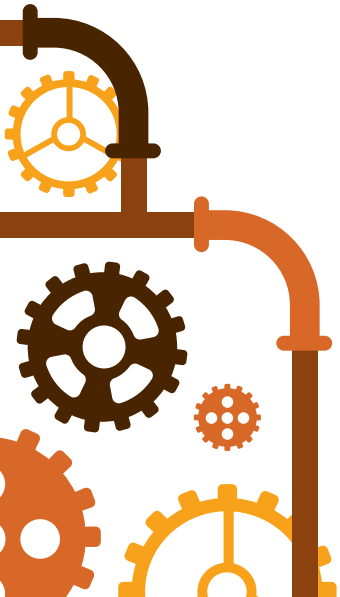
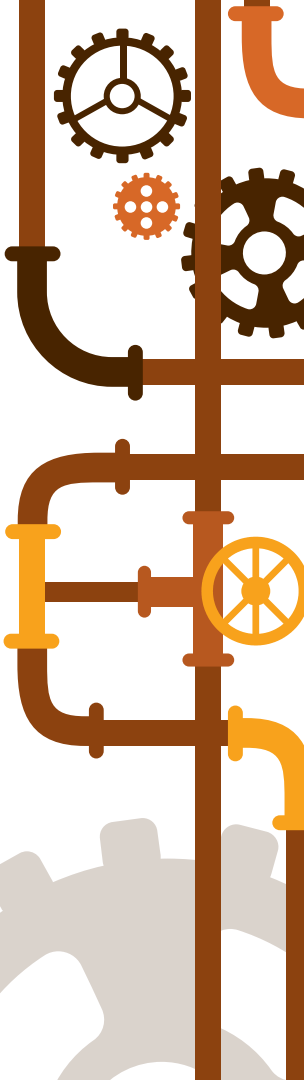
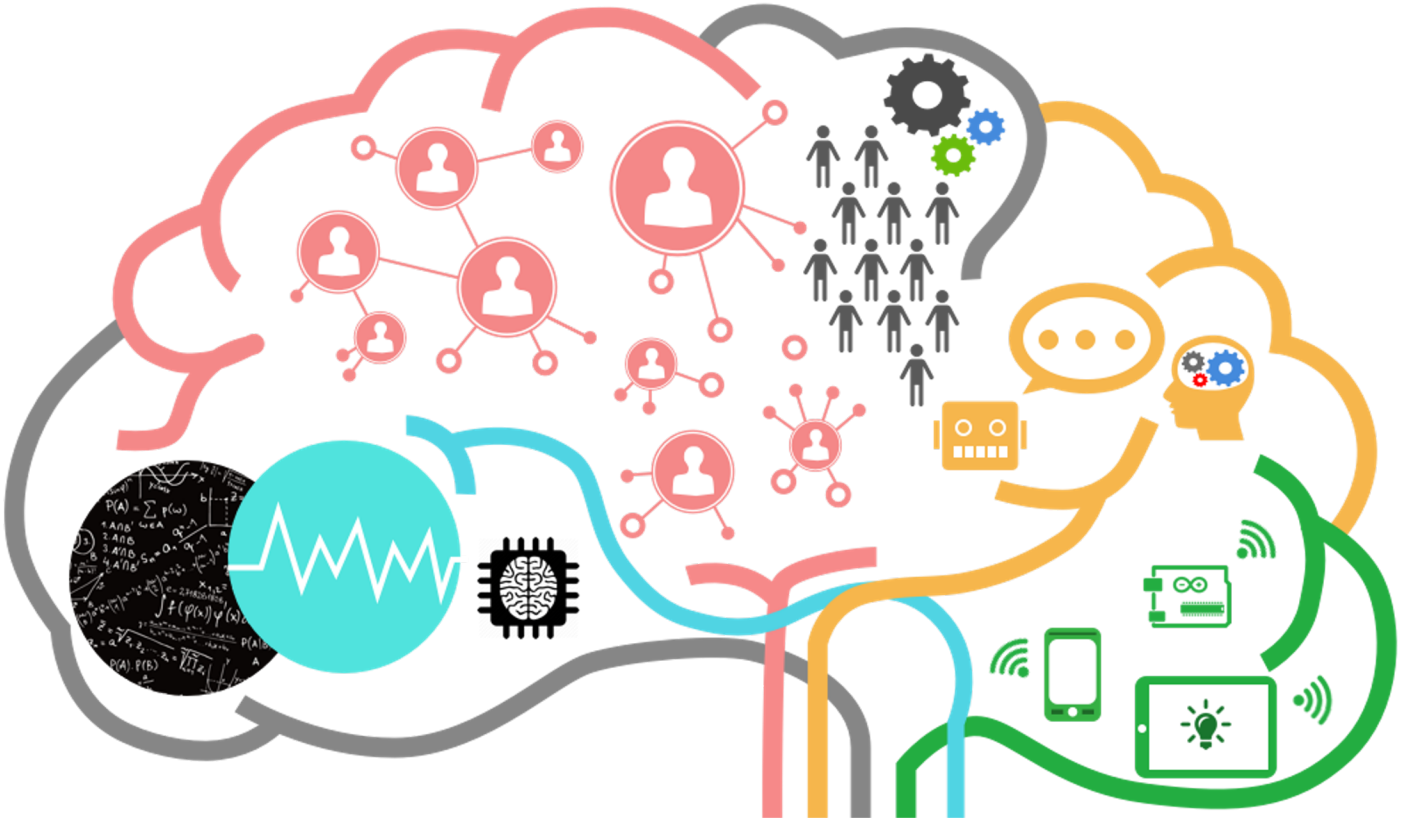



CS 482/682: Introduction

Fall 2021



Who am I?

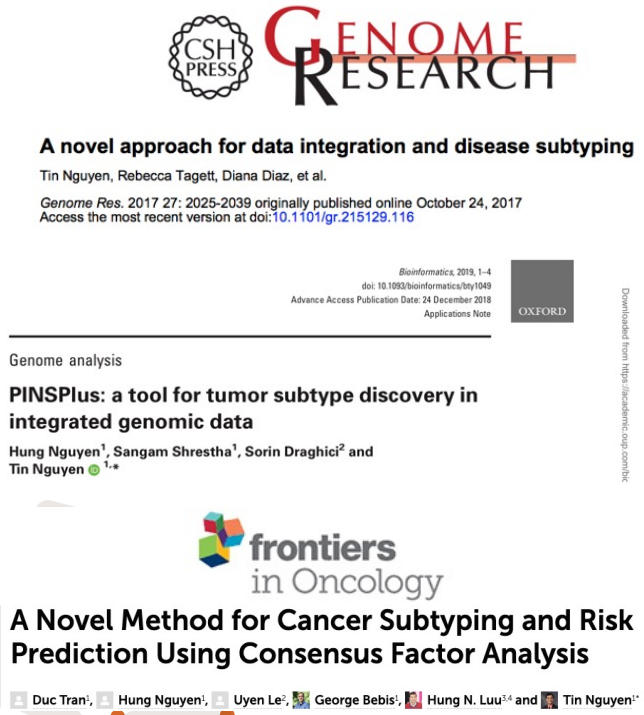
Prof. Tin Nguyen

B.S. & M.S. in Computer Science: Eotvos Lorand University, Budapest
Ph.D. in Computer Science: Wayne State University

Research Interests: Bioinformatics, Machine Learning, Cancer Subtyping, Biological Networks

Teaches:
- CS 365 - Mathematics of Computer Science
- CS 4/661 - Statistics in Bioinformatics
- CS 4/691 - Intro to Bioinformatics
- **CS 4/682 - Artificial Intelligence**
- CS 791 - Advanced Bioinformatics

Some recent pubs.



CSH PRESS GENOME RESEARCH

A novel approach for data integration and disease subtyping

Tin Nguyen, Rebecca Tagett, Diana Diaz, et al.

Genome Res. 2017 27: 2025-2039 originally published online October 24, 2017
Access the most recent version at doi:10.1101/gr.215129.116

Bioinformatics, 2019, 1–4
doi: 10.1093/bioinformatics/bty1049
Advance Access Publication Date: 24 December 2018
Applications Note

OXFORD

Genome analysis

PINSPlus: a tool for tumor subtype discovery in integrated genomic data

Hung Nguyen[1], Sangam Shrestha[1], Sorin Draghici[2] and Tin Nguyen[1,*]

Downloaded from https://academic.oup.com/bic

frontiers in Oncology

A Novel Method for Cancer Subtyping and Risk Prediction Using Consensus Factor Analysis

Duc Tran[1], Hung Nguyen[1], Uyen Le[2], George Bebis[1], Hung N. Luu[3,4] and Tin Nguyen[1,*]

nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-019-09799-2 OPEN

Community assessment to advance computational prediction of cancer drug combinations in a pharmacogenomic screen

Nguyen *et al. Genome Biology* (2019) 20:203
https://doi.org/10.1186/s13059-019-1790-4

Genome Biology

RESEARCH Open Access

Identifying significantly impacted pathways: a comprehensive review and assessment

Check for updates

NBIA: a network-based integrative analysis framework – applied to pathway analysis

Tin Nguyen[1*], Adib Shafi[3], Tuan-Minh Nguyen[3], A. Grant Schissle

nature SCIENTIFIC REPORTS

nature COMMUNICATIONS

Fast and precise single-cell data analysis using hierarchical autoencoder

Duc Tran, Hung Nguyen, Bang Tran, Carlo La Vecchia, Hung N. Luu, Tin Nguyen

OXFORD Briefings in Bioinformatics

A comprehensive survey of regulatory network inference methods using single-cell RNA sequencing data

Hung Nguyen, Duc Tran, Bang Tran, Bahadir Pehlivan and Tin Nguyen

Published Online: 24 September, 2020 | Supp Info: http://doi.org/10.26508/lsa.202000867
Downloaded from life-science-alliance.org on 17 December, 2020

Research Article

TRANSPARENT PROCESS OPEN ACCESS Life Science Alliance

Check for updates

Gene selection for optimal prediction of cell position in tissues from single-cell transcriptomics data

Course Objectives (not necessarily in order):

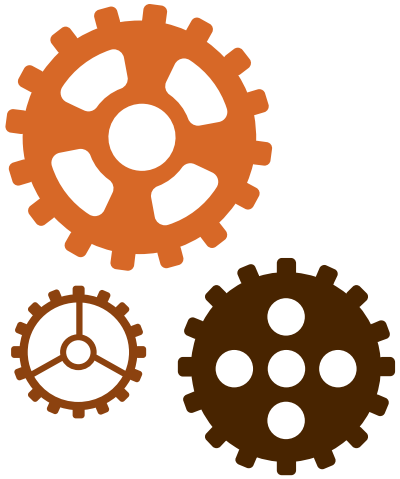
- What is Artificial Intelligence?
  - What is Intelligence?
  - How can computing principles be used to create artificial intelligence?
  - How can a problem be understood to best select the algorithms necessary to solve it?
- How can AI be used?
  - What classes of problems can AI solve well/poorly?
  - What are the rights and responsibilities for creating an artificial agent that interacts with people and the environment?

Student Outcomes (ABET)

1. Identify, formulate, analyze, and solve complex computing or engineering problems by applying principles of computing, engineering, science, and mathematics.

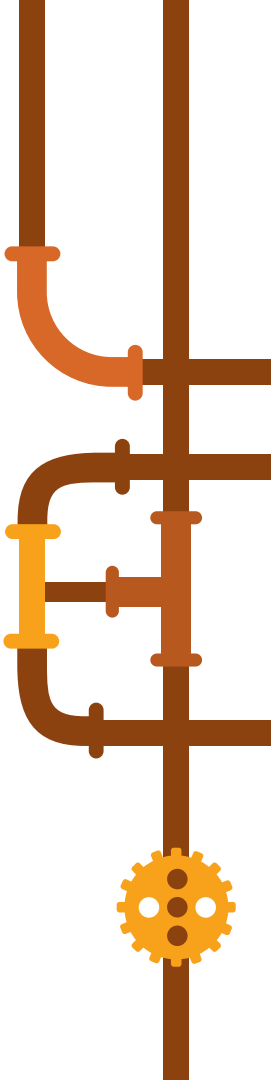
4. **Recognize professional responsibilities and make informed judgments in engineering and computing practice based on legal and ethical principles, considering the impact of solutions in global, economic, environmental, and societal contexts.**

7. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.

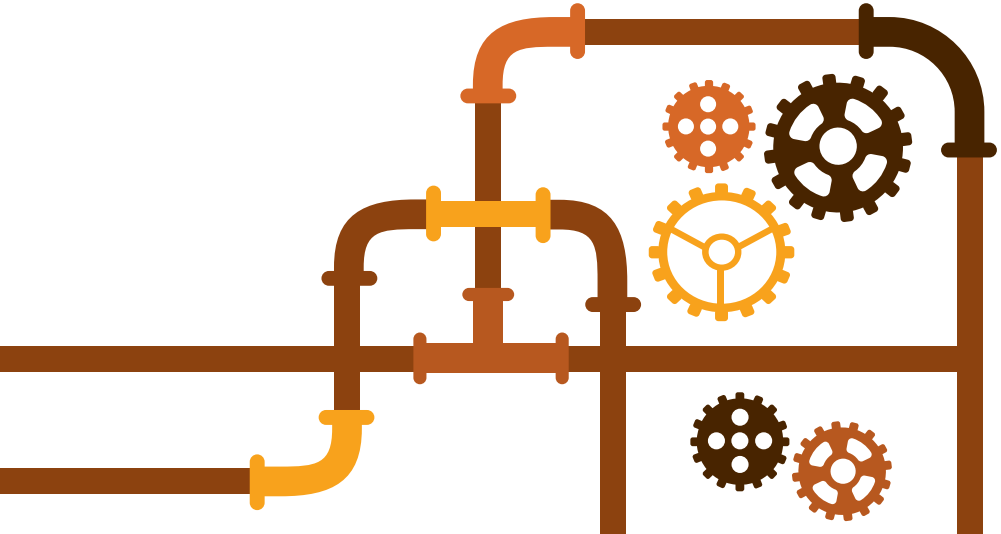


Today's Objectives:

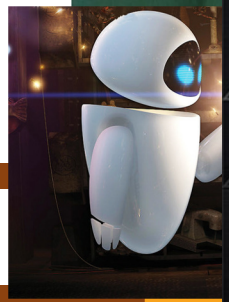
- What is AI?
- How Can AI Be Used?
- Course Topics
- Course Mechanics

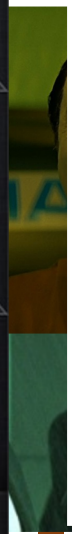


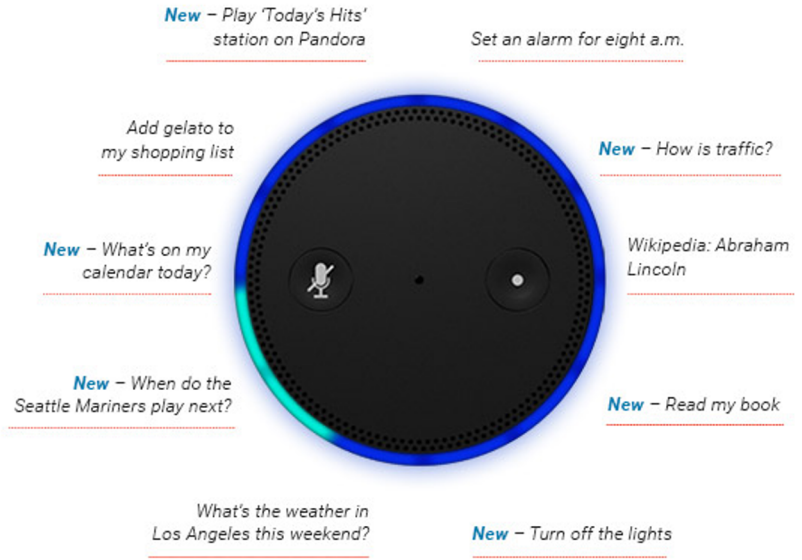
How Can AI Be Used?



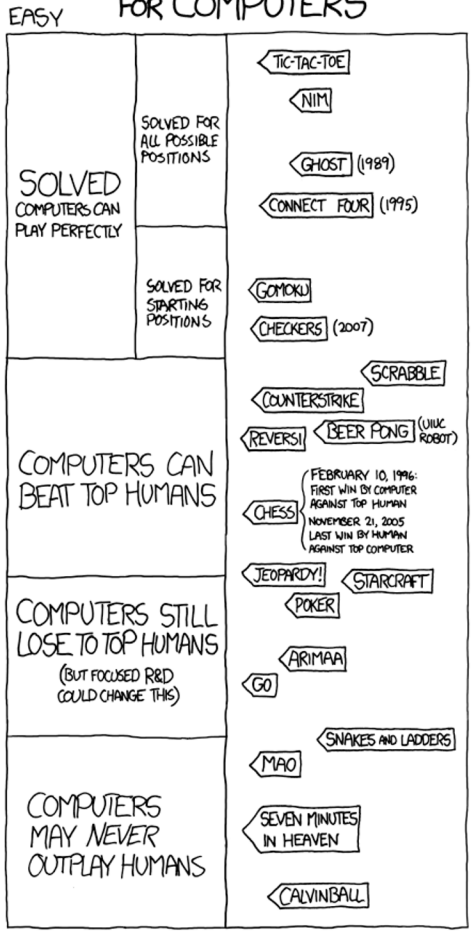
Our understanding of AI is a combination of fact and fiction



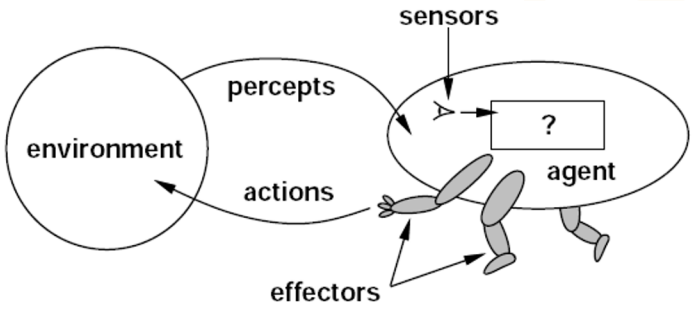




DIFFICULTY OF VARIOUS GAMES FOR COMPUTERS

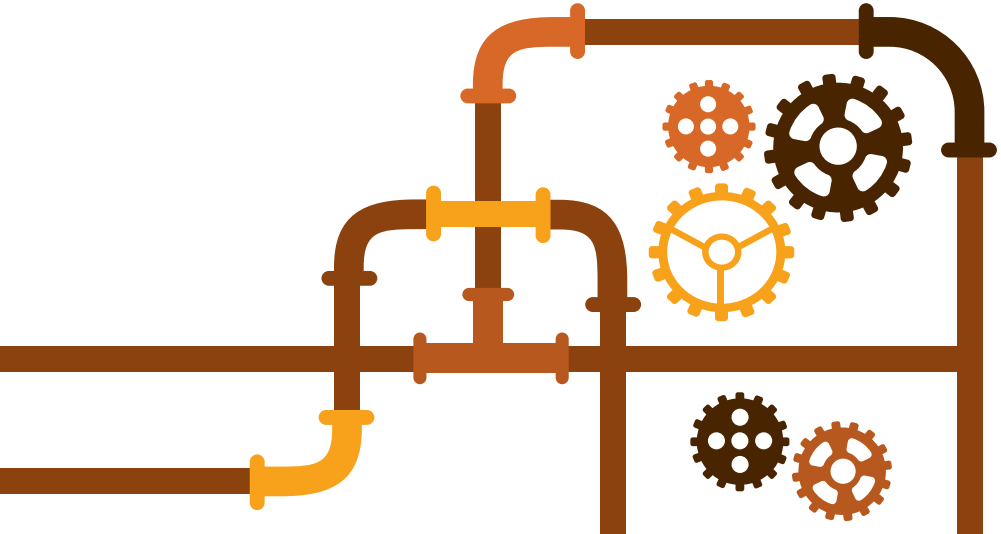


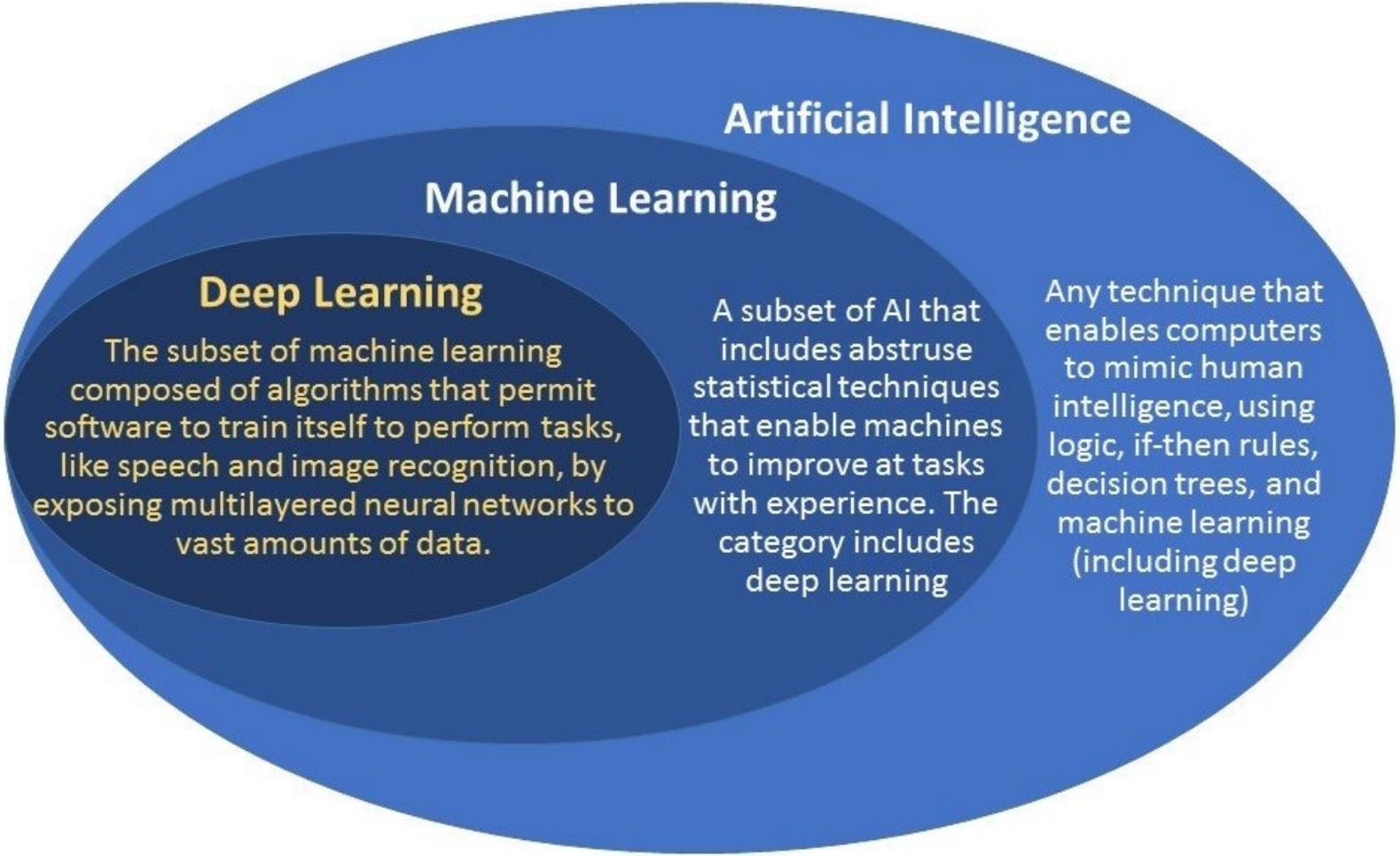
Intelligent Agents

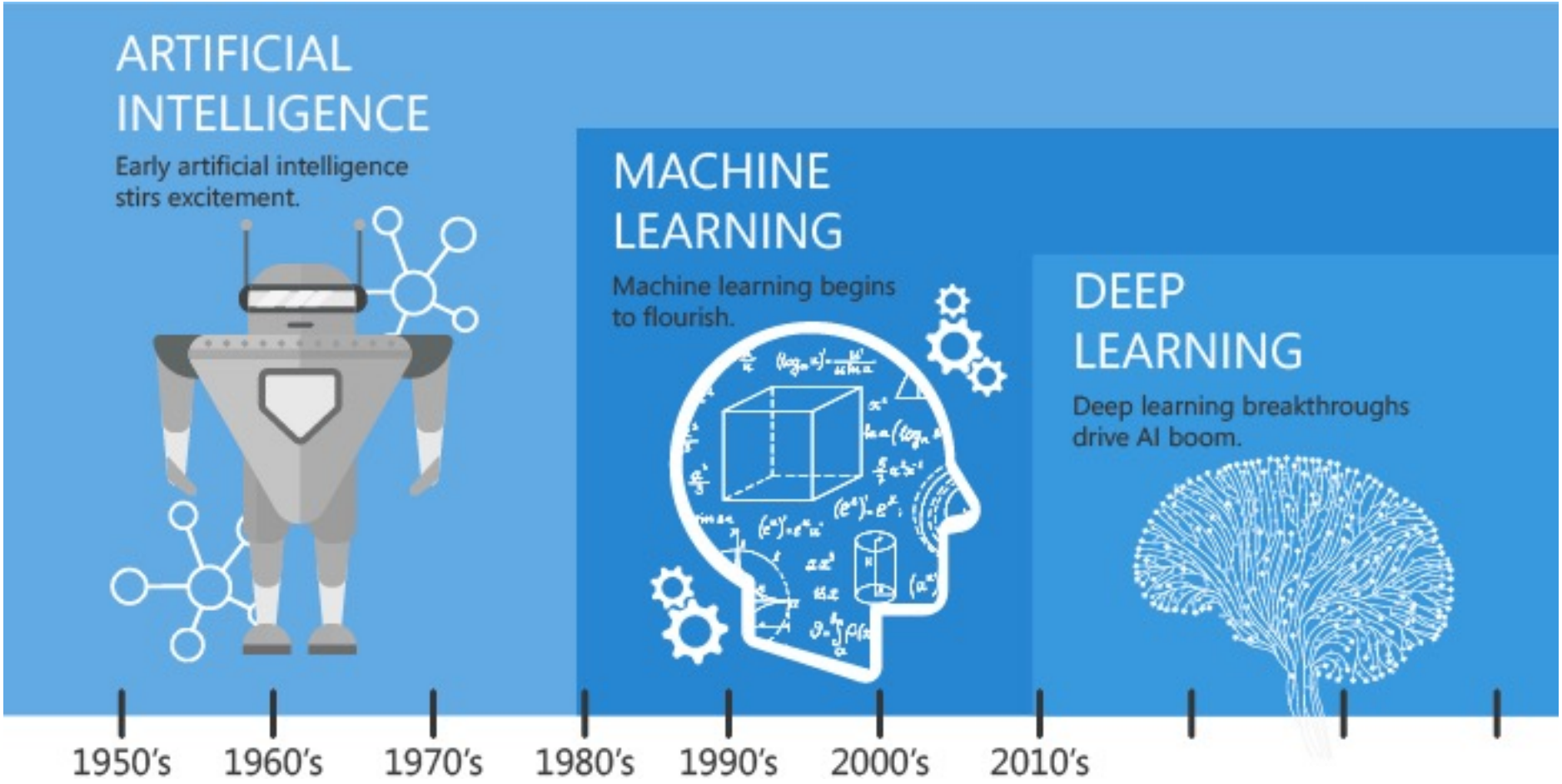


Environment	Observable	Deterministic	Episodic	Static	Discrete
	Do sensors give complete world state?	Can next state be determined by current state and action?	Does quality of an action depend only on current state?	Does the env. stay the same while the agent thinks?	Are the number of percepts and actions limited?
Chess (no clock)	Fully	Yes	No	Yes	Yes
Poker	Partially	No	No	Yes	Yes
Taxi Driving	Partially	No	No	No	No
Image analysis	Fully	Yes	Yes	Semi	No
Part-picking robot	Partially	No	Yes	No	No

What is AI?




Artificial Intelligence
Any technique that enables computers to mimic human intelligence, using logic, if-then rules, decision trees, and machine learning (including deep learning)
Machine Learning
A subset of AI that includes abstruse statistical techniques that enable machines to improve at tasks with experience. The category includes deep learning
Deep Learning
The subset of machine learning composed of algorithms that permit software to train itself to perform tasks, like speech and image recognition, by exposing multilayered neural networks to vast amounts of data.



https://towardsdatascience.com/artificial-intelligence-vs-machine-learning-vs-deep-learning-2210ba8cc4ac

Definitions of AI

Think like Humans "The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning..." – Bellman, 1978	**Think Rationally** "The study of mental faculties through the use of computational models" – Charniak and McDermott, 1985
Act like Humans "The art of creating machines that perform functions that require intelligence when performed by people." – Kurzweil, 1990	**Act Rationally** "A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes." – Schalkoff, 1990

Thought

Action

Defined in terms of Humans

Defined in terms of Logic

Syllabus

Course Topics

How can computers represent information for problem-solving? (Core)

- Search
- Reasoning and Planning
- Uncertainty
- Decision Making

How can computers learn new information? (Core)

- Reinforcement Learning
- Neural Nets
- Genetic Algorithms

How can computers interact with the real world? (Applied)

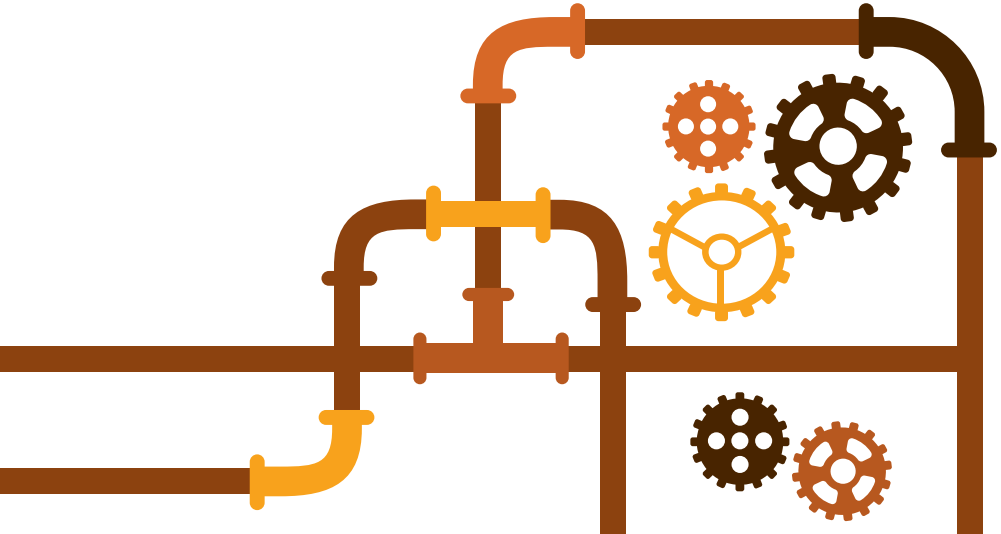
- Perception
- Robotics

How can computers interact with people? (Applied)

- Communication
- Human-Robot Interaction

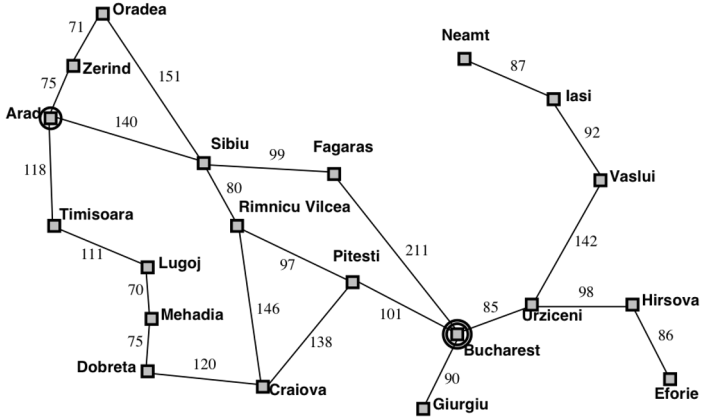
What is the Future of AI (Applied)
Ethics and Justice in AI (Applied)

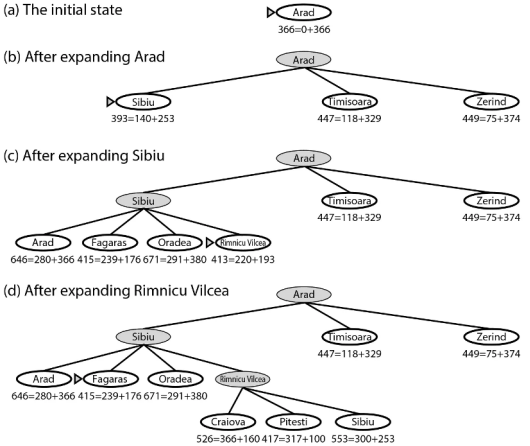
How can computers represent information for problem-solving?



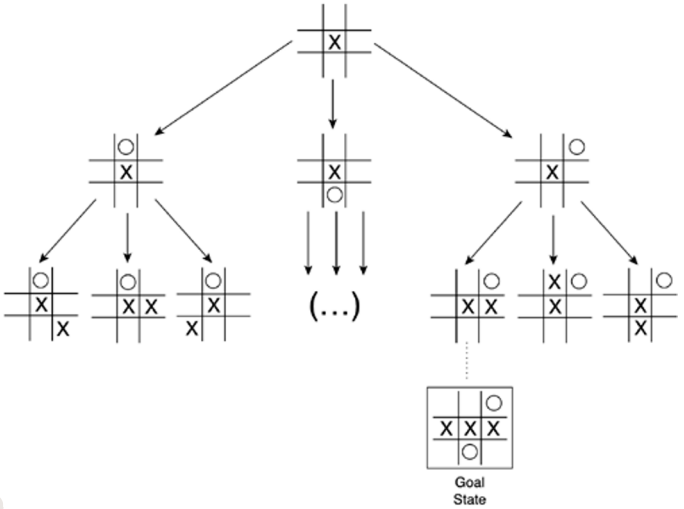
(Core)

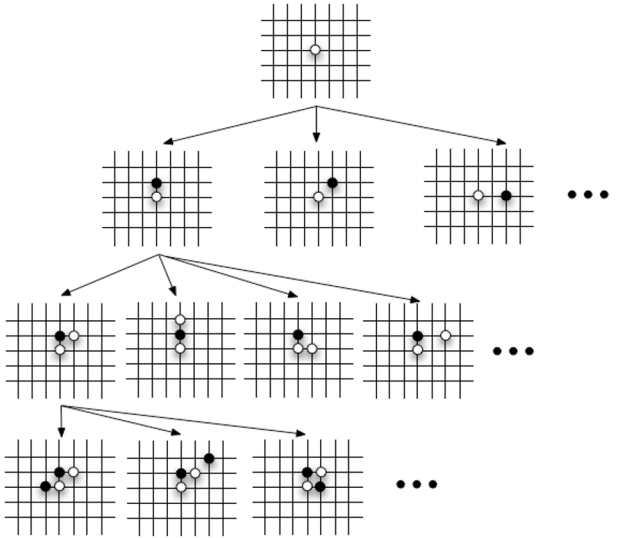
Search


Oradea
71
Zerind
75
151
Arad
140
Sibiu
99
Fagaras
118
80
Rimnicu Vilcea
Timisoara
111
Lugoj
97
Pitesti
211
70
Mehadia
146
101
75
138
Dobreta
120
Craiova
Bucharest
Neamt
87
Iasi
92
Vaslui
142
98
Urziceni
Hirsova
85
86
90
Giurgiu
Eforie

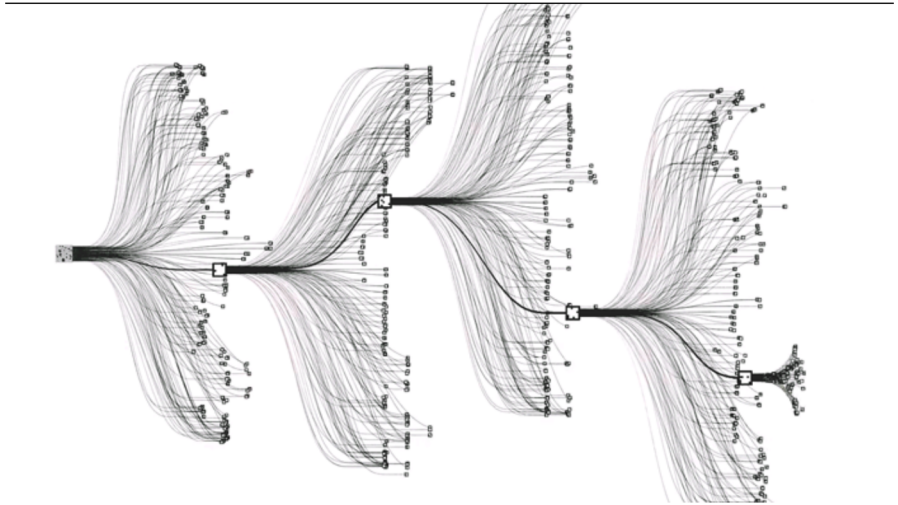

(a) The initial state
Arad
366=0+366
(b) After expanding Arad
Arad
Sibiu
Timisoara
Zerind
393=140+253
447=118+329
449=75+374
(c) After expanding Sibiu
Arad
Sibiu
Timisoara
Zerind
447=118+329
449=75+374
Arad
Fagaras
Oradea
Rimnicu Vilcea
646=280+366
415=239+176
671=291+380
413=220+193
(d) After expanding Rimnicu Vilcea
Arad
Sibiu
Timisoara
Zerind
447=118+329
449=75+374
Arad
Fagaras
Oradea
Rimnicu Vilcea
646=280+366
415=239+176
671=291+380
Craiova
Pitesti
Sibiu
526=366+160
417=317+100
553=300+253

