/planning

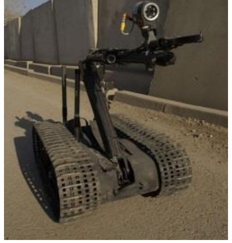


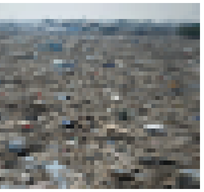
Route planning: (e.g., Google maps); search + heuristics

Logistics planning: hospitals organize bed schedules, staff rotations

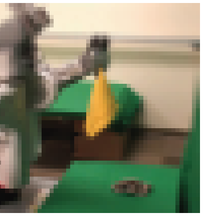
Formal verification: prove correctness of hardware/software (e.g., NASA, Intel); logic/theorem proving

Robotics

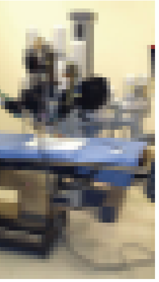




Disaster areas: after earthquakes, surveillance robots check for survivors and structural integrity



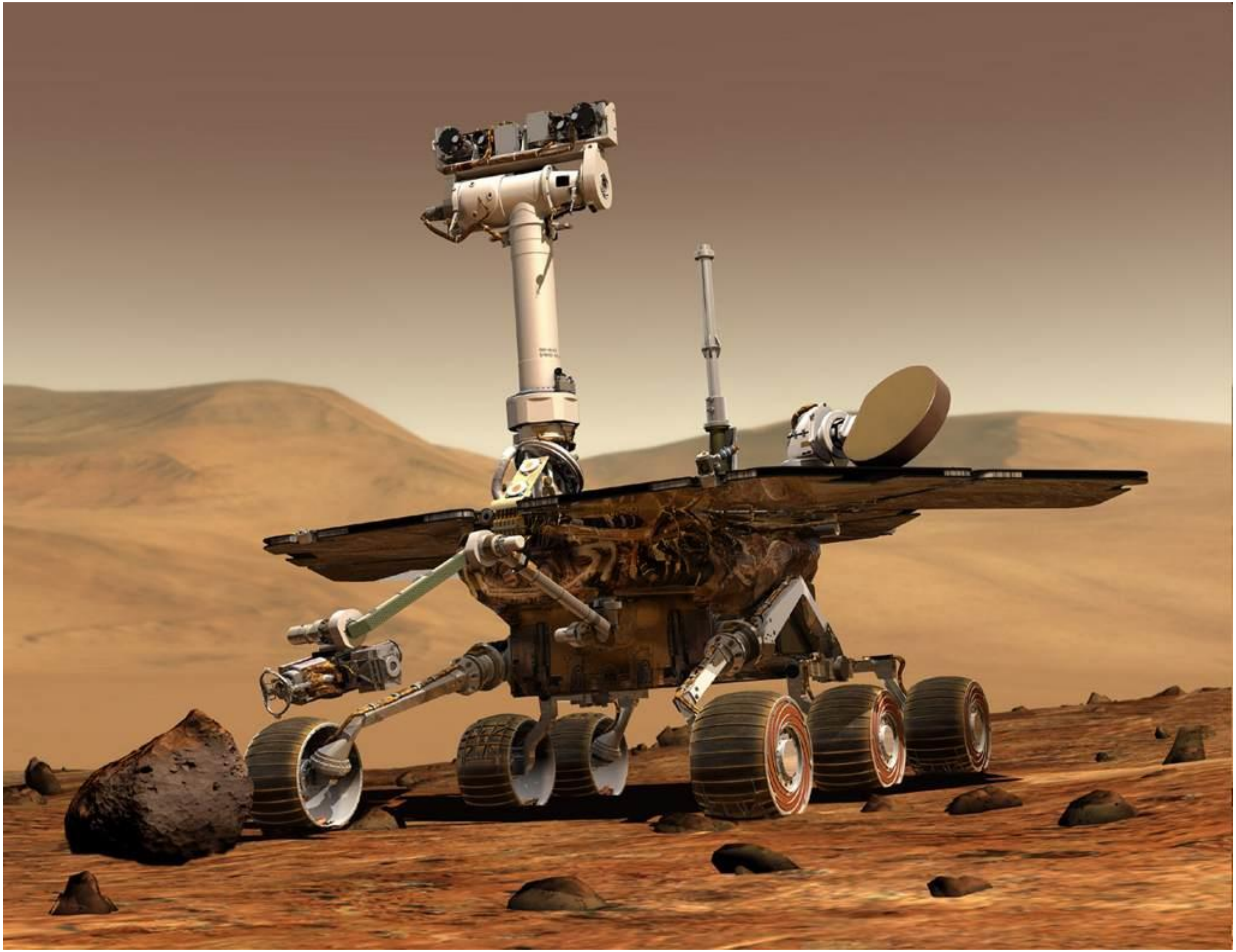
Household chores: towel folding [Abbeel at Berkeley]



Robotic surgery: less invasive, can perform some actions better than humans

Autonomous vehicles: (e.g., Google Car)

Mars Rover



Game playing

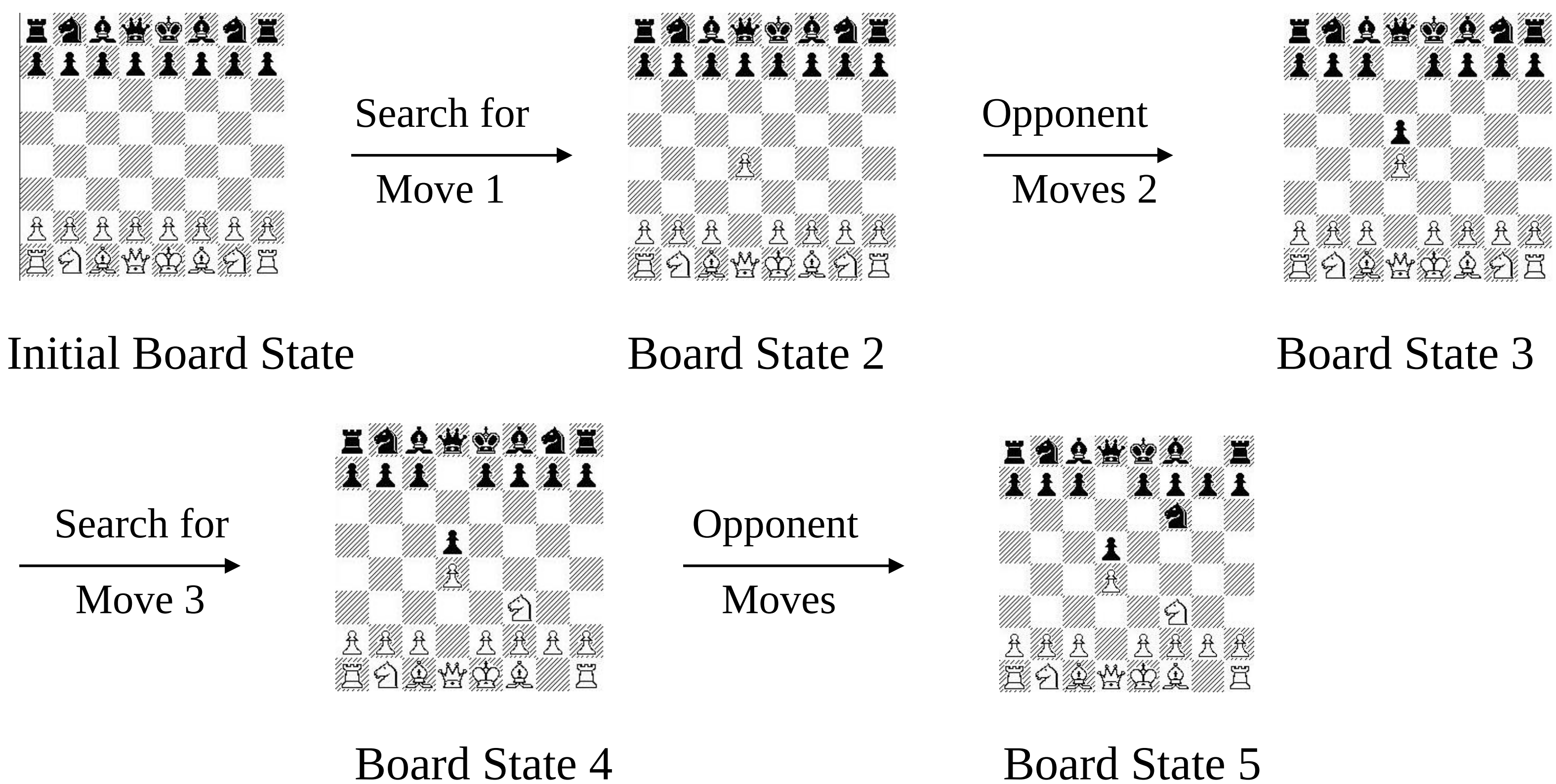
Game playing is a search problem Defined by:

- **Initial state**
- **Successor function**
- **Goal test**
- **Path cost / utility / payoff function**

Characteristics of game playing:

- **Initial state**: initial board position and player
- **Operators**: one for each legal move
- **Terminal states**: a set of states that mark the end of the game
- **Utility function**: assigns numeric value to each terminal state
- **Game tree**: represents all possible game scenarios

(Our) Basis of Game Playing: Search for best move every time



May, 1997: Deep Blue beats the World Chess Champion

You can buy machines that can play master level **chess** for a few hundred dollars. There is some IS in them, but they play well against people mainly through brute force computation

looking at hundreds of thousands of positions. To beat a world champion by brute force and known reliable heuristics requires being able to look at 200 million positions per second.

Deep Blue had Kasparov in deep thought (CNN)

vs.

The cunning Deep Blue (CNN)

I could feel human-level intelligence across the room

Intelligent Systems in Your Everyday Life

- **Post Office**

– automatic address recognition and sorting of mail

- **Banks**

– automatic check readers, signature verification systems

– automated loan application classification

- **Telephone Companies**

– automatic voice recognition for directory inquiries

– automatic fraud detection,

– classification of phone numbers into groups

- **Credit Card Companies**

– automated fraud detection, automated screening of applications

- **Computer Companies**

– automated diagnosis for help-desk applications

- **Artificial Intelligence involves the study of:**

– automated recognition and understanding of speech, images, etc
– learning and adaptation
– planning, reasoning, and decision-making

- **AI has made substantial progress in**

– recognition and learning
– some planning and reasoning problems

- **AI Applications**

– improvements in hardware and algorithms => AI applications in industry, finance, medicine, and science.

What Can AI Do? From these examples

- Play a game of table tennis? yes
- Drive safely along a road with signals? yes
- Drive safely along any road? no
- Buy a week's worth of groceries on the web?
- Buy a week's worth of groceries at Berkeley Bowl?
- Discover and prove a new mathematical theorem?
- Converse successfully with another person for an hour?
- Perform a complex surgical operation?
- Unload a dishwasher and put everything away?
- Translate spoken English into spoken Arabic in real time? yes
- Write an intentionally funny story? no , because not number

summary if limitied application then yes else no.