ENCS3340 - Artificial Intelligence

Introduction

What is Artificial Artificial Intelligence?

- Let's define intelligence first.

- Intelligence, based on Wikipedia, is the capacity for:
  - Abstraction
  - Logic
  - Understanding
  - Self-awareness
  - Learning
  - Emotional knowledge
  - Reasoning
  - Planning
  - Creativity
  - Critical thinking
  - Problem-solving.

I.e. the ability to perceive or infer information, and to retain it as knowledge to be applied towards adaptive behaviors within an environment or context.

What is Artificial Artificial Intelligence?

- No standard definition of AI among those working in the field.

- AI has even been defined as:

  "... the collection of problems and methodologies studied by artificial intelligence researchers." - Luger and StubbleField

- The textbook discusses four different schools of thought:
  - Machines that **think like humans**
  - Machines that **act like humans**
  - Machines that **think rationally**
  - Machines that **act rationally**

2 Dimensions to Describe AI

- 4 points of views: Systems that can ….

	Cognitive Approach	Engineering / Rational Approach
Behavior	act like humans	act rationally
Reasoning	think like humans	think rationally

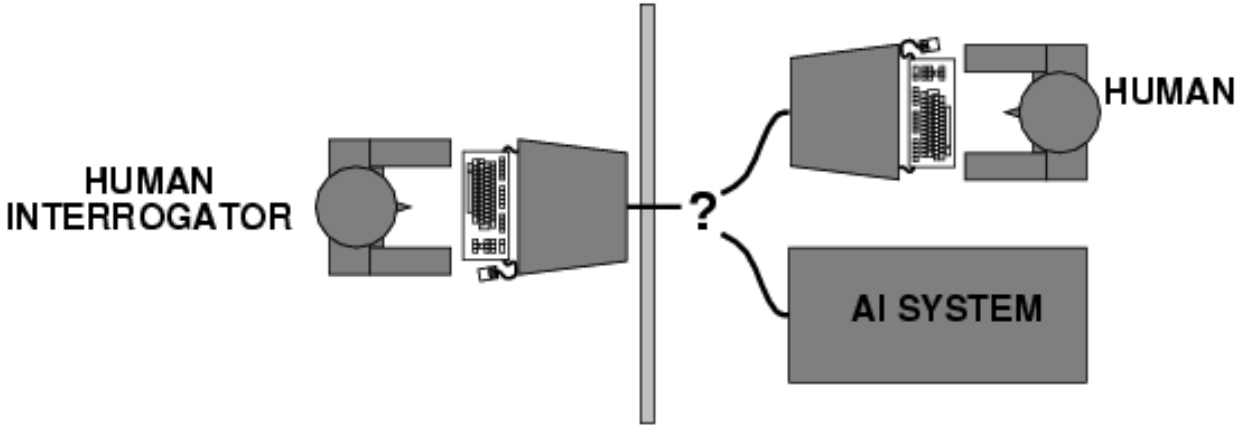
- Engineering Approach:
  - Tries to find optimal solution.
  - No matter how (not necessarily what human do)

- Cognitive Approach:
  - Tries to understand the process
  - Tries to reproduce human behavior (even if wrong results)

A Test for Intelligence

The Turing Test

- Proposed by Alan Turing in 1950
- If a human interrogator cannot tell the computer and human apart, then the computer is intelligent
- Measures the intelligence of a computer vs. a human
- Turing predicted that by 2000, a machine might have a 30% chance of fooling a person for 5 minutes



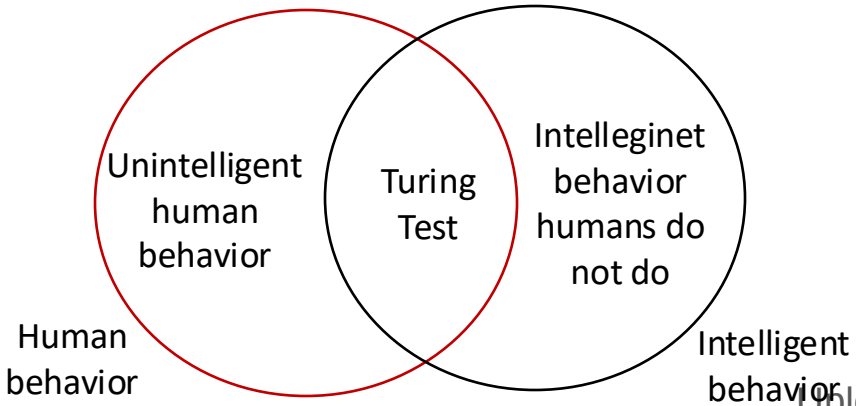
The Turing Test

What capabilities would a computer need to have to pass the Turing Test?

- Natural language processing
- Knowledge representation
- Automated reasoning
- Machine learning
- ….

Turing Test: Criticism

- Not reproducible
- Not constructive
  - Not a good way to solve practical problems
- Not amenable to mathematical analysis
- Machine intelligence designed w.r.t. humans
  - Some human behavior is not intelligent
  - Some intelligent behavior may not be human



What do we do in AI?

- Search / Heuristic Search
- Automatic Game Playing
- Planning Systems
- Knowledge Representation
- Logic and Inference
- Natural Language Processing
- Dealing with uncertainty – probability and decision theory
- Machine Learning
- Vision & Robotics
- Philosophical Issues
- …

Disciplines involved in AI

- Computer science:
  - Algorithms and data structures to implement theories
- Philosophy:
  - logic, methods of reasoning, foundation of learning, rationality
- Mathematics:
  - formal representation and proof, algorithms, computations, (un)decidability, (in)tractability, probability
- Psychology:
  - Experimental techniques (psycholinguistics, ...)
- Linguistics:
  - Knowledge representation, grammars
- mechanical engineering.
- ….

Applications of AI

Games

Chess

Deep Blue, 1997
AlphaZero, 2017

Go

AlphaGo, 2017

Applications of AI

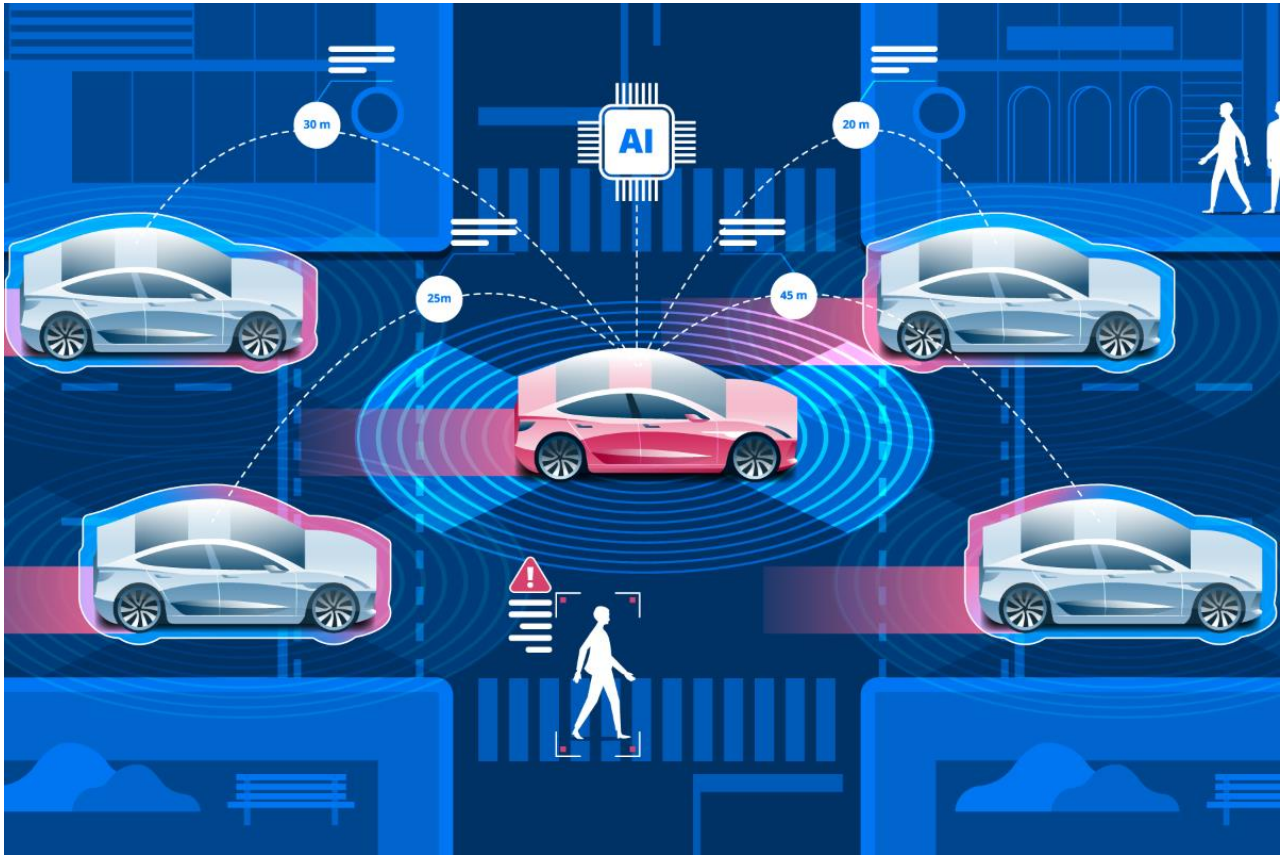
Robotics

Mars rovers

RoboCup

Applications of AI

Autonomous Driving

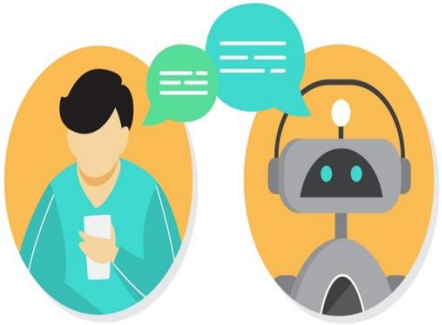


Applications of AI

Natural Language Understanding

Automatic speech recognition

Question Answering



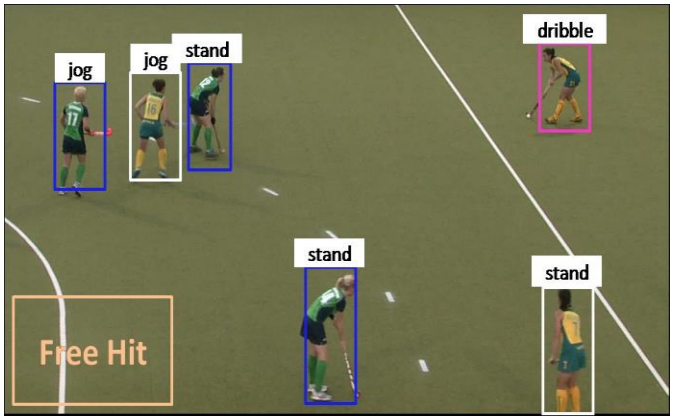
Machine Translation

Applications of AI

Computer Vision

Scene Understanding

Activity Recognition



Face Detection

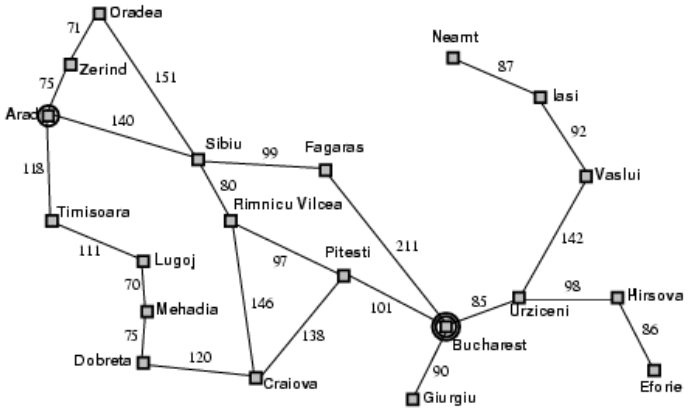
Applications of AI

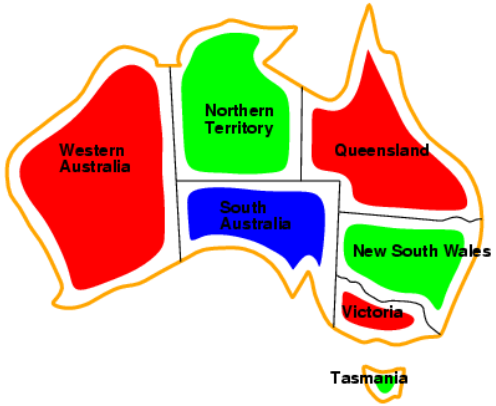
And Many More Applications …..

- Recommendation Systems
- Search Engines
- Spam Filtering
- Planning
- Navigation Systems
- Semantic Web
- Reasoning
- Medical Diagnosis Systems
- ….

Course Topics

- **Search**
  - Uninformed search [tree/graph traversal]
  - Informed search, heuristics [A*]
  - Constraint satisfaction problems [map coloring]
  - Games [Chess]





- **Logic** [Propositional and First-Order Logic, inference/proving theorems]

```
man(marcus)
fromPompae(marcus)
∀X fromPompae(X) ⇒ roman(X)
```

Course Topics

- **Machine Learning [learning from examples]**
  - Supervised and unsupervised learning
  - Decision trees
  - Naïve Bayes
  - Neural Networks
  - Clustering

- **Applications [if time permits]**
  - Natural Language Processing
  - Computer Vision
  - Robotics
  - …

Intelligent Agents

Recap: What is AI?

- 4 points of views: Systems that can ….

	Cognitive Approach	Engineering / Rational Approach
Behavior	act like humans	act rationally
Reasoning	think like humans	think rationally

- The textbook advocates "acting rationally"

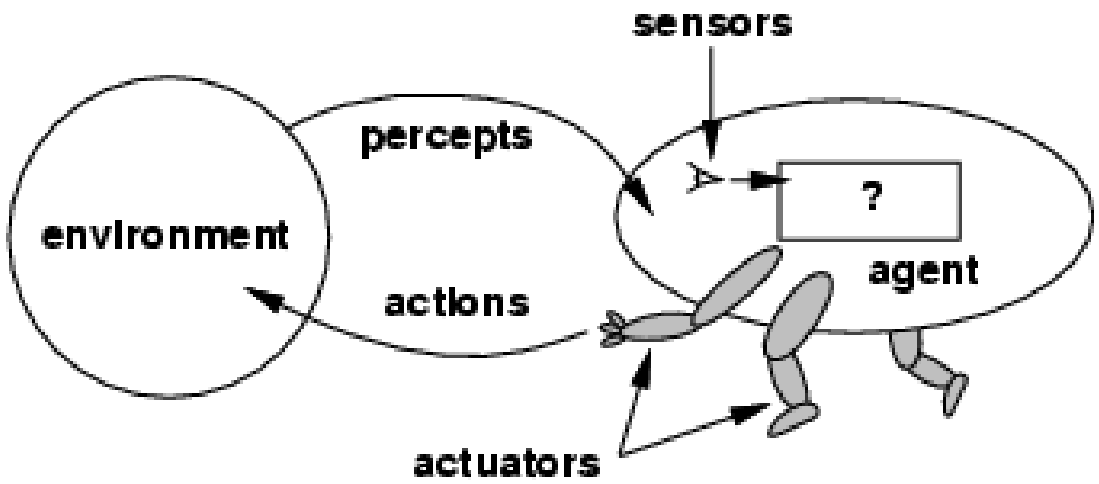
- Acting rationally: Rational Agent
  - Rational behavior: doing the right thing
  - The right thing: that which is expected to maximize goal achievement, given the available information
  - Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of rational action

Agents

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators

- Abstractly, an agent is a function from percept histories to actions

$$[f: \mathcal{P}^* \rightarrow \mathcal{A}]$$



- The agent program runs on the physical architecture to produce f

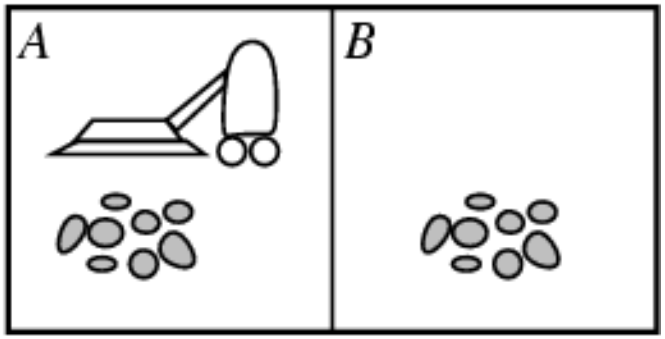
Example of Agents

- Human agent:
  - eyes, ears, and other organs for sensors
  - hands, legs, mouth, and other body parts for actuators

- Robotic agent:
  - cameras and infrared range finders for sensors
  - various motors for actuators

- software agent:
  - functions as sensors: information provided as input to functions in the form of encoded bit strings or symbols
  - functions as actuators: results/outputs of the function

Example: Vacuum-cleaner world



- Percepts: location and contents, e.g.,

  [A,Dirty]

- Actions: Left, Right, Suck, NoOp

Rational Agents

- An agent should strive to "do the right thing", based on what it can perceive and the actions it can perform.
- The right action is the one that will cause the agent to be most successful
- Performance measure: An objective criterion for success of an agent's behavior
- Possible performance measures of a vacuum-cleaner agent:
  - amount of dirt cleaned up,
  - amount of time taken,
  - amount of electricity consumed,
  - amount of noise generated, etc
- **Rational Agent**: For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.

PEAS

- PEAS: Performance measure, Environment, Actuators, Sensors
- Performance measure: used to evaluate how well an agent solves the task at hand
- Environment: surroundings beyond the control of the agent
- Actuators: determine the actions the agent can perform
- Sensors: provide information about the current state of the environment

PEAS examples

Agent: automated taxi driver

- **Performance measure**: Safe, fast, legal, comfortable trip, maximize profits
- **Environment**: Roads, other traffic, pedestrians, customers
- **Actuators**: Steering wheel, accelerator, brake, signal, horn
- **Sensors**: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

PEAS examples

Agent: Medical diagnosis system

- **Performance measure**: Healthy patient, minimize costs, lawsuits
- **Environment**: Patient, hospital, staff
- **Actuators**: Screen display (questions, tests, diagnoses, treatments, referrals)
- **Sensors**: Keyboard (entry of symptoms, findings, patient's answers)

PEAS examples

Agent: Part-picking robot in a factory

- **Performance measure**: Percentage of parts in correct bins
- **Environment**: Conveyor belt with parts, bins
- **Actuators**: Jointed arm and hand
- **Sensors**: Camera, joint angle sensors

Environment Types

- **Fully observable (vs. partially observable):**
  - An agent's sensors give it access to the complete state of the environment at each point in time.

- **Deterministic (vs. stochastic):**
  - The next state of the environment is completely determined by the current state and the action executed by the agent.

- **Episodic (vs. sequential):**
  - The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.

Environment Types

- **Static (vs. dynamic):**
  - The environment is unchanged while an agent is deliberating. (The environment is **semidynamic** if the environment itself does not change with the passage of time but the agent's performance score does)

- **Discrete (vs. continuous):**
  - A limited number of distinct, clearly defined percepts and actions.

- **Single agent (vs. multiagent):**
  - An agent operating by itself in an environment.

Environment Types

	Chess with a clock	Chess without a clock	Taxi driving
Fully observable	Yes	Yes	No
Deterministic	Strategic	Strategic	No
Episodic	No	No	No
Static	Semi	Yes	No
Discrete	Yes	Yes	No
Single agent	No	No	No

- The environment type largely determines the agent design

- The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

Agent types

Five basic types in order of increasing generality:

- Simple reflex agents
  - select actions on the basis of the current percept, ignoring the rest of the percept history.
- Model-based reflex agents
  - maintain some sort of internal state that depends on the percept history and thereby reflects at least some of the unobserved aspects of the current state.
- Goal-based agents
  - needs some sort of goal information that describes situations that are desirable
- Utility-based agents
  - chooses actions to maximize its utility
- Learning agents