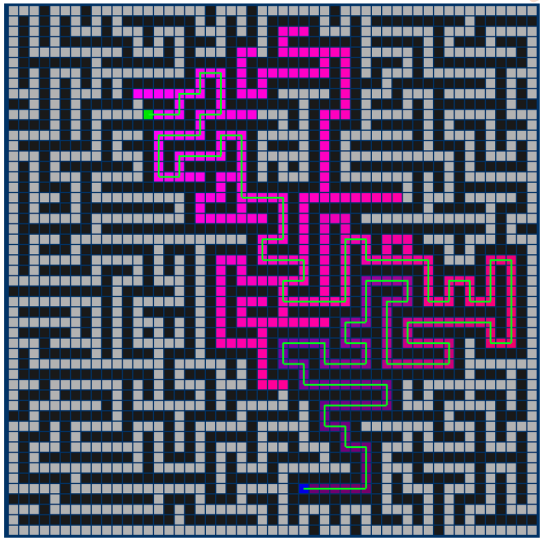
Search and Game Playing



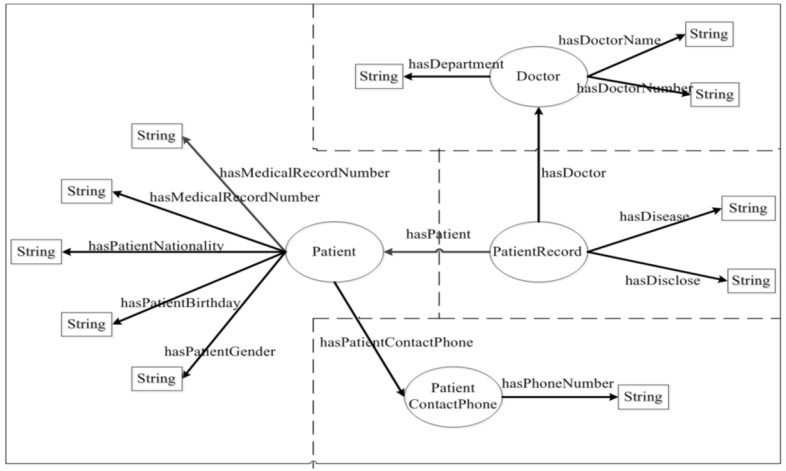


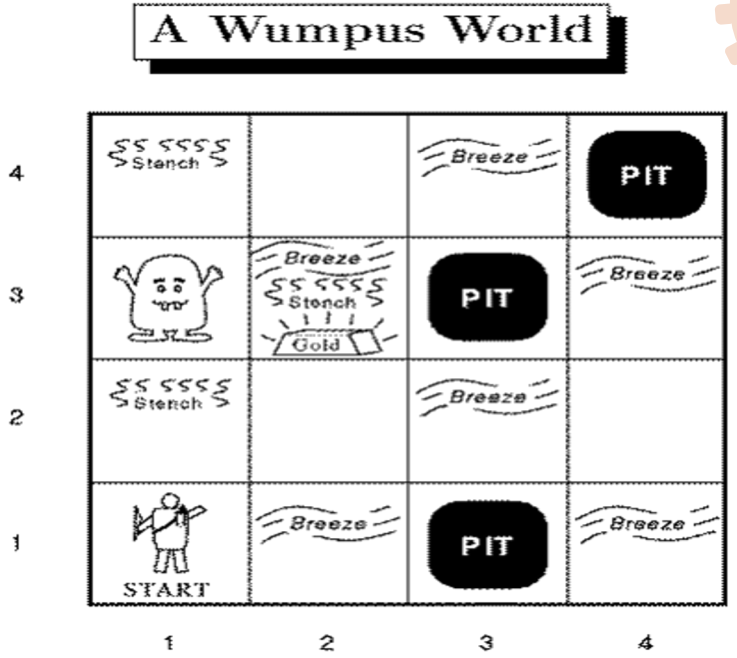
Heuristic Approaches For Search





Knowledge Representation





First-Order Logic

Existential and Universal Quantifiers

"Fifi is a pink poodle"

$$\text{Pink}(\text{Fifi}) \wedge \text{Poodle}(\text{Fifi})$$

"Fifi is the only pink poodle"

i.e. "Fifi is a pink poodle & every pink poodle is identical to Fifi"

$$\text{Pink}(\text{Fifi}) \wedge \text{Poodle}(\text{Fifi}) \wedge \forall x.(\text{Pink}(x) \wedge \text{Poodle}(x)) \Rightarrow x=\text{Fifi}$$

"No-one likes Fifi"

i.e. "for every person x, it is not the case that x likes Fifi"

$$\forall x.\text{Person}(x) \Rightarrow \neg\text{Likes}(x, \text{Fifi})$$

"If x eats y then y is inside x right afterwards"

$$\forall x \forall y \forall e.\text{Eat}(x,y,e) \Rightarrow \text{Inside}(y,x,\text{Result-state}(e))$$

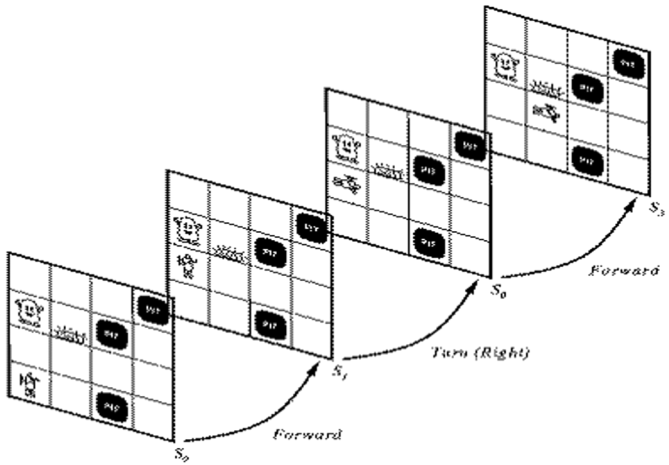
$$\forall x \forall y \forall e \forall e'.\text{Eat}(x,y,e) \wedge \text{Rightafter}(e,e') \Rightarrow \text{Inside}(y,x,e')$$

Situation Calculus

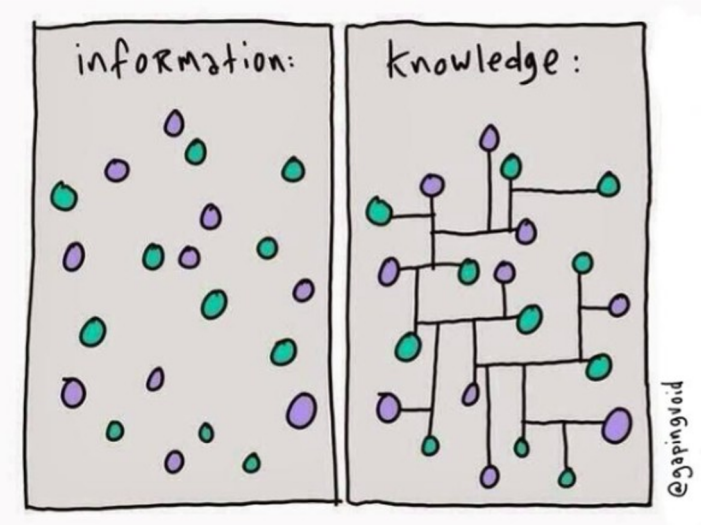
$\text{At}(\text{Agent},[1,1],S_0) \wedge \text{At}(\text{Agent},[1,2],S_1)$

Changes from one situation to the next

$\text{Result}(\text{Forward}, S_0) \Rightarrow S_1$

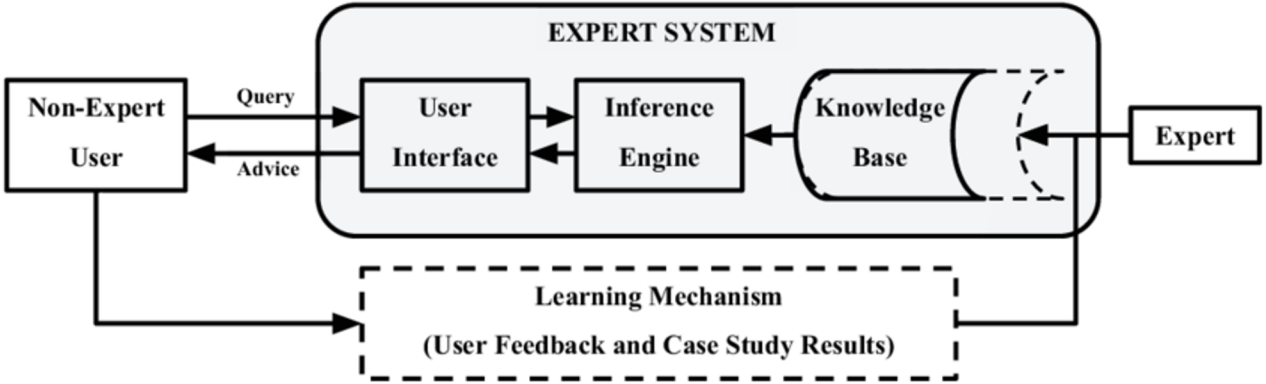


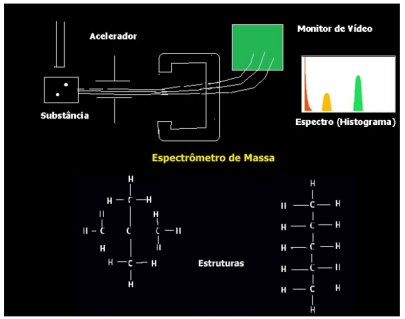
Building a Knowledge Base



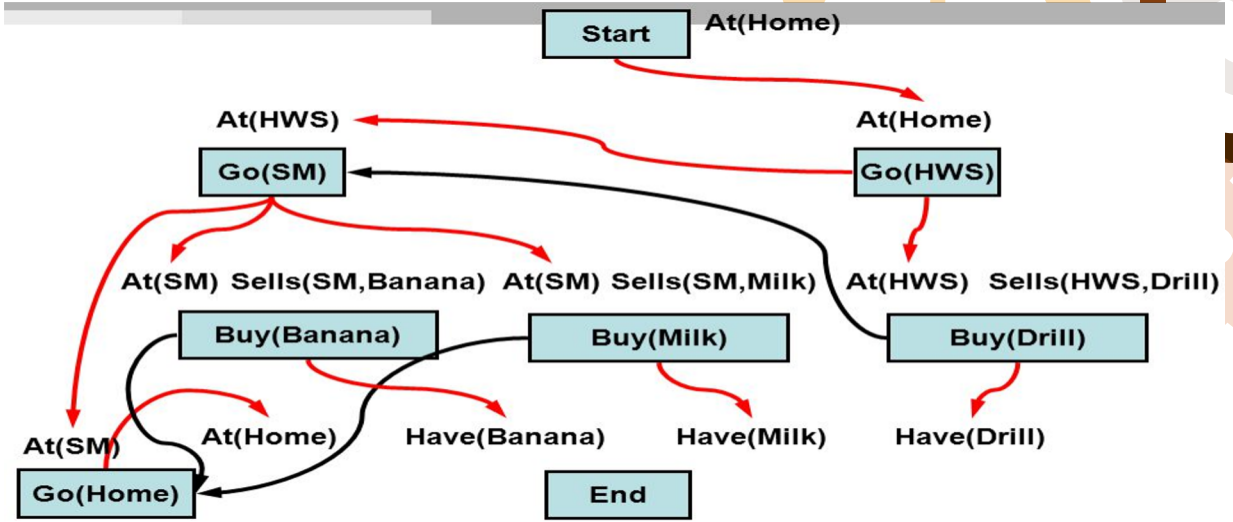
For a given topic:
Vocabulary of predicates, functions, and constants ⇒ Ontology
Encode general knowledge within the domain ⇒ limiting errors
Encode a description of the specific problem
Pose queries and get answers

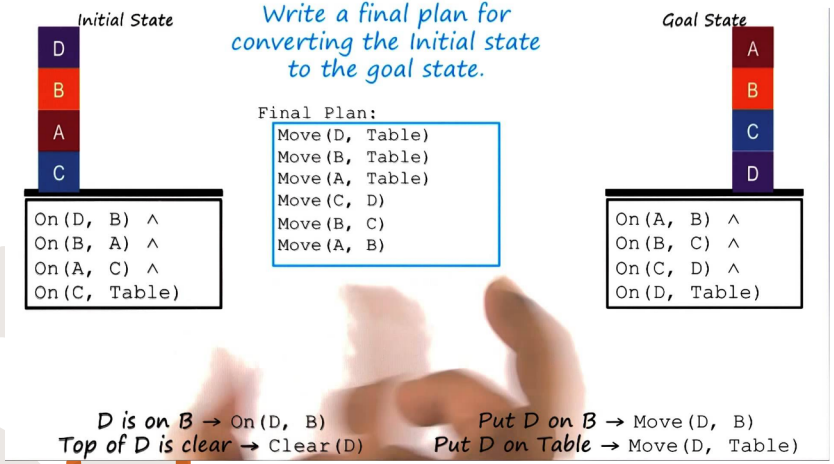
Expert Systems



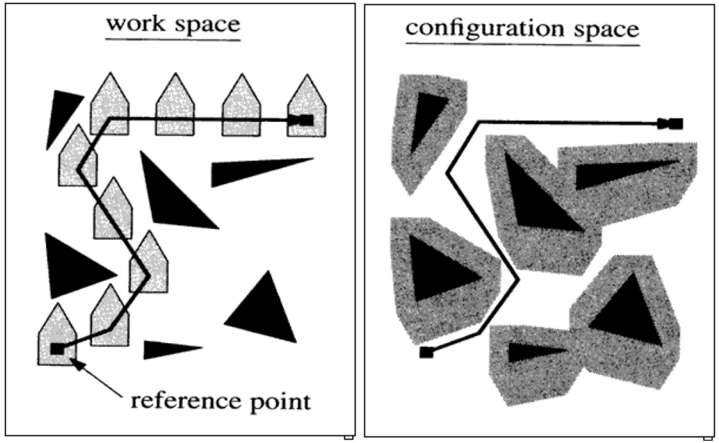


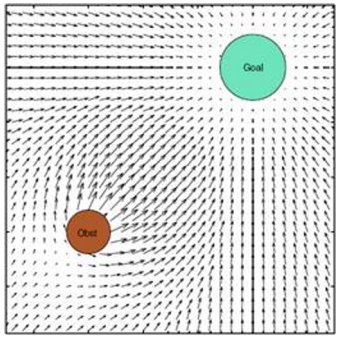
Planning

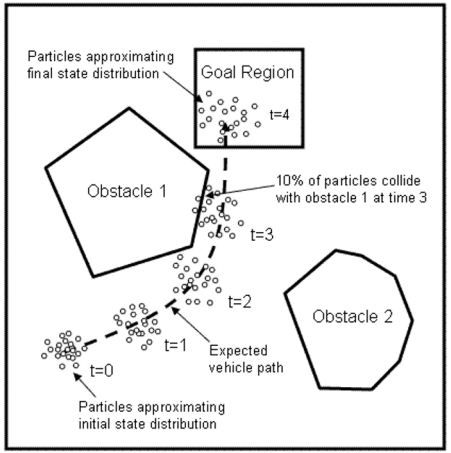

Start
At(Home)
At(HWS)
At(Home)
Go(SM)
Go(HWS)
At(SM)
Sells(SM,Banana)
At(SM)
Sells(SM,Milk)
At(HWS)
Sells(HWS,Drill)
Buy(Banana)
Buy(Milk)
Buy(Drill)
At(SM)
At(Home)
Have(Banana)
Have(Milk)
Have(Drill)
Go(Home)
End

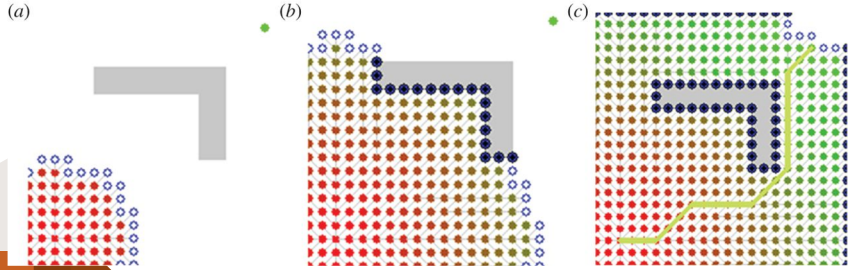

Initial State
D
B
A
C
On(D, B) ∧
On(B, A) ∧
On(A, C) ∧
On(C, Table)
Write a final plan for converting the Initial state to the goal state.
Final Plan:
Move(D, Table)
Move(B, Table)
Move(A, Table)
Move(C, D)
Move(B, C)
Move(A, B)
Goal State
A
B
C
D
On(A, B) ∧
On(B, C) ∧
On(C, D) ∧
On(D, Table)
D is on B → On(D, B)
Top of D is clear → Clear(D)
Put D on B → Move(D, B)
Put D on Table → Move(D, Table)

Planning in the Real World: Robot path planning

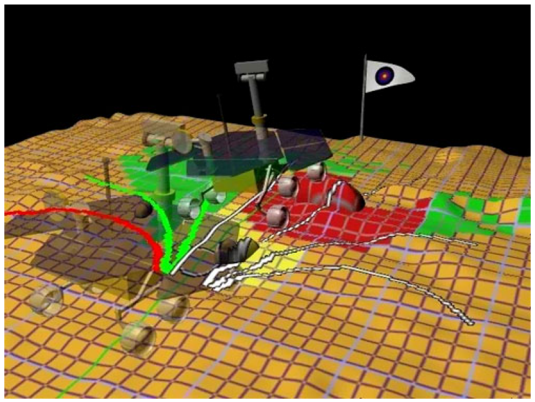


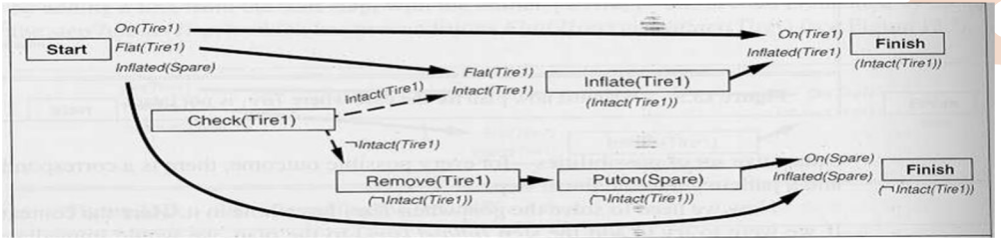


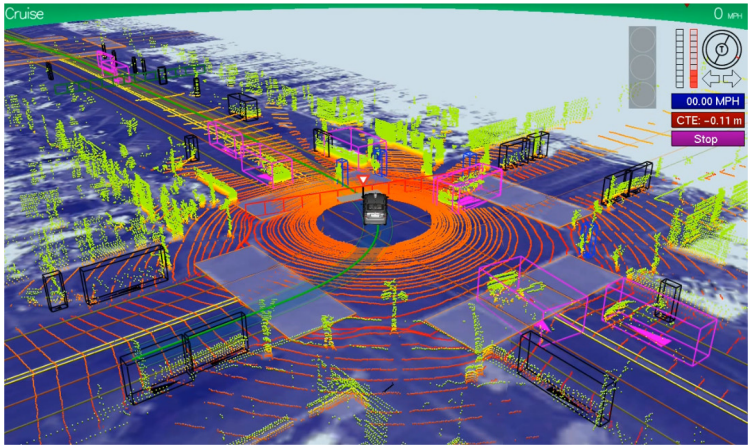




Planning in Real-World Systems



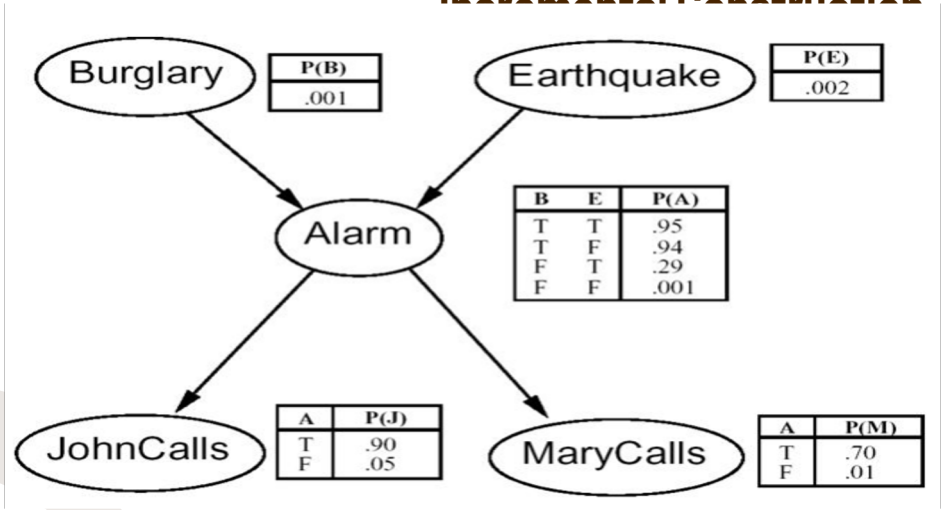


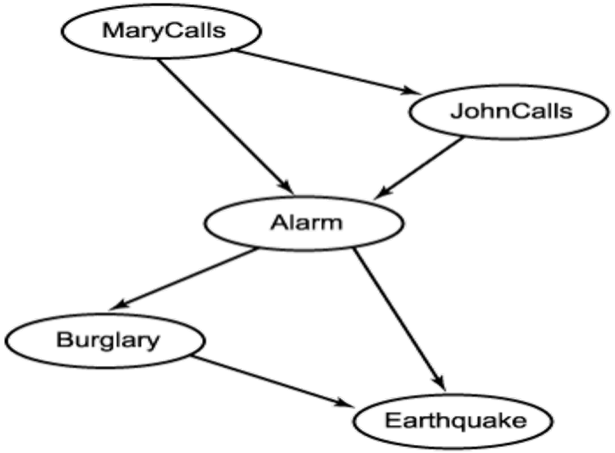


Uncertainty and Decision-Making

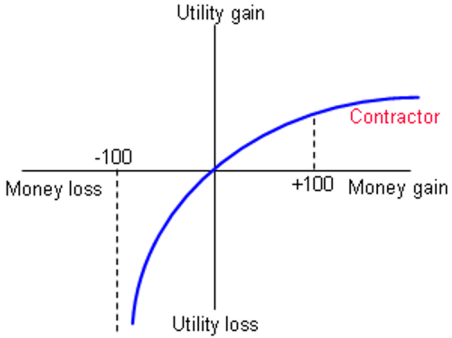
Belief Networks

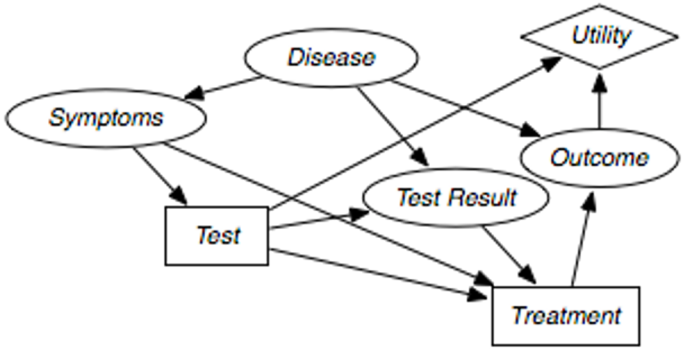
Incremental Construction





Utility Theory and Decision Theory





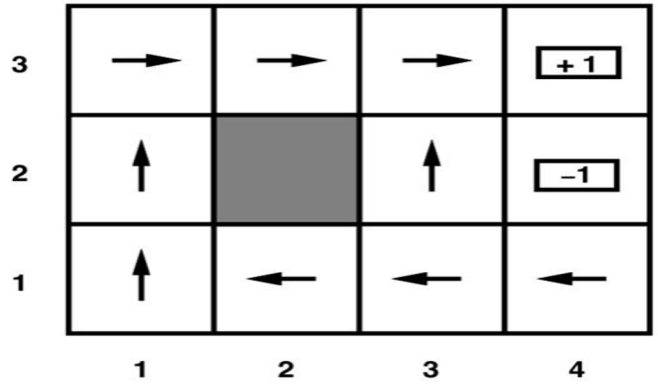
Risk Assessment

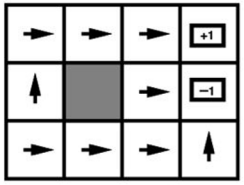
- QALY: quality-adjusted life year (year in good health)
- Micromort: a one in 1,000,000 chance of death
    - worth about $20 in 1980 dollars ~$50 today

Decision Theory

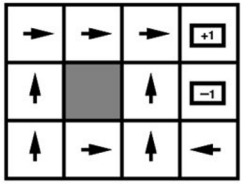
Grid world

- Optimal policies for other values of R(s):

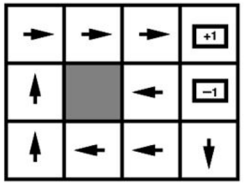




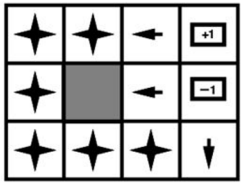
$R(s) < -1.6284$



$-0.4278 < R(s) < -0.0850$

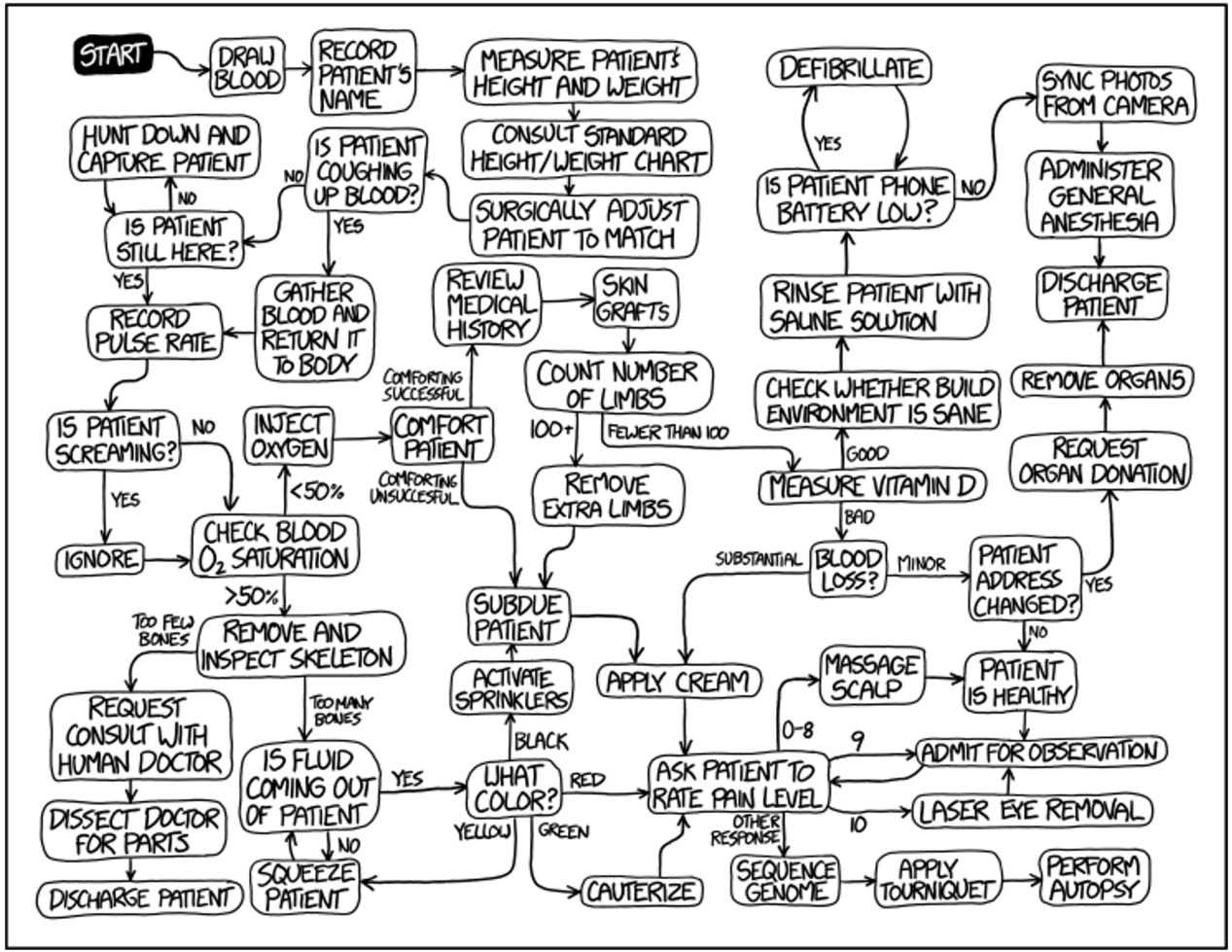


$-0.0221 < R(s) < 0$

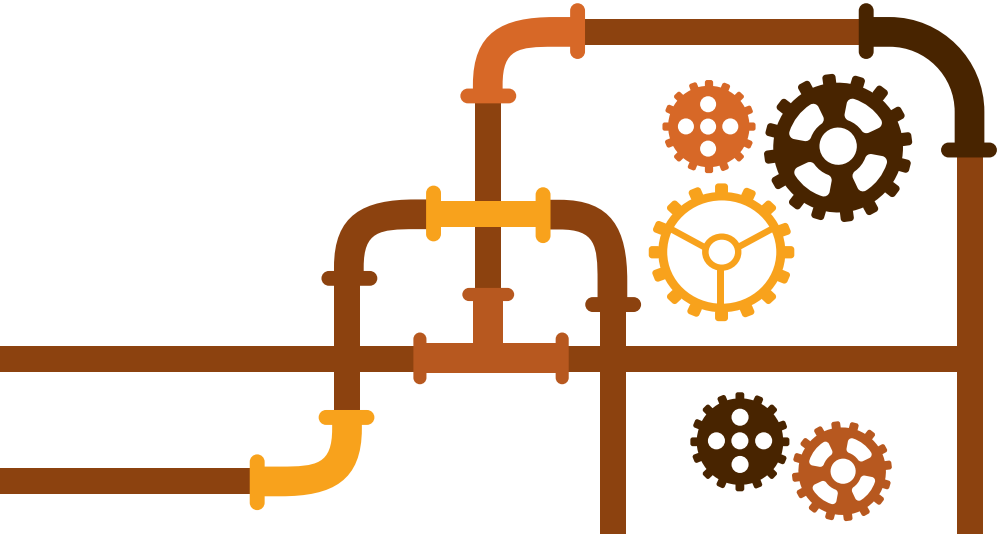


$R(s) > 0$

A GUIDE TO THE MEDICAL DIAGNOSTIC AND TREATMENT ALGORITHM USED BY IBM'S WATSON COMPUTER SYSTEM



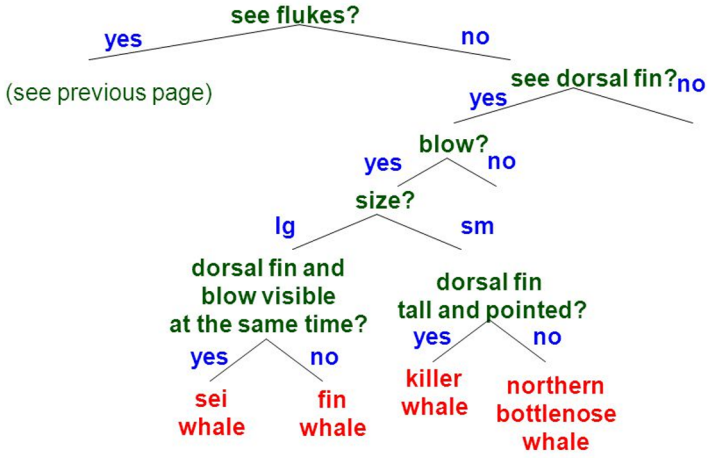
How can computers learn new information?

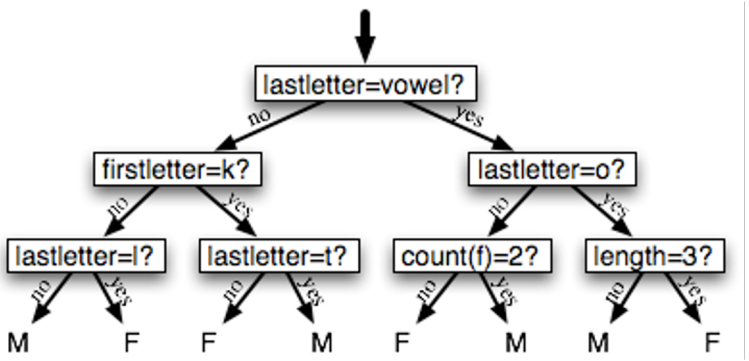


(Core)

Learning from Observations

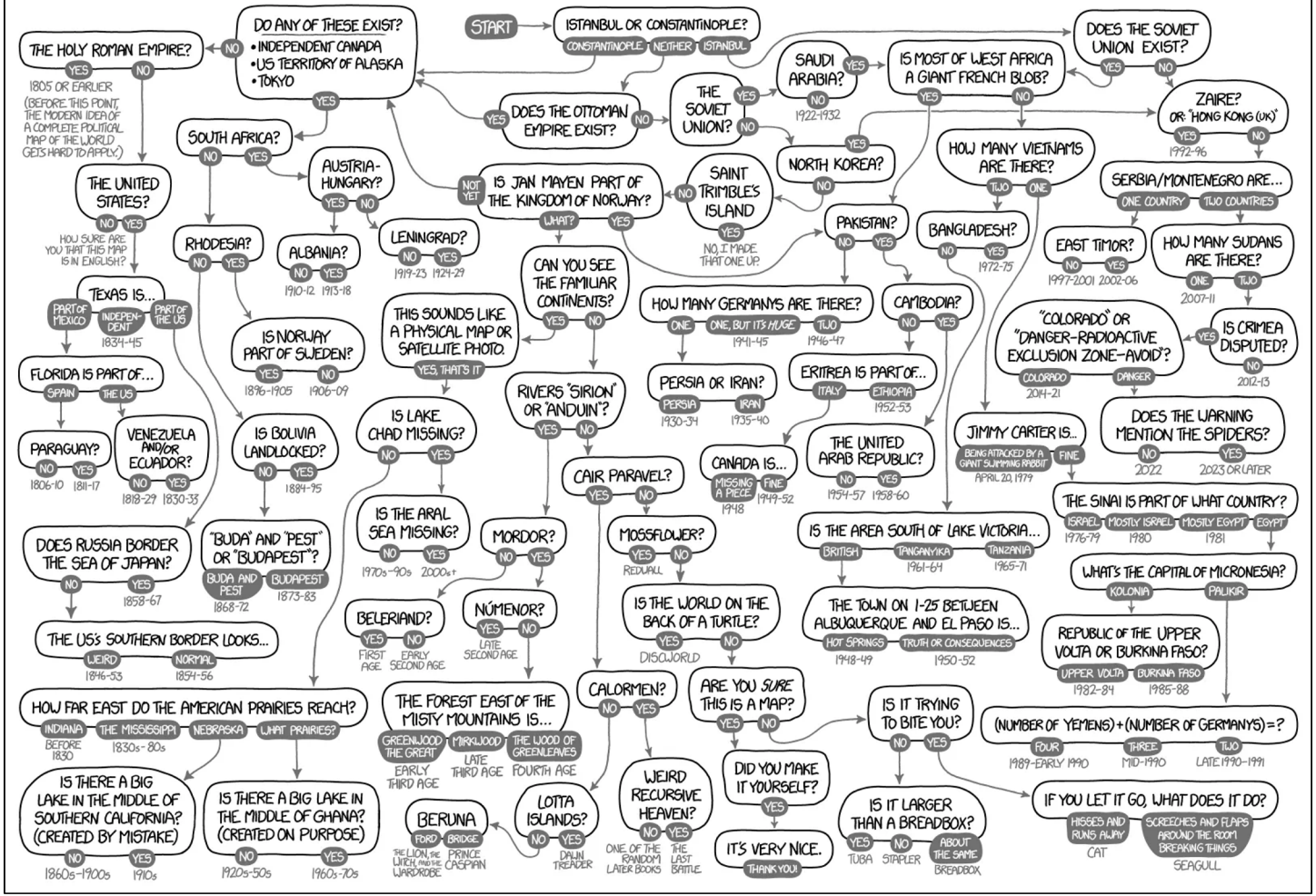
Reverse engineered decision tree of the whale watcher expert system (cont'd)



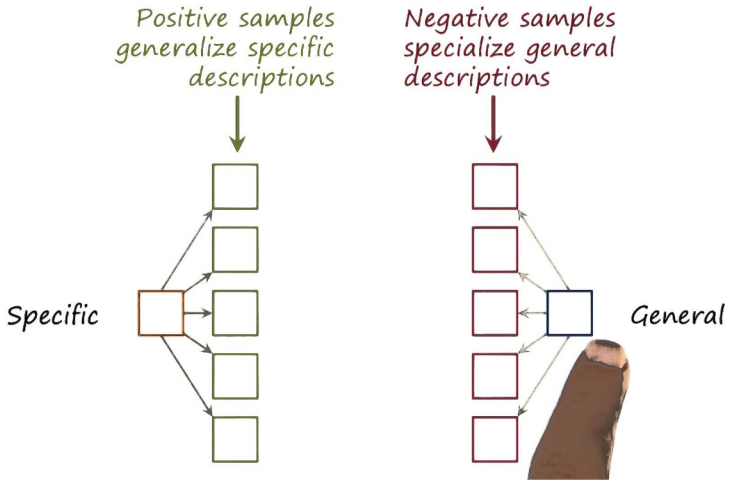


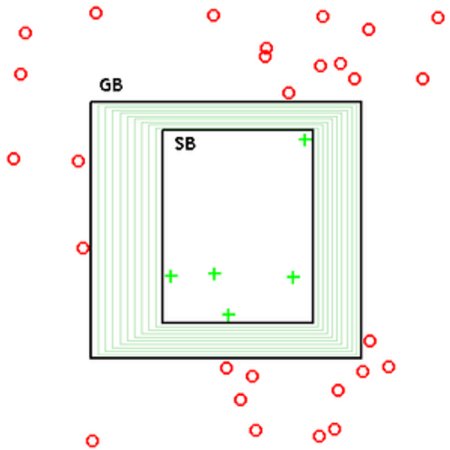
GUIDE TO FIGURING OUT THE AGE OF AN UNDATED WORLD MAP

(ASSUMING IT'S COMPLETE, LABELED IN ENGLISH, AND DETAILED ENOUGH)

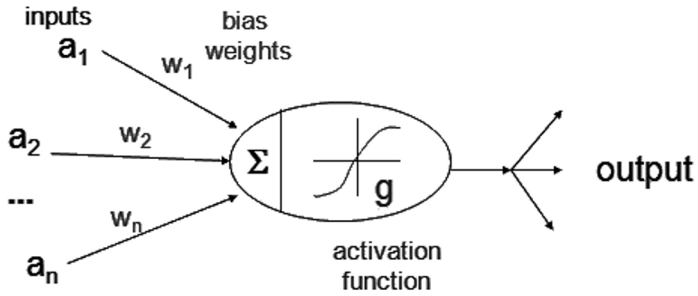


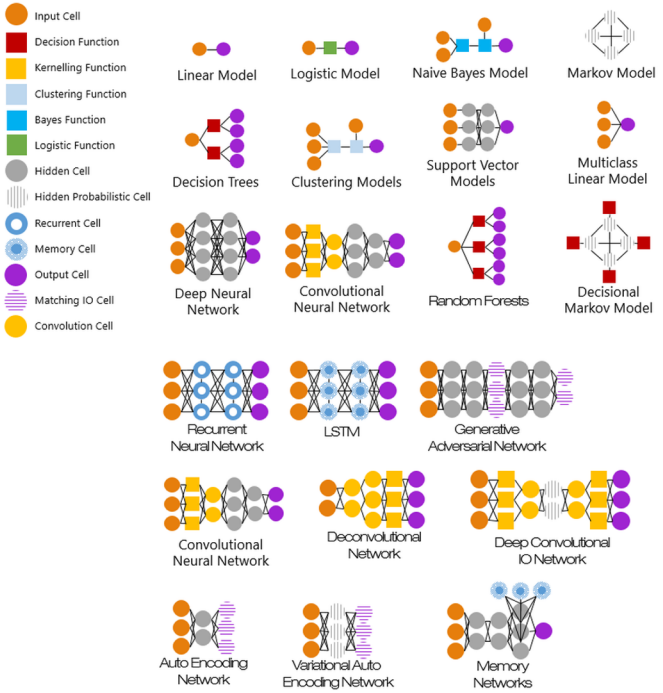
Learning Using Version Spaces



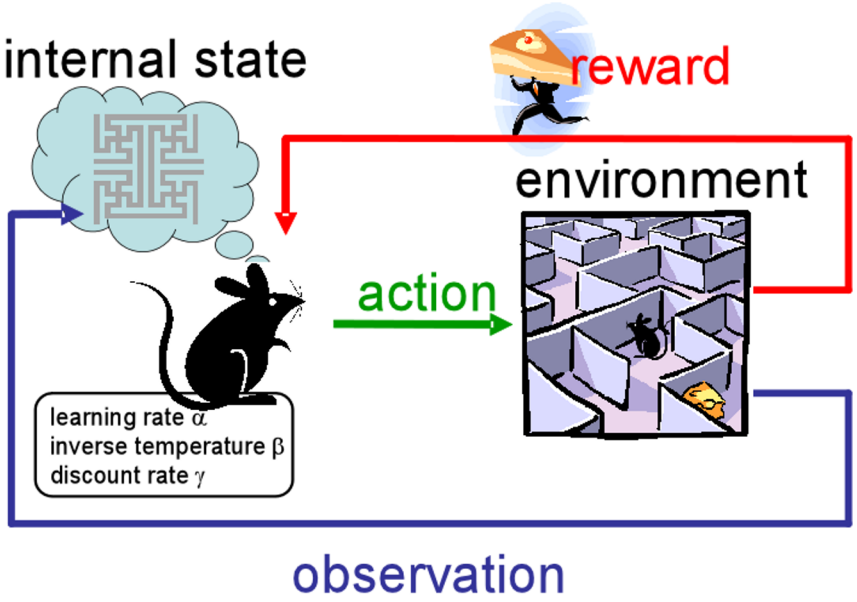


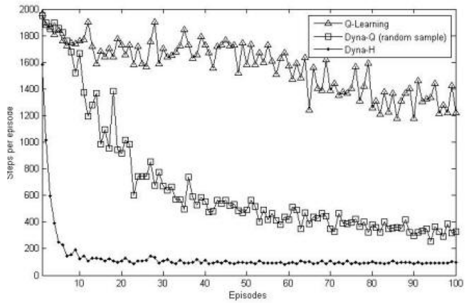
Learning Using Neural Networks



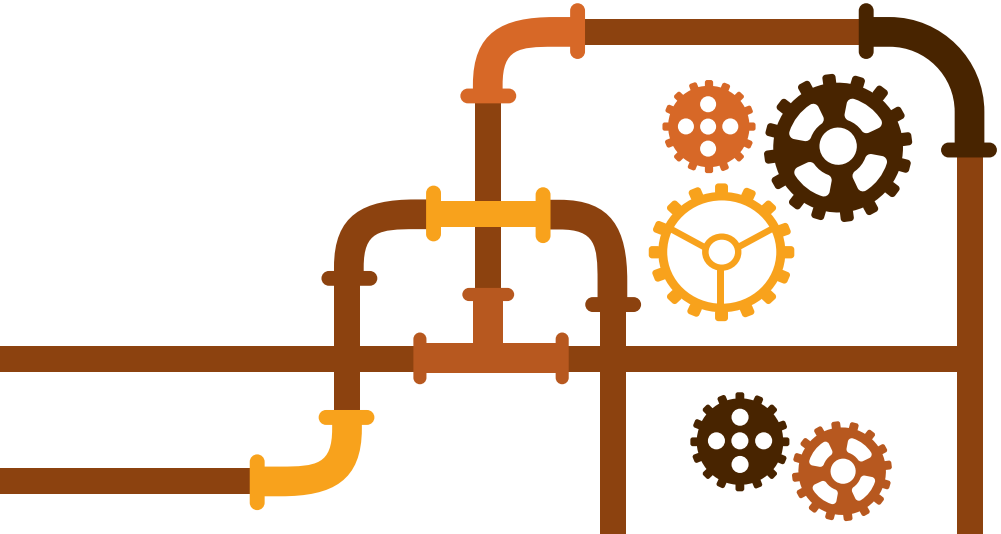


Reinforcement Learning





How can computers interact with the real world?



(Applied)

Perception

A. Sobel kernel

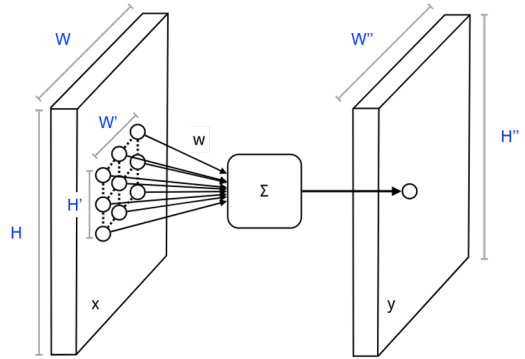
B: Gaussian kernel (5x5)

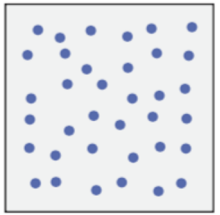
C. Gaussian kernel (12x12)

D. Mean value kernel (5x5)

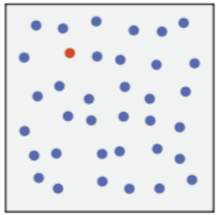
E. Emboss kernel

F. Motion Blur kernel

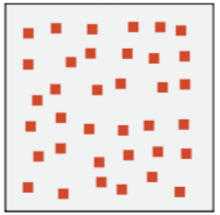




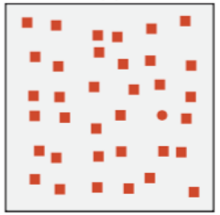
(a)



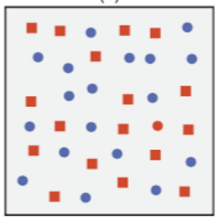
(b)



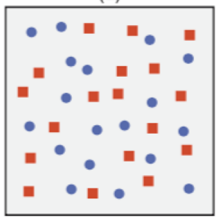
(c)



(d)

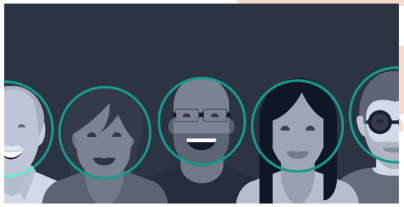


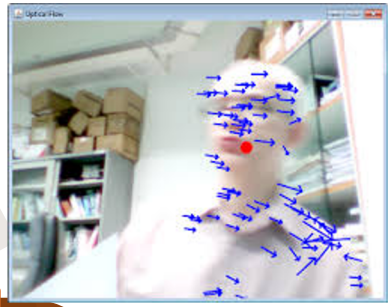
(e)



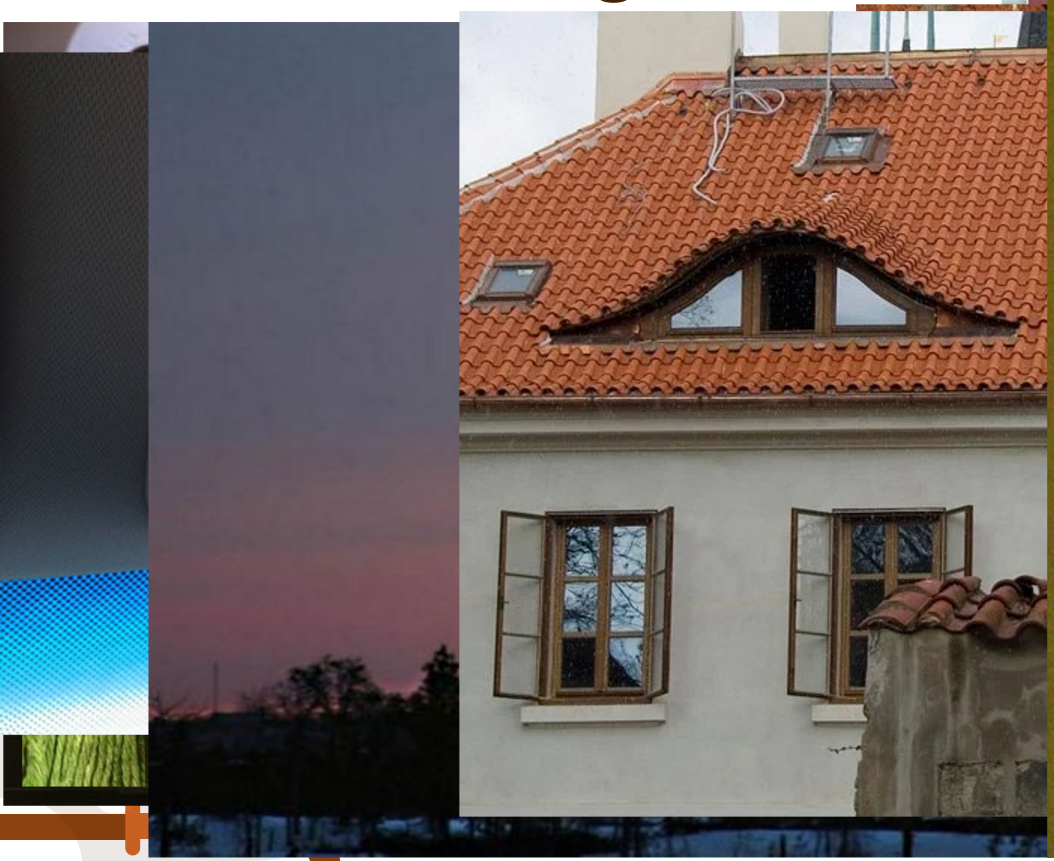
(f)

Higher-Level Perception

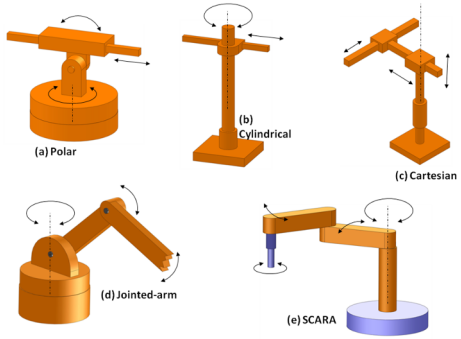


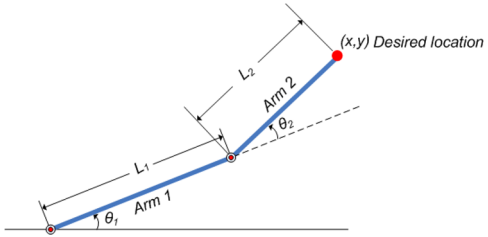


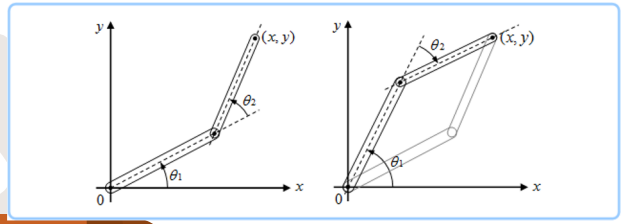
Faces in things



Robotics: Kinematics





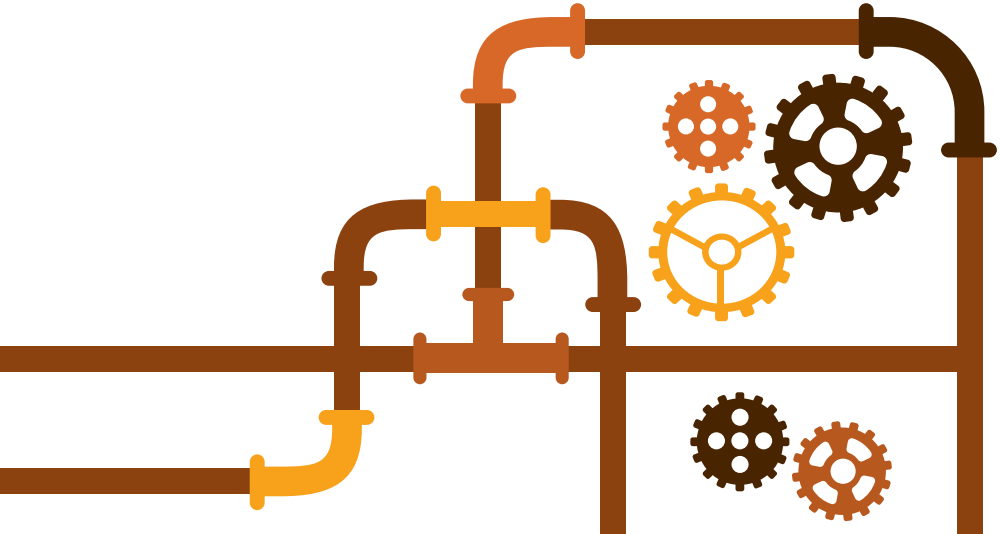


Basic Joint Types

Forward Kinematics

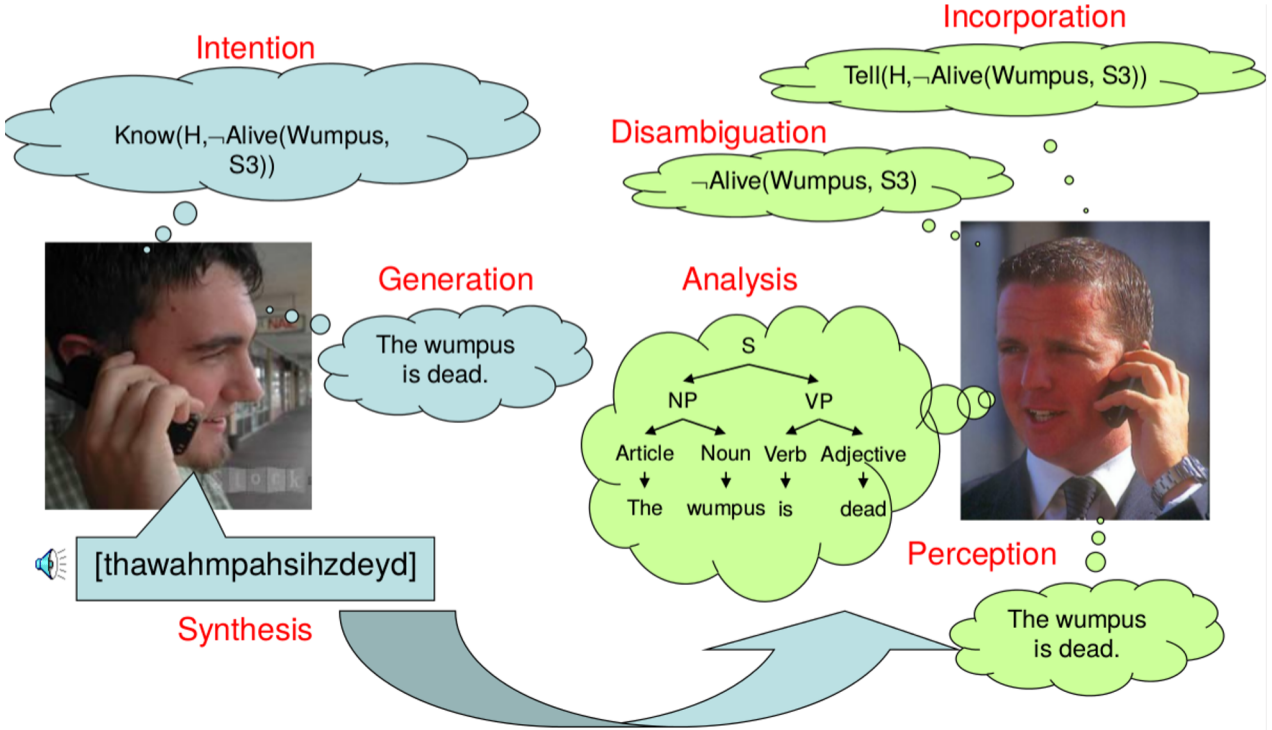
Inverse Kinematics

How can computers interact with people?

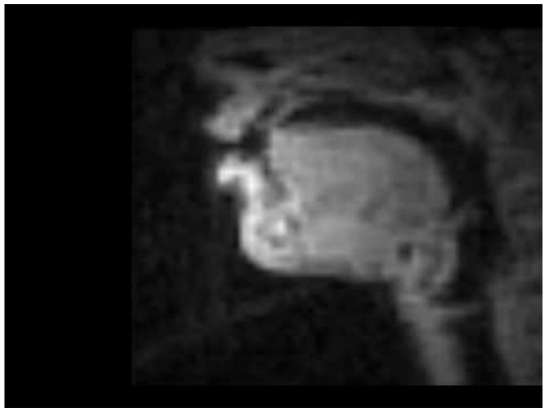


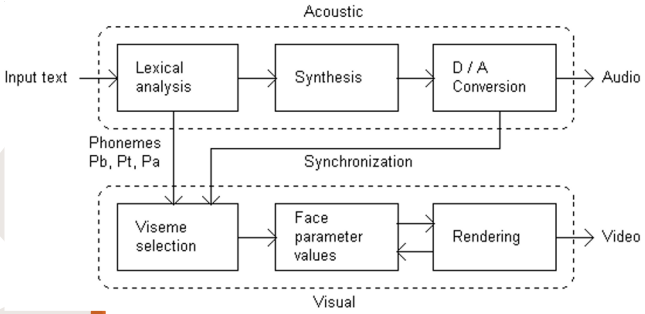
(Applied)

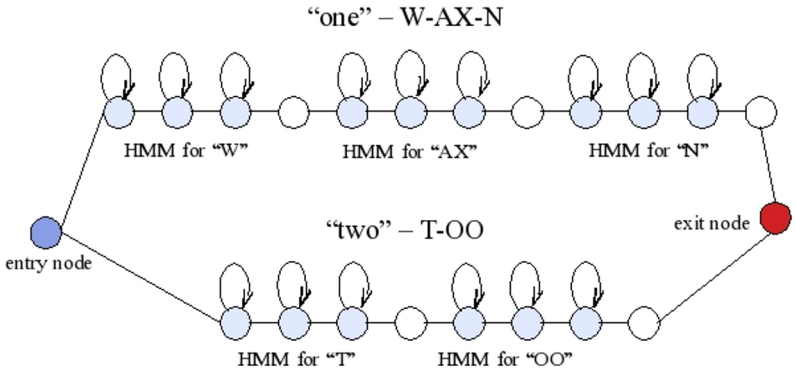
Communication: Grammars, Syntax, and Semantics



Communication







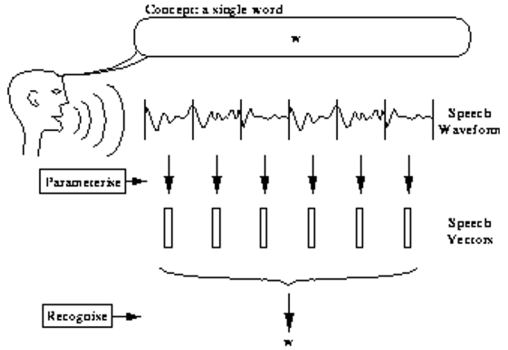
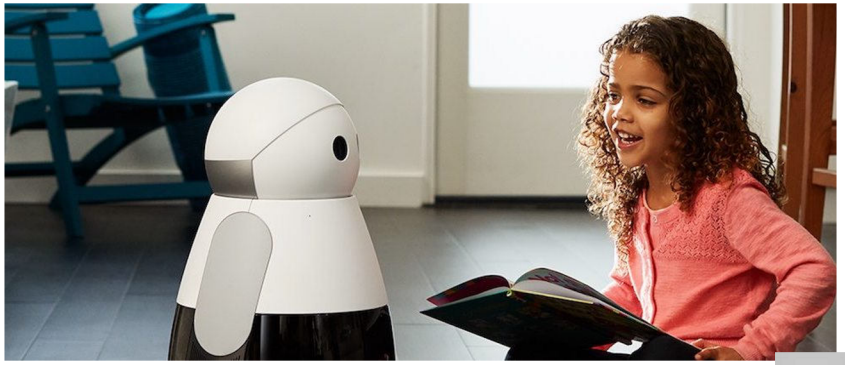
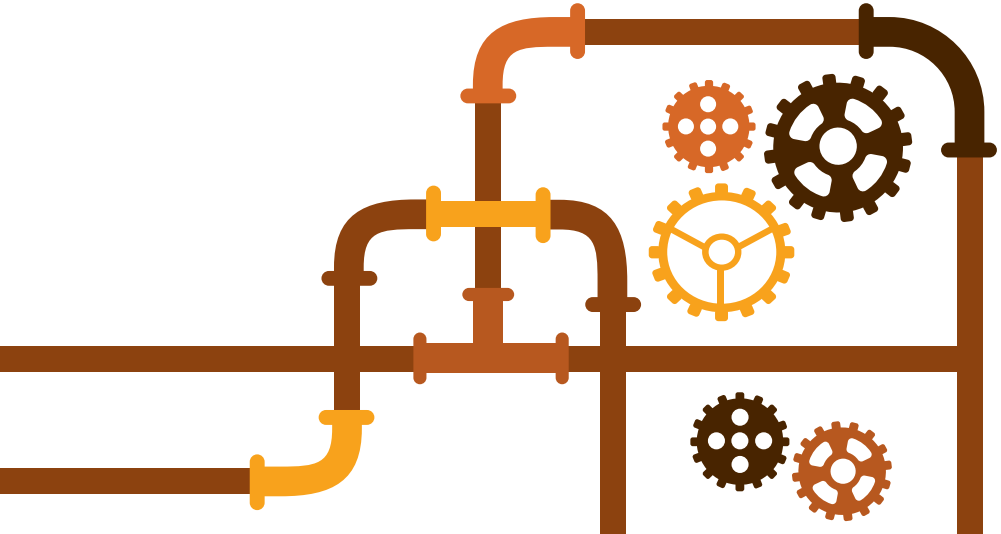


Fig. 1.2 Isolated Word Problem

Social Robotics and HRI

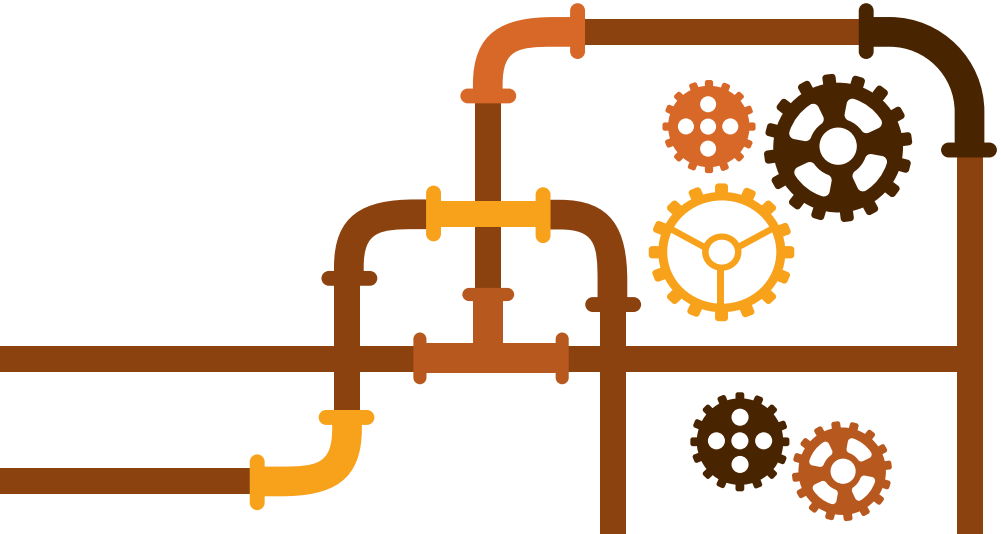


What is the Future of AI?



(Continuing Thread)

Ethics and Justice in AI



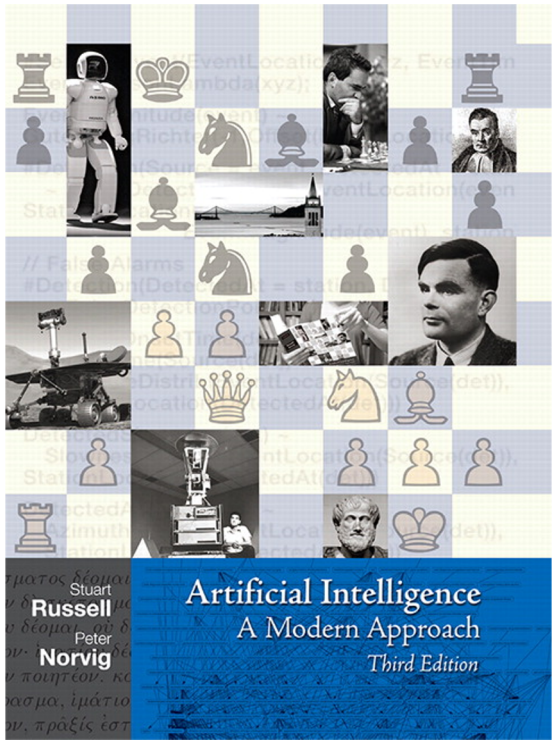
(Continuing Thread)

Course Mechanics

Mechanics

- Text
- Grading
- Problems
- Collaboration Policy
- Attendance Policy
- Web page
- Contact Info

Required Text



A standard (and comprehensive) text
!!! 3rd edition !!!
Required reading: 50-75 pages/week
Online version is available

Grading

- Grading distribution is as follows:
  - Midterm : 20%
  - Final : 30% (undergrad) or 20% (grad)
  - Pop Quizzes: 30%
  - Problem Sets / Projects: 30%
- Subject to change
- Exam dates will be set in advance and only athletic, medical (with Dr's note), and conference presentations will be acceptable reasons to make up a missed midterm

Collaboration Policy

- HW assignments (and exams) are your individual responsibility, plagiarism **will not be tolerated**
- You are encouraged to discuss assignments with TA, or with other students
- However, every assignment that is turned in has to be your work that you have done **on your own**
- You will not copy, nor will you allow your work to be copied

Attendance Policy

- Attendance is critical to success in this course
- Lectures **will** contain material that is not covered by text/lecture slides
- You are responsible for **all** material presented in lectures, assignment reading, and project assignments

Web page/Syllabus

- up on webcampus/ more details to follow