ARTIFICIAL INTELLIGENCE
LECTURE 01

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INSTRUCTOR

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GRADING

Quiz / Assignment 25%

- There will be surprise quizzes. It can be taken at any time during Lecture.
- Assignments will be announced with a specific deadline. Instructions will be provided along with the assignment statement.

Mid Term 25%

Final Exam 50%

Late Policy: Assignments will not be accepted later than the deadline.

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PLAGIARISM POLICY

Any assignment found 30% or more copied from the internet will be marked 0 (ZERO).

Any assignment copied from the class mate will also be marked 0 (ZERO).

- Both for the source and the copied one.

No consideration will be made regarding plagiarized assignments.

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COURSE DETAILS

Course Title: CSC 462 Artificial Intelligence

Pre Req: CSC 102 Discrete Structures

Credits: 3 + 1

Course Contents:

This course gives a broad overview of the fundamental theories and techniques of Artificial Intelligence. Topics include: Overview of Artificial Intelligence; Agents & Environments; Problem-Solving; Adversarial Search; Constraint Satisfaction Problems; Knowledge Representation & Reasoning; Uncertainty; and Automated Planning.

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RESOURCES

1. Artificial Intelligence: A Modern Approach 4th Edition, Russell, S., & Norvig, P., (2020), Prentice Hall

We will refer to other sources whenever the need be.

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SYLLABUS

Unit	Topic
1.	Artificial Intelligence: Definitions, Overview, History, Rationality, Agents, and Environments.
2.	Problem-Solving: Problem-Solving Agents; Searching: Search Algorithms, Uninformed & Informed Search Strategies, Local Search & Optimization Problems, and Heuristic Functions.
3.	Adversarial Search: Game Theory, Heuristic, Min-Max Procedure & Alpha-Beta Pruning; and Monte Carlo Simulation.
4.	Constraint Satisfaction Problems (CSPs): Defining, Constraint Propagation, Inference, and Backtracking.
5.	Knowledge Representation & Reasoning: Knowledge-Based Agents, Propositional Logic, Propositional Theorem Proving, CNF & DNF, Horn Clauses, Forward & Backward Chaining, Knowledge Engineering in First-Order Logic; and Expert System.
6.	Uncertainty: Quantifying Uncertainty; Acting under Uncertainty; Representing Knowledge in an Uncertain Domain, Time & Uncertainty, and Inference in Temporal Models.
7.	Automated Planning: Definition, Algorithms, Heuristics & Hierarchical Planning, Acting in Nondeterministic Domains, Time, Schedules, and Resources.

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OBJECTIVES

Student Outcomes (SOs)

S.#	Description
1	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements
2	Identify, formulate, research literature, and solve *complex* computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines.
4	Create, select, adapt, and apply appropriate techniques, resources, and modern computing tools to *complex* computing activities, with an understanding of the limitations.

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COURSE LEARNING OUTCOMES

Course Learning Outcomes (CLO)				
Sr.#	**Unit #**	**Course Learning Outcomes**	**Blooms Taxonomy Learning Level**	**SO**
CLO's for Theory				
CLO-1	1	Articulate how artificial intelligence enables the capabilities of a computer, machine, or system to mimic the human brain.	*Understanding*	1
CLO-2	2-3	Apply various AI problem solving and searching techniques to a real-world problem.	*Applying*	1,2
CLO-3	4	Formulate a problem specified in natural language as a constraint satisfaction problem.	*Applying*	2
CLO-4	5	Apply resolution to a set of logic statements to answer a query.	*Applying*	2
CLO-5	6-7	Compare various planning strategies for different applications under uncertainty.	*Analyzing*	2
CLO for Lab				
CLO-6	2-4	Implement various searching technique, CSP and knowledge-based system to solve a problem.	*Applying*	2,4

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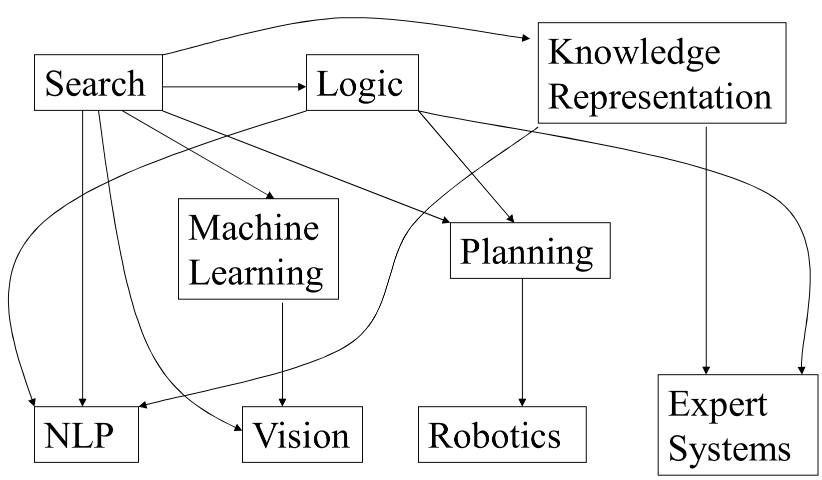
AREAS OF AI AND SOME DEPENDENCIES



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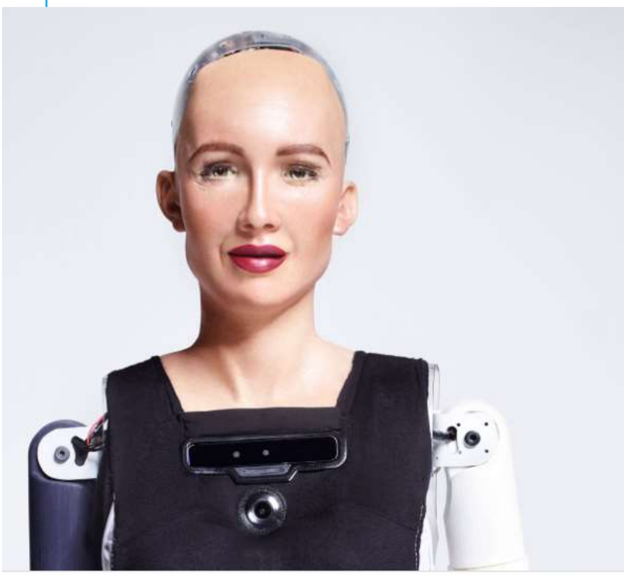
SOPHIA – HANSON ROBOTICS



Sophia

Hanson Robotics' most advanced human-like robot, Sophia, personifies our dreams for the future of AI. As a unique combination of science, engineering, and artistry, Sophia is simultaneously a human-crafted science fiction character depicting the future of AI and robotics, and a platform for advanced robotics and AI research.

The character of Sophia captures the imagination of global audiences. She is the world's first robot citizen and the first robot Innovation Ambassador for the United Nations Development Programme. Sophia is now a household name, with appearances on the Tonight Show and Good Morning Britain, in addition to speaking at hundreds of conferences around the world.

Sophia is also a framework for cutting edge robotics and AI research, particularly for understanding human-robot interactions and their potential service and entertainment applications. For example, she has been used for research as part of the Loving AI project, which seeks to understand how robots can adapt to users' needs through intra and interpersonal development.

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AI APPLICATIONS

Autonomous Planning & Scheduling:

- Autonomous rovers.

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AI APPLICATIONS

Autonomous Planning & Scheduling:

- Telescope scheduling

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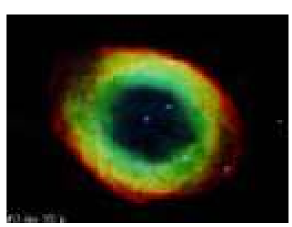
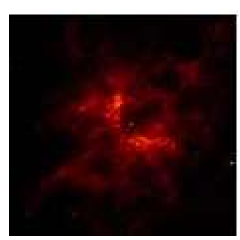
AI APPLICATIONS

Autonomous Planning & Scheduling:

- Analysis of data:





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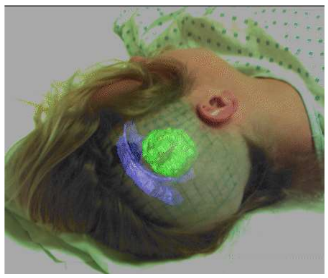
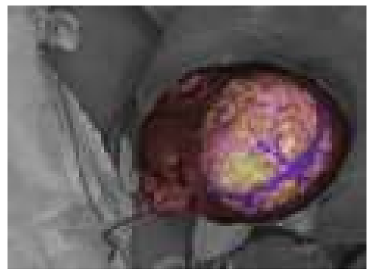
AI APPLICATIONS

Medicine:

- Image guided surgery





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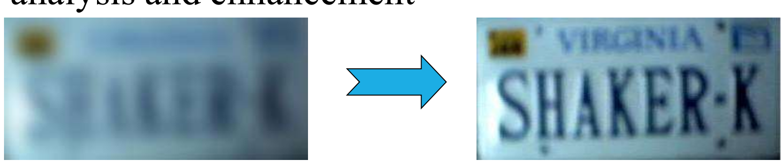
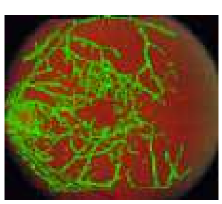
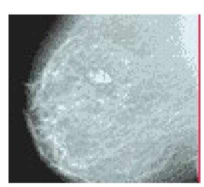
AI APPLICATIONS

Medicine:

- Image analysis and enhancement







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AI APPLICATIONS

Transportation:

- Autonomous vehicle control:

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AI APPLICATIONS

Transportation:

- Pedestrian detection:

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AI APPLICATIONS

Games:

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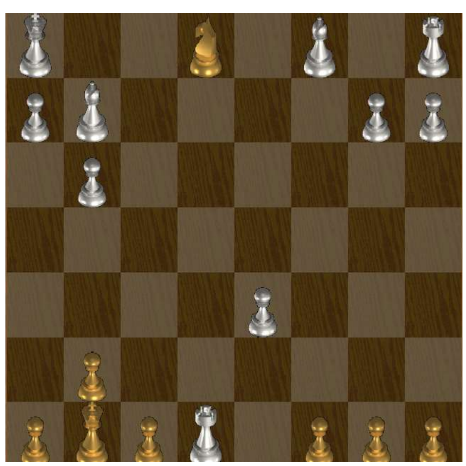
AI APPLICATIONS

Games:



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AI APPLICATIONS

Robotic toys:

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AI APPLICATIONS

Other application areas:

Bioinformatics:
- Gene expression data analysis
- Prediction of protein structure

Text classification, document sorting:
- Web pages, e-mails
- Articles in the news

Video, image classification

Music composition, picture drawing

Natural Language Processing .

Perception.

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WHAT IS ARTIFICIAL INTELLIGENCE ?

making computers that think?

the automation of activities we associate with human thinking, like decision making, learning ... ?

the art of creating machines that perform functions that require intelligence when performed by people ?

the study of mental faculties through the use of computational models ?

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WHAT IS ARTIFICIAL INTELLIGENCE ?

the study of computations that make it possible to perceive, reason and act ?

a field of study that seeks to explain and emulate intelligent behaviour in terms of computational processes ?

a branch of computer science that is concerned with the automation of intelligent behaviour ?

anything in Computing Science that we don't yet know how to do properly ? (!)

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WHAT IS ARTIFICIAL INTELLIGENCE ?

	HUMAN	RATIONAL
THOUGHT	**Systems that think like humans**	**Systems that think rationally**
BEHAVIOUR	**Systems that act like humans**	**Systems that act rationally**

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SYSTEMS THAT ACT LIKE HUMANS: TURING TEST

"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil)

"The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight)

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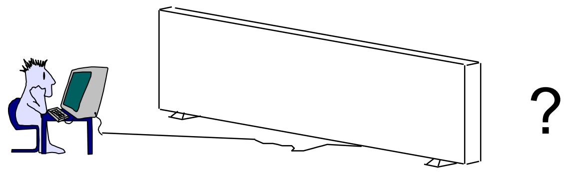
SYSTEMS THAT ACT LIKE HUMANS



You enter a room which has a computer terminal. You have a fixed period of time to type what you want into the terminal, and study the replies. At the other end of the line is either a human being or a computer system.

If it is a computer system, and at the end of the period you cannot reliably determine whether it is a system or a human, then the system is deemed to be intelligent.

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SYSTEMS THAT ACT LIKE HUMANS

The Turing Test approach
- a human questioner cannot tell if
  - there is a computer or a human answering his question, via teletype (remote communication)
- The computer must behave intelligently

Intelligent behavior
- to achieve human-level performance in all cognitive tasks

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SYSTEMS THAT ACT LIKE HUMANS

These cognitive tasks include:

- Natural language processing
  - for communication with human
- Knowledge representation
  - to store information effectively & efficiently
- Automated reasoning
  - to retrieve & answer questions using the stored information
- Machine learning
  - to adapt to new circumstances

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THE TOTAL TURING TEST

Includes two more issues:

- *Computer vision*
  - to perceive objects (seeing)
- *Robotics*
  - to move objects (acting)

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WHAT IS ARTIFICIAL INTELLIGENCE ?

	HUMAN	RATIONAL
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SYSTEMS THAT THINK LIKE HUMANS: COGNITIVE MODELING

Humans as observed from 'inside'

How do we know how humans think?

- Introspection vs. psychological experiments

Cognitive Science

"The exciting new effort to make computers think … machines with *minds* in the full and literal sense" (Haugeland)

"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …" (Bellman)

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WHAT IS ARTIFICIAL INTELLIGENCE ?

	HUMAN	RATIONAL
THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally

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SYSTEMS THAT THINK 'RATIONALLY' "LAWS OF THOUGHT"

Humans are not always 'rational'

Rational - defined in terms of logic?

Logic can't express everything (e.g. uncertainty)

Logical approach is often not feasible in terms of computation time (needs 'guidance')

"The study of mental facilities through the use of computational models" (Charniak and McDermott)

"The study of the computations that make it possible to perceive, reason, and act" (Winston)

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WHAT IS ARTIFICIAL INTELLIGENCE ?

THOUGHT	Systems that think like humans	Systems that think rationally
BEHAVIOