Artificial Intelligence History & Applications

Yamuna Prasad

Most of the contents in the slides are borrowed from web & S. Rusell's AI book

Outline for AI part

Definitions & History
Agents
Searches: (uninformed/informed)
Uninformed search: DFS, BFS, Depth Limited DFS, Iterative deepening search and bidirectional search, uniform cost search etc
Informed (Heuristic) Search: Best First Search, Hill Climbing and its variants, simulated annealing, A* and its variants etc

Philosophy of AI

AI: The Very Idea by John Haugeland (http://philosophy.uchicago.edu/faculty/haugeland.html)
Machines Who Think by Pamela McCorduck (http://www.pamelamc.com/html/machines_who_think.html)

Some Definitions

We call programs intelligent if they exhibit behaviors that would be regarded intelligent if they were exhibited by human beings.

Herbert Simon

Physicists ask what kind of place this universe is and seek to characterize its behavior systematically. Biologists ask what it means for a physical systems to be living. We in AI wonder what kind of information-processing system can ask such questions.

Avron Barr & Edward Feigenbaum

AI is the study of techniques for solving exponentially hard problems in polynomial time by exploiting knowledge about problem domain

Elaine Rich

AI is the study of mental faculties through the use of computational models.

Eugene Charniak and Drew McDermott

"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)
"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)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990) "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

Figure 1.1 Some definitions of AI. They are organized into four categories:

Systems that think like humans.	Systems that think rationally.
Systems that act like humans.	Systems that act rationally.

Brief Definition of AI

- The study of computer systems that attempt to model and apply the intelligence of the human mind.
- A branch of computer science dealing with the simulation of intelligent behavior in computers.
- The capability of a machine to imitate intelligent human behavior.

Questions

What is intelligence? (understand, learn,adapt, rational…..)

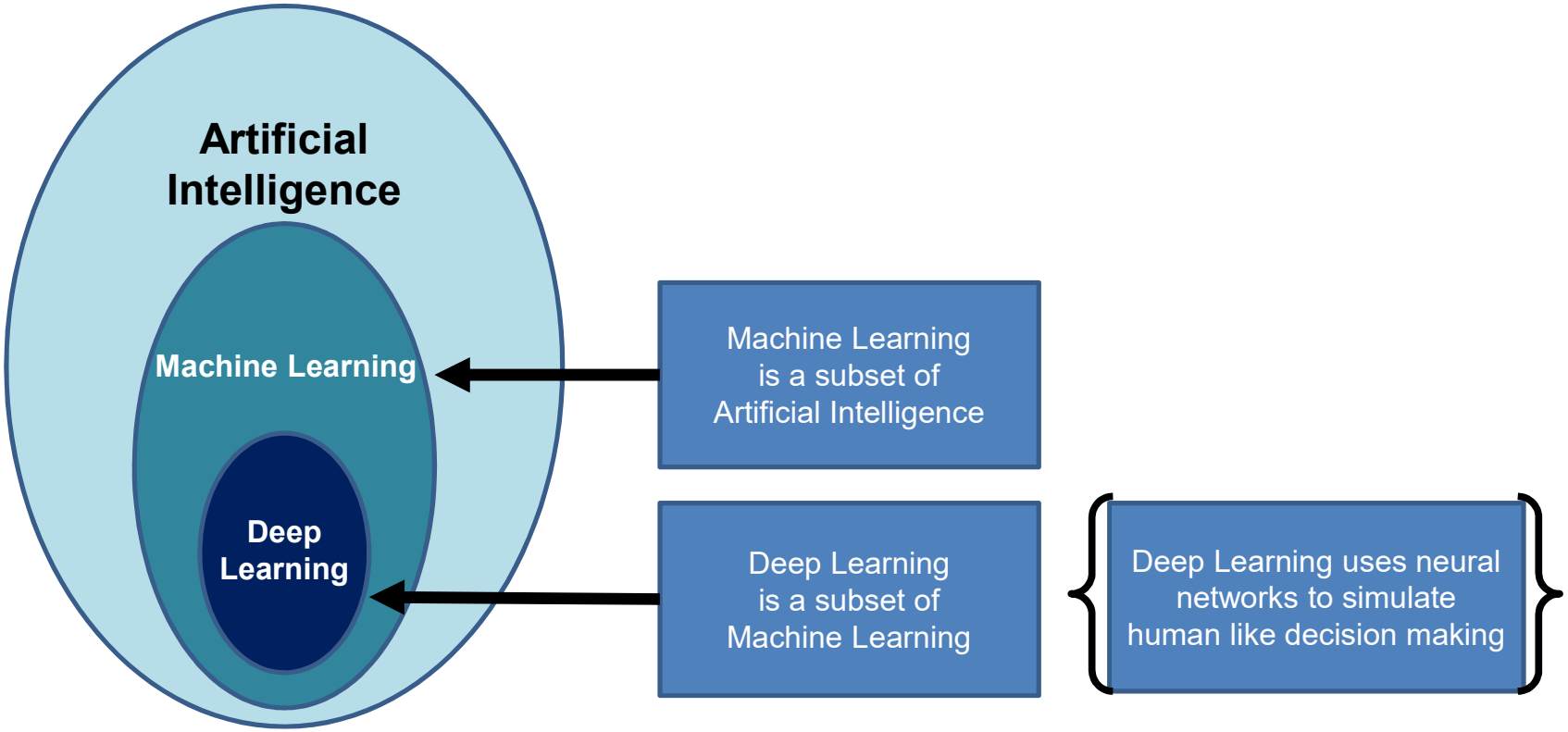
What is thinking

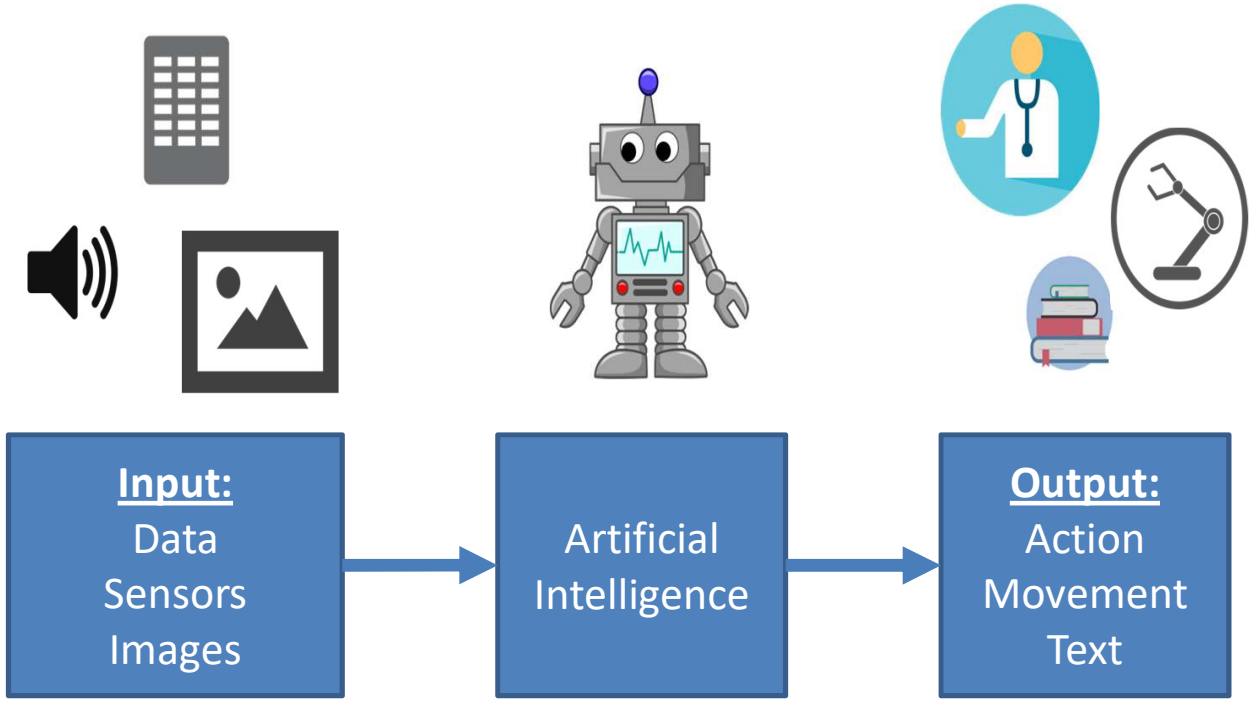
What is a machine?

Is the computer a machine?

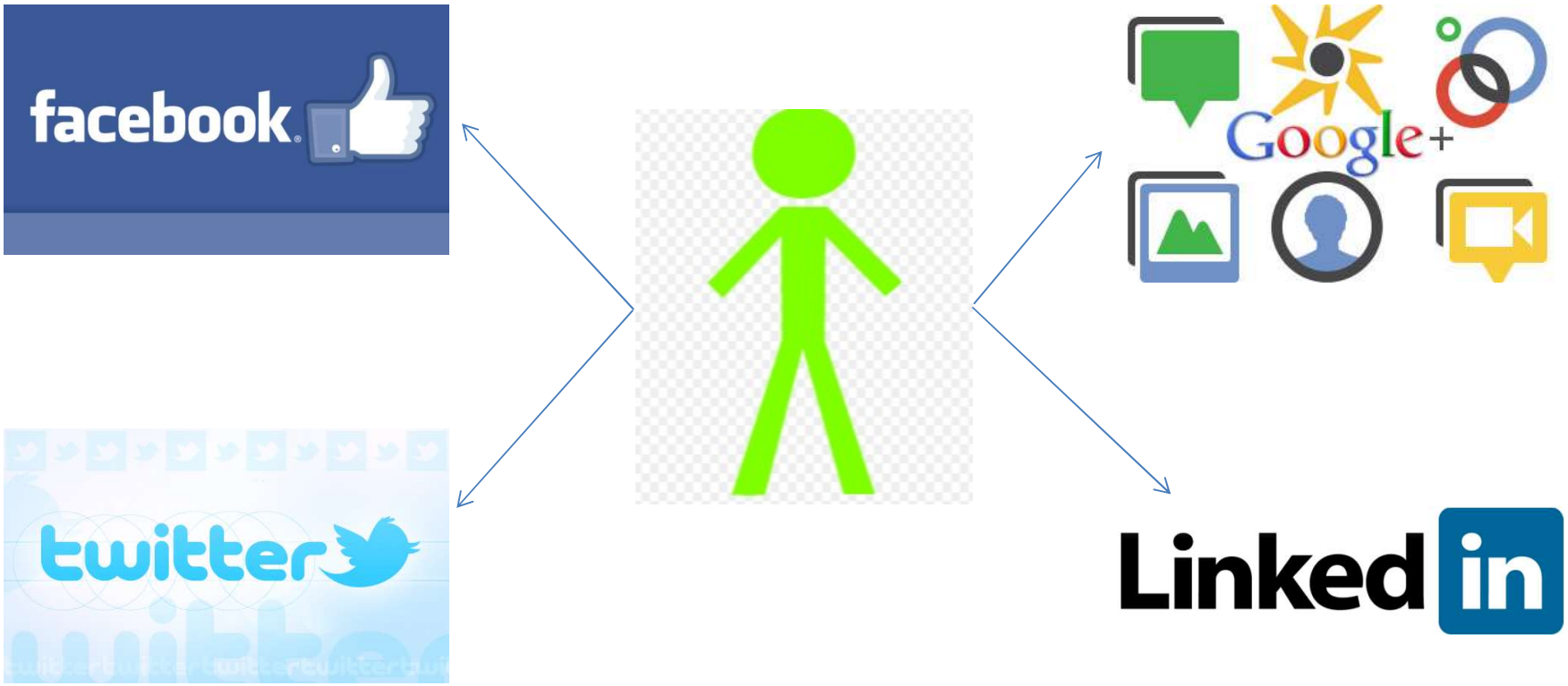
Can a machine think?

If yes are we Machines?


Artificial Intelligence
Machine Learning
Deep Learning
Machine Learning is a subset of Artificial Intelligence
Deep Learning is a subset of Machine Learning
Deep Learning uses neural networks to simulate human like decision making


Input:
Data
Sensors
Images
Artificial
Intelligence
Output:
Action
Movement
Text

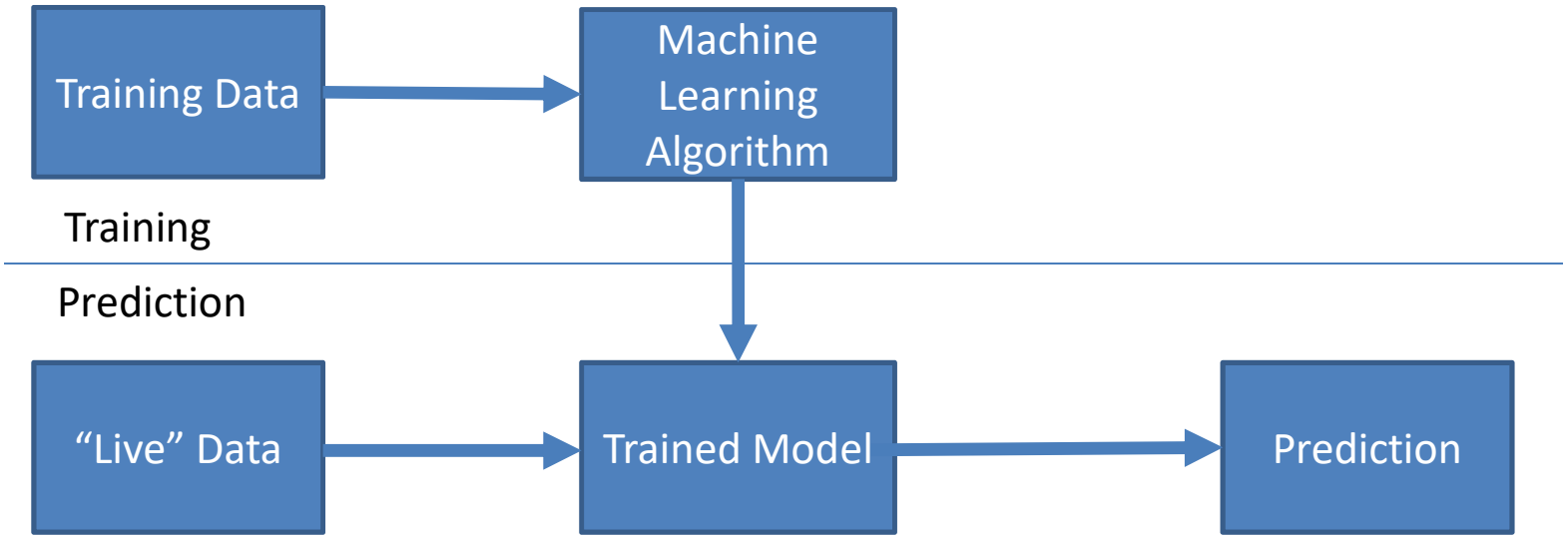
Motivation (Social Media)

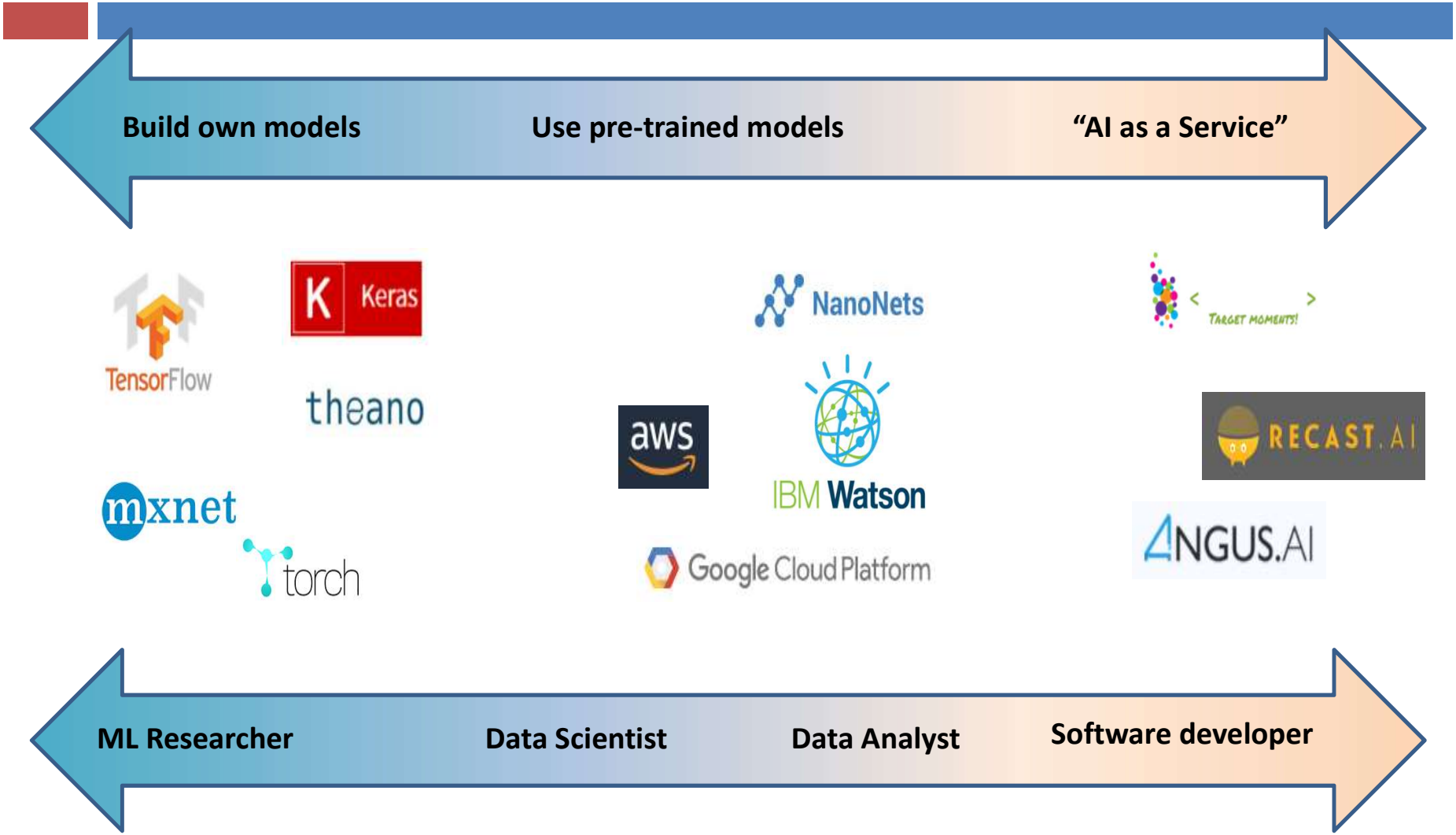


- User Location, Sentiment analysis,

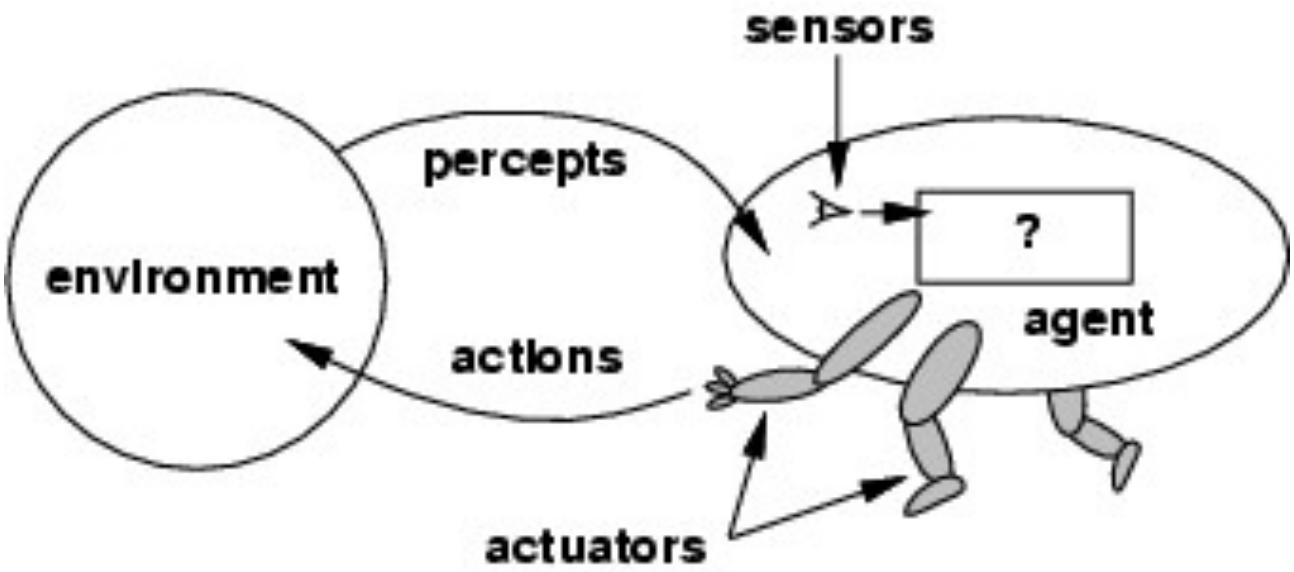
Machine Learning

- Type of Artificial Intelligence that provides computers with the ability to **learn without being explicitly programmed**
- **Various techniques** can be used to for it learn make predictions based on data




Build own models
Use pre-trained models
"AI as a Service"
TensorFlow
Keras
theano
mxnet
torch
aws
NanoNets
IBM Watson
Google Cloud Platform
TARGET MOMENTS!
RECAST.AI
ANGUS.AI
ML Researcher
Data Scientist
Data Analyst
Software developer

An agent perceives its environment via sensors and acts upon that environment through its actuators



Examples: Human, Robot with sensors & cameras, thermostat detecting room tempreature, self driving car, automated vaccum cleaners etc.

Agents

Human

- Eyes, ears, skin, taste buds etc. (sensors)
- Hands, fingers, legs, mouth etc. (Actuators)

Robot (Xavier(CMU), Cog(MIT), Aibo(Sony))

- Camera, Infrared, bumper etc. (sensors)
- Grippers, wheels, lights, speakers etc. (Actuators)

Software agents (Softbots)

- Functions as sensors
- Functions as actuators

Softbots : askjeeves.com

Expert Systems

Autonomous spacecraft

Intelligent buildings

PEAS (Performance measure, Environment, Actuators, Sensors)

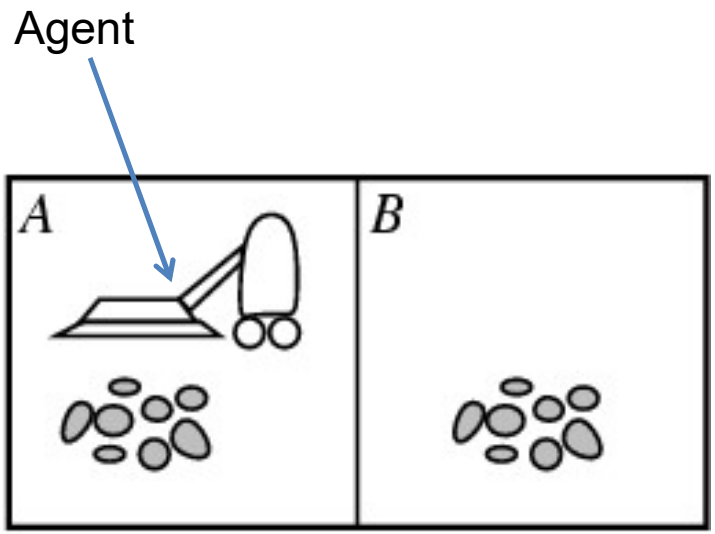
An *objective criterion for success* of an agent's behaviour

iRobot Roomba® 400
Vacuum Cleaning Robot

iRobot Corporation

Founder Rodney Brooks (MIT)

- Powerful suction and rotating brushes
- Automatically navigates for best cleaning coverage
- Cleans under and around furniture, into corners and along wall edges
- Self-adjusts from carpets to hard floors and back again
- Automatically avoids stairs, drop-offs and off-limit areas
- Simple to use— just press the Clean button and Roomba does the rest



Percepts: robot senses it's location and "cleanliness."

So, location and contents, e.g., [A, Dirty], [B, Clean].

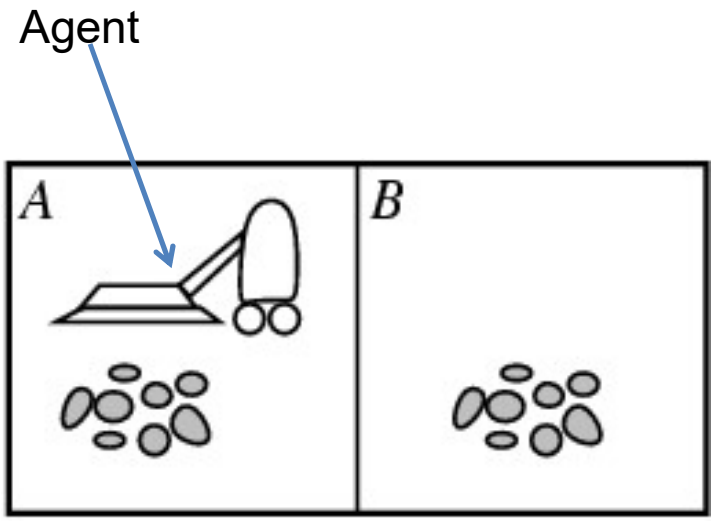
With 2 locations, we get **4 different possible sensor inputs.**

Actions: *Left*, *Right*, *Suck*, *NoOp*

Percepts	Actions
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
⋮	⋮
[A, Clean], [A, Clean], [A, Dirty]	suck

Percepts	Actions
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
⋮	⋮
[A, Clean], [A, Clean], [A, Dirty]	suck

Action sequence of length K, gives 4^K different possible sequences. At least many entries are needed in the table. So, even in this very toy world, with K = 20, you need a table with over 4^20 > 10^12 entries.



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Agents

- Have sensors, actuators
- Have goals
- Implements mapping from percepts sequence to actions
- Performance Measures
- **Autonomous Agent:** decides autonomously which action to take in the current situation to maximize progress towards its goal

Intelligence
- Sensing
- Acting
- Understanding, reasoning, learning

Blind actions (no intelligence)

Rational Agents

AI is about building Rational agents
Rational agent always does right things
Perfect Rationality

Knows all, takes action to maximize its utility

Bounded Rationality (Herbert simon, 1972)

Limitations of human mind, humans must use approximate methods to handle many task

Nearly optimal with respect to its goal and constraints

Rational Action: maximizes the expected value of performance measure given the percept sequence to date

Omniscience

A rational agent is not omniscient

- It does not know the actual outcome of its actions
- It may not know certain aspects of its environment

Rationality must take into account the limitations of the agent

- Percept sequence, background knowledge, feasible actions
- Deal with the expected outcome of actions

Agent Environment

Fully Observable: Chess
Partially Observable: Poker

Episodic: subsequent episodes do not depend on what actions occurred in previous episodes
Sequential: the agent engages in a series of connected episodes

Agent types

State based agents:

Actions based on state of the world and knowledge

Goal based agents:

Actions based on state of the world and knowledge and goals (search is a universal problem solving mechanism in AI)

Systematic exploration of alternatives

Environment

Static

Does not changes while the agent is thinking

Dynamic

Changes dynamically

Discrete/Continuous: If the number of distinct percepts and actions is limited, the environment is discrete, otherwise it is continuous

Other agents: single agent/multi-agents

Environment can contain other intelligent agents

Complex Environment

Knowledge rich: lots of information
Input rich: enormous amount of inputs/percepts

Agent manages such environment through sensing strategies and attentional mechanisms

Agent Types

Table based agents

- Info comes from sensors
- Look up tables
- Triggers actions through actuators

Reactive Agent: the current state is as the sensors see it right now

Tables may become very large, all work done by the designer, no autonomy, all actions are predetermined learning might take a very long time

Mapping defined by programs

Rule based
Neural networks
Algorithms

Subsumption Architecture

- Rodney Brooks, 1986
- Sensory input and simple action (similar to lower animals)
- Follow the evolutionary path and build simple agents
- Bottom up design
- Different layers of behavior, higher layers can override lower layers and each activity consist of a finite state machine

Subsumption (Mobile Robo Example)

Layer 0: Avoid obstacles (sonar, HALT, Feel Force)
Layer 1: Wander behavior (Generates random headings, avoids reads repulsive force, generates new heading, feeds to turn and forward)
Layer 2: exploration behavior

Performance measures of a vacuum-cleaner agent

- amount of dirt cleaned up
- amount of time taken
- amount of electricity consumed
- level of noise generated etc.

Performance measures: Self Driving Car

- time to reach destination
- safety
- predictability of behavior for other agents
- reliability etc.

Performance measures: Game Playing

- win/loss percentage (maximize)
- robustness
- unpredictability (to “confuse” opponent) etc.

Performance measure: An *objective criterion for success* of an agent's behaviour.

Performance measure of game-playing agent: win/loss percentage (maximize), robustness, unpredictability (to “confuse” opponent), etc.

PEAS: Performance measure, Environment, Actuators, Sensors

Example: the task of designing a self-driving car

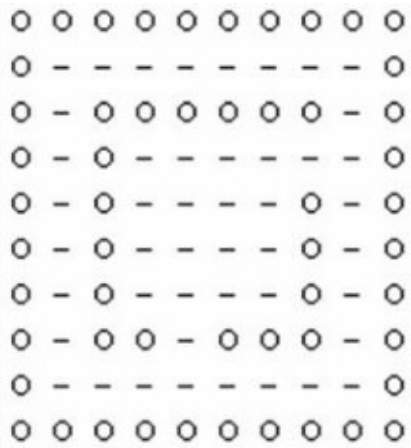
- **Performance measure** Safe, fast, legal, comfortable trip
- **Environment** Roads, other traffic, pedestrians
- **Actuators** Steering wheel, accelerator, brake, signal, horn
- **Sensors** Cameras, LIDAR (light/radar), speedometer, GPS, odometer
- engine sensors, keyboard

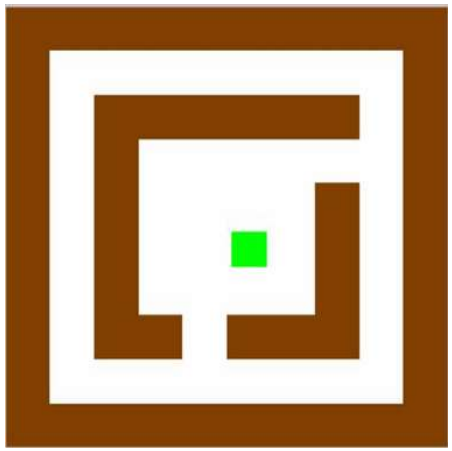
Modified Vacuum Cleaner Example

(1) The environment is a 10x10 maze.
(2) Each cell is either a wall or a room.
(3) The walls are always clean.
(4) The agent cannot pass through the wall.
(5) The agent can go north, south, east, and west. Each move costs 1 point of energy.
(6) The agent can suck, each time decreasing 1 unit of dirt. Each suck costs 2 point of energy.
(7) The agent can stay idle, costing no energy.

Performance measure

Given a period *T*, the goal is
(1) minimize the sum of square of amount of dirt in all rooms over *T*
(2) minimize the consumed energy





Searching applications

Web crawling
Social networking
Network broadcasting
Garbage collection
Solving puzzles etc

Basic searches