ARTIFICIAL INTELLIGENCE

KNOWLEDGE REPRESENTATION

GOAL FOR TODAY

- Quality of the work to be submitted
- How will this online course look like?
- Knowledge representation
- Reasoning
- Propositional logic

COURSE DESCRIPTION

One-hour synchronous communication, readings, discussions, and evaluation

Lesson 1. Introduction

Lesson 2. Knowledge representation; Reasoning; Propositional Logic

Lesson 3. Predicate Logic

Lessons 4-5 Search Strategies; Prolog (I and II)

Lesson 6. Expert Systems

Lesson 7. Natural Language Processing

Lesson 8-9. Learning; Machine Learning; Python; Deep Learning (I and II)

Lesson 10. Catch-up; Presentations

Tentative ! Done by June 19nd

- Regular readings and discussions in Slack (10%)
  - Individual
- Homeworks (30%)
  - Course notes
  - Exercises – Propositional logic / Predicate logic / Prolog / Grammars
  - To be provided in a shareable file
  - Individual
- (Directed) Labs and project (Python) (40%)
  - Deep learning example
    - To be explained in a 2-minute video
    - Individual
  - Project
    - To be presented (5 minutes per team)
    - Team of 2-3 students
- Exam (20%)
  - Quiz (only)

LESSON 11 – KNOWLEDGE REPRESENTATION

WHAT IS KNOWLEDGE?

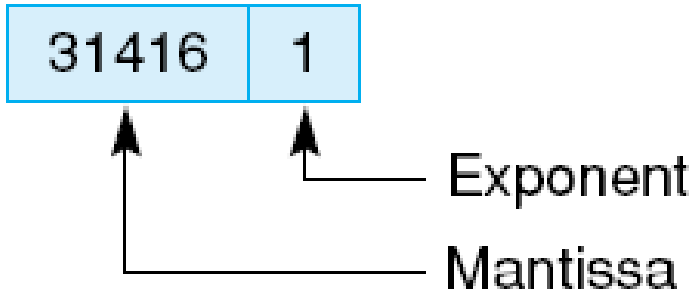
- Knowledge is crucial in intelligence – to make decision, to understand language, to recognize objects, to interpret situations etc.
- Humans store lots of knowledge and interconnection pieces in their brains. We have a huge amount of knowledge
- Declarative knowledge – facts (e.g., I live in Thies)
- Procedural knowledge – how-to do things (e.g., how to go to Thies from where I am)
- Domain knowledge – (e.g., transportation, health, biology)
- Domain-independent knowledge – (e.g., A bus is a vehicle)
- General or common-sense knowledge – acquired and considered known by humans (e.g., children are younger than their parents, people rarely reach 100 years, 1+1=2)

HOW TO REPRESENT KNOWLEDGE ? EXAMPLE OF DIFFERENT REPRESENTATIONS OF A NUMBER

The real number: π

The decimal equivalent: 3.1415927 . . .

The floating point representation:



The representation in computer memory: 11100010

KNOWLEDGE REPRESENTATION

- We need to represent knowledge in a form accurate from the human source and understandable by computers
- The chosen representation is an important factor in influencing how the problem will be solved
- Knowledge does not exist in isolation; elements are related to each others
  - Eliza could not answer questions efficiently because it is not understand context
- Knowledge representation schemes
  - Logical representation – Declarative; Expressions in formal logic represent knowledge (e.g., parent(john, paul))
  - Procedural representation – Set of instructions to solve a problem; Facts, rules to apply, (if then), and methods to apply
  - Network representation – Knowledge is captured as a graph where nodes are objects or concepts, and edges are relationships or associations
  - Structured representation – Complex structures
    - Frames to represent information about an object (Minsky 1975)
    - Scripts to represent events (Schank, & Alberson 1977)
- Important questions: Correctness, completeness, consistency, and changes of knowledge

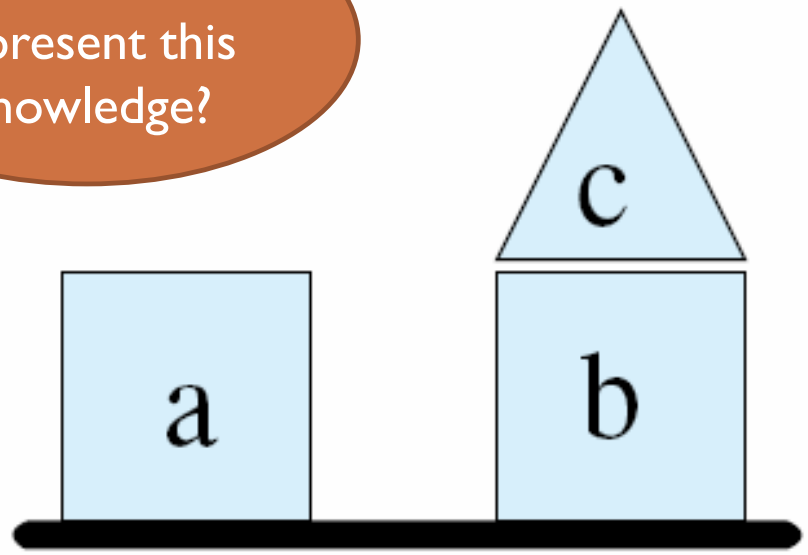
METRICS TO ASSESS KNOWLEDGE REPRESENTATION SCHEMES

- Expressiveness – Represent different types and granularities of knowledge (clear and understandable)
- Effectiveness – Provide a way to infer new knowledge from old one
- Efficiency – Efficiently gather knowledge and infer new knowledge from old one
- Explanation – Provide an explanation of how knowledge is inferred and allow justifications of its reasoning

- Symbolic AI is more expressive and explanatory than non-symbolic AI
- Non-symbolic AI is more efficient than symbolic AI

EXAMPLES OF LOGICAL REPRESENTATION OF KNOWLEDGE

How to represent this knowledge?



ontable(a)

ontable(b)

on(c,b)

triangle(c)

square(a)

square(b)

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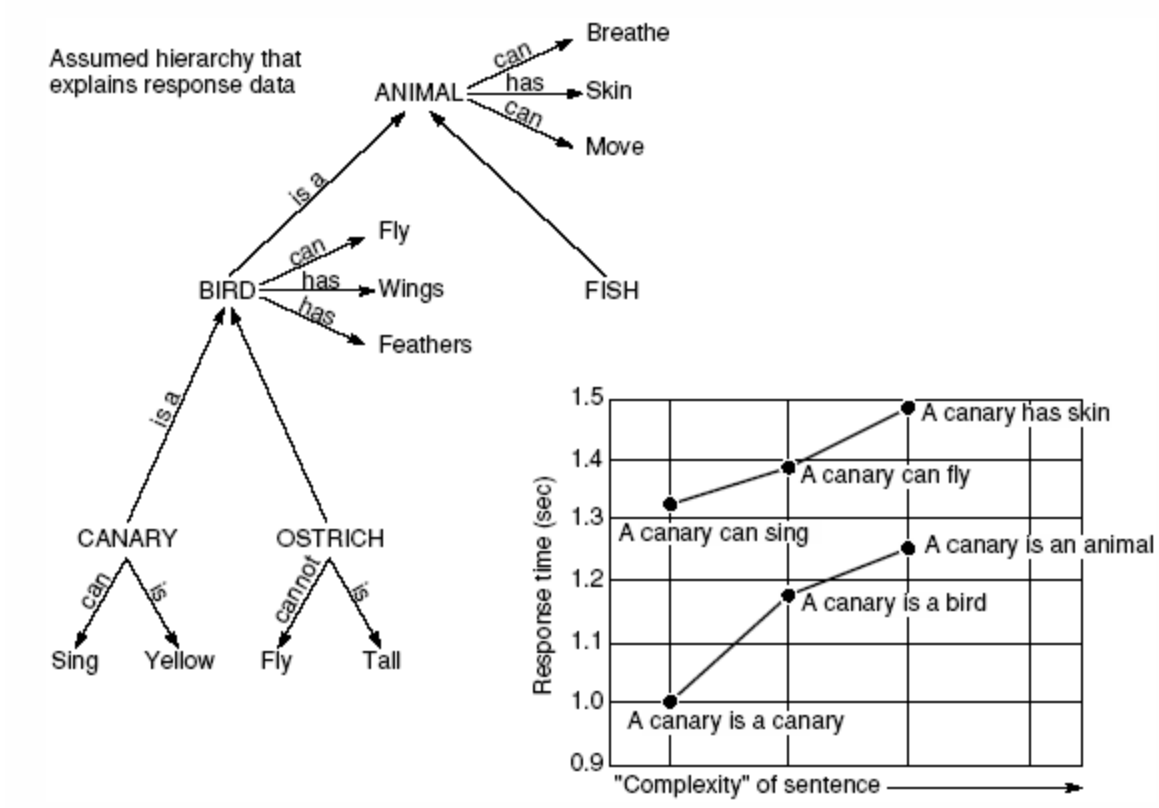
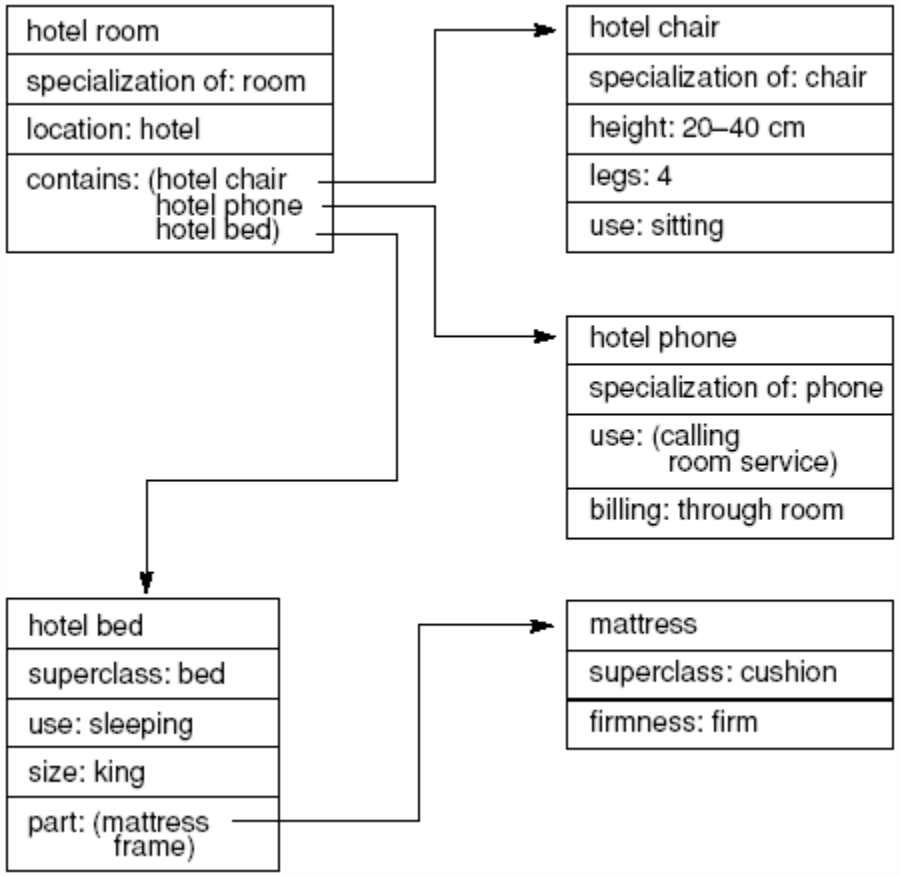
EXAMPLE OF NETWORK REPRESENTATION OF KNOWLEDGE TO UNDERSTAND INFORMATION ABOUT BIRDS



Semantic network developed by Collins and Quillian in their research on human information storage and response times (Harmon and King, 1985)

FRAME REPRESENTATION OF A HOTEL ROOM (SIMILAR TO DATABASE DESIGN)



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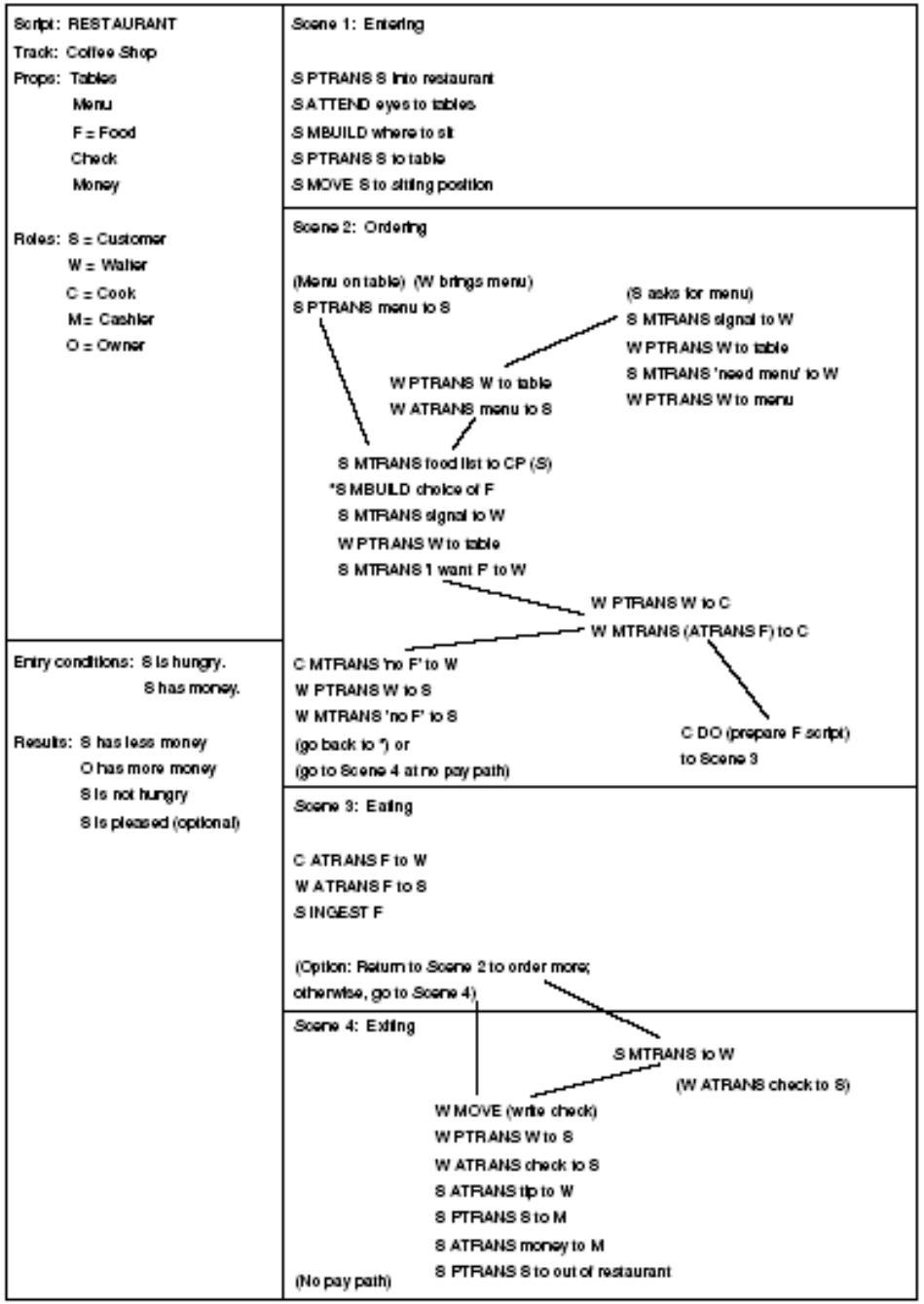
SCRIPT REPRESENTATION (RESTAURANT)



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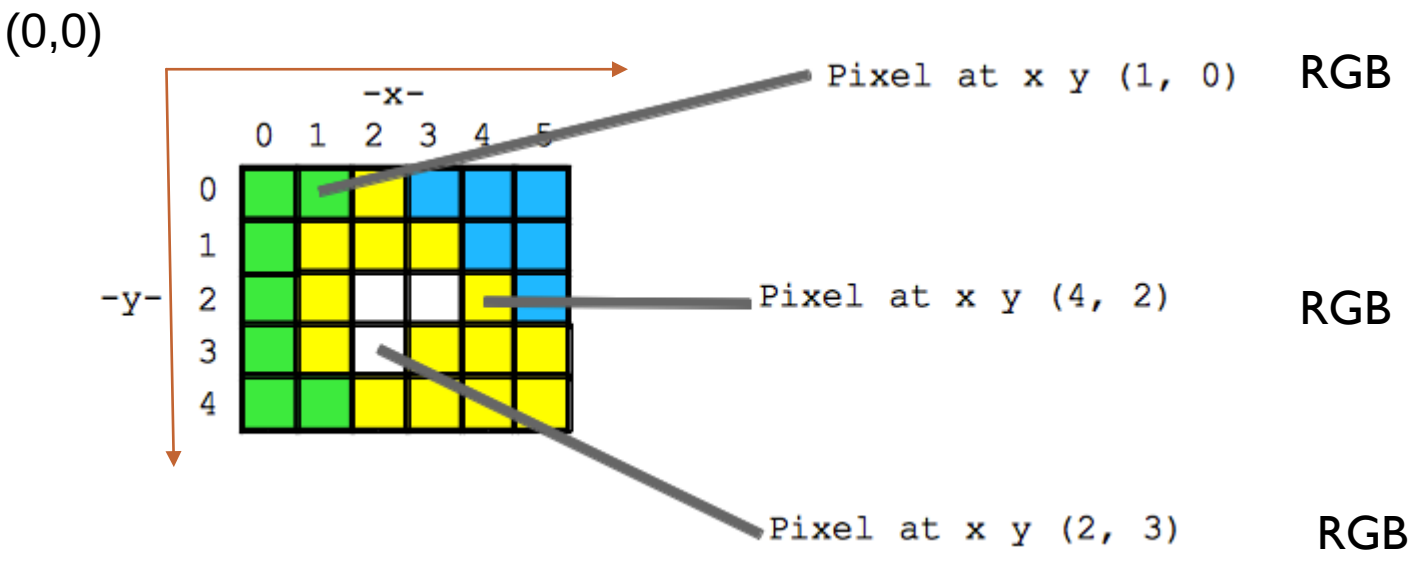
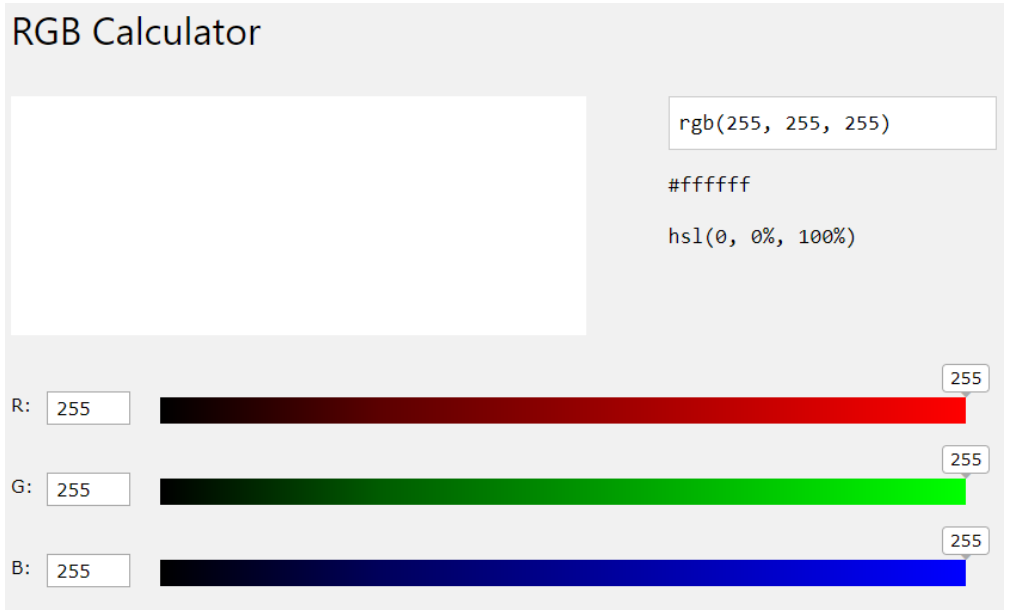
HOW TO REPRESENT A PICTURE?

Used in Deep Learning

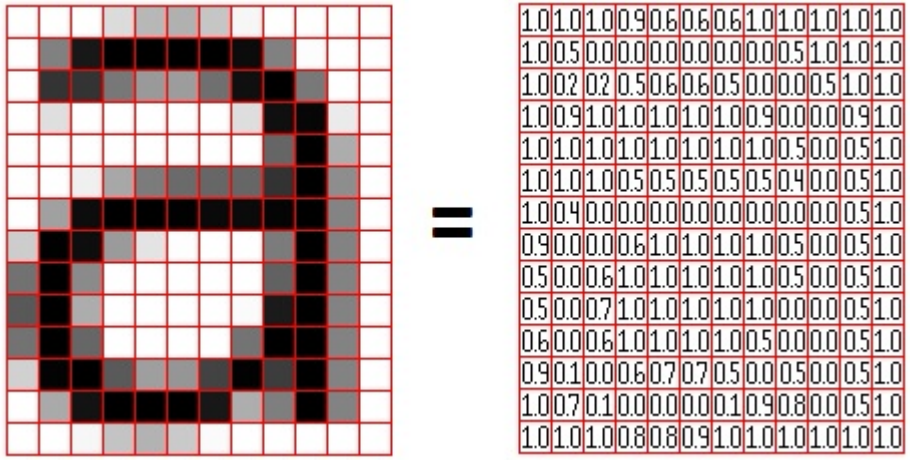




https://web.stanford.edu/class/cs101/image-diagram1.png

https://www.w3schools.com/colors/colors_rgb.asp

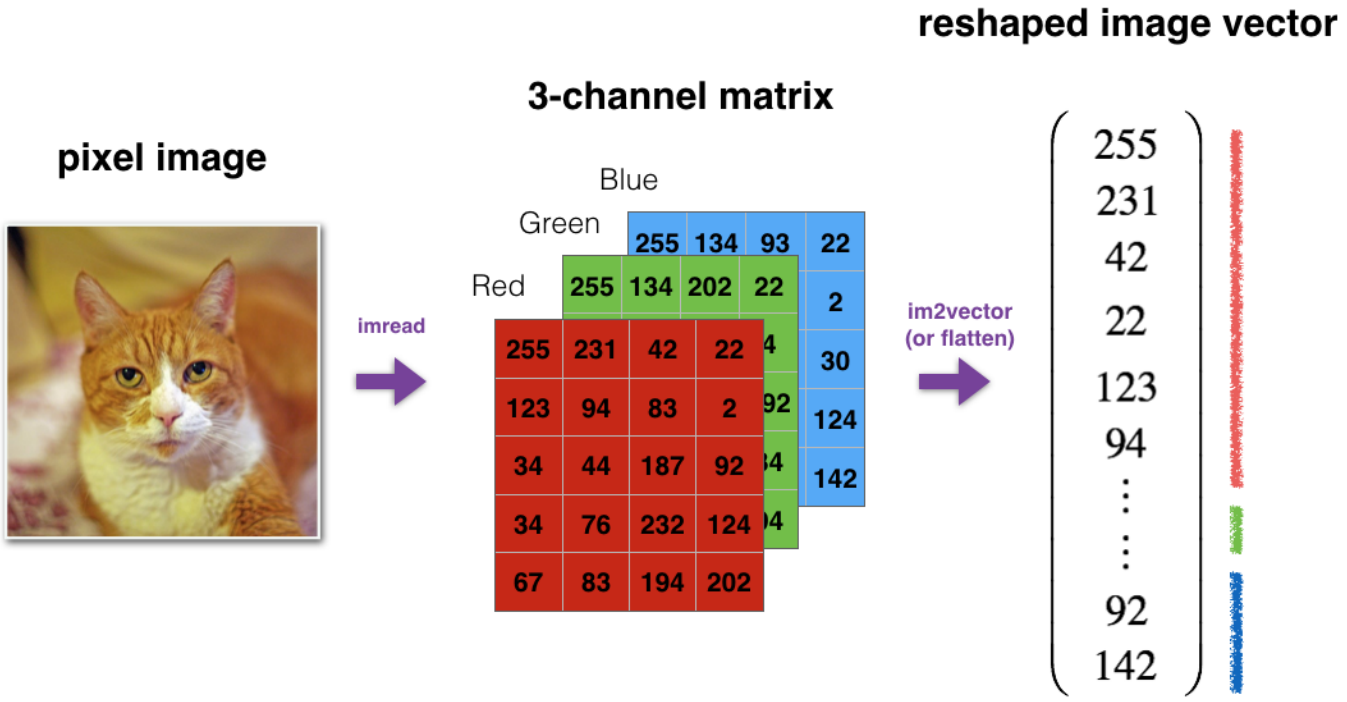
HOW TO REPRESENT A PICTURE?



=

1.0	1.0	1.0	0.9	0.6	0.6	0.6	1.0	1.0	1.0	1.0	1.0
1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.0	1.0
1.0	0.2	0.2	0.5	0.6	0.6	0.5	0.0	0.0	0.5	1.0	1.0
1.0	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.0	0.0	0.9	1.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.4	0.0	0.5	1.0
1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0
0.9	0.0	0.0	0.6	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
0.5	0.0	0.6	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
0.5	0.0	0.7	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.5	1.0
0.6	0.0	0.6	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.5	1.0
0.9	0.1	0.0	0.6	0.7	0.7	0.5	0.0	0.5	0.0	0.5	1.0
1.0	0.7	0.1	0.0	0.0	0.0	0.1	0.9	0.8	0.0	0.5	1.0
1.0	1.0	1.0	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0

GREYSCALE IMAGE



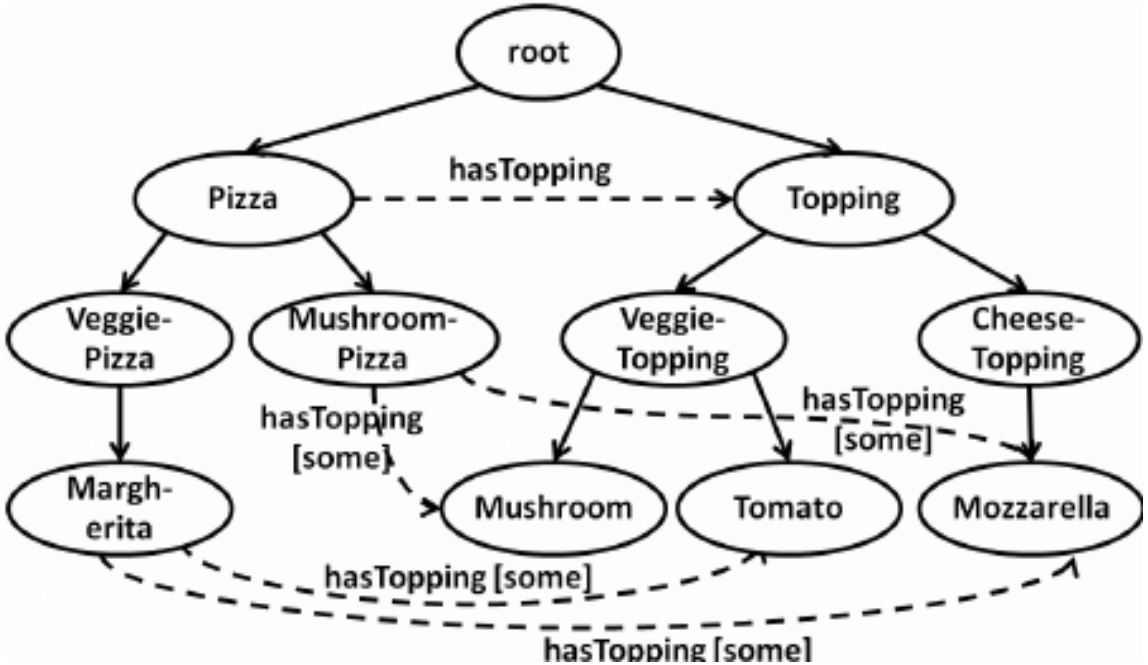
COLOR IMAGE

https://i.imgur.com/s0qk6ga.jpg

https://necromuralist.github.io/neural_networks/posts/image-to-vector/

ONTOLOGIES TO REPRESENT A DOMAIN OF INTEREST

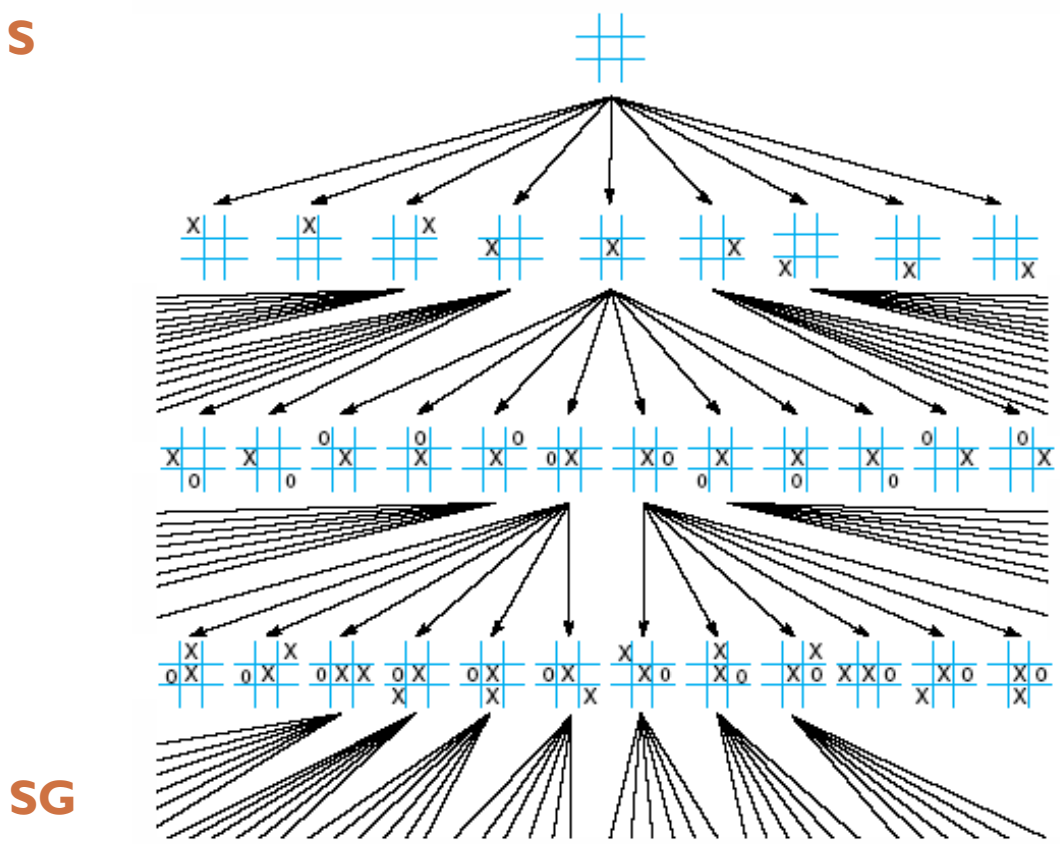
- Context is very important
- Ontologies are topics in themselves (not covered in the course)



https://www.researchgate.net/publication/236842047_Efficient_Regression_Testing_of_Ontology-Driven_Systems/figures?lo=1

STATE SPACE SEARCH FOR TIC-TAC-TOE

- The concept of searching is important in AI as searching is a problem solving methodology
- Game problems can be expressed with searching
- Here we are looking at a state space search representation for tic-tac-toe where we have a start state (S) and goal states (SG). The states are modified based on the rules of the game. Players will adopt strategies (heuristics)
- How many goal states are there?



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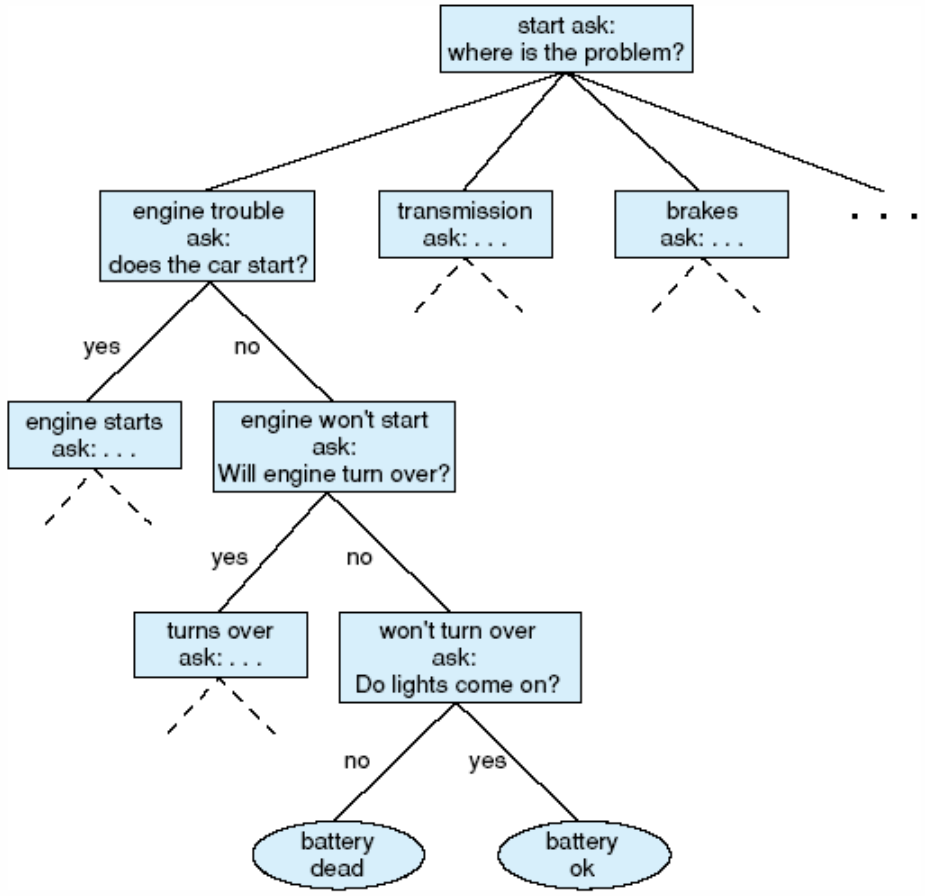
STATE SPACE SEARCH FOR AUTOMOTIVE DIAGNOSIS



- State space search methodologies are not sufficient to automate intelligent problem-solving behaviors, otherwise AI would already be at a next level
- It works on specific domain only
- It is often not practical
- Chess has ~10^{120} different board states > number f molecules in the universe or the number of nanoseconds that have passed since the bing bang

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HOMEWORK

HOMEWORK

- READ : Slides
- EXERCICE :
  - Why is the representation of π 1110001?
  - How many possible games are there in Tic Tac Toe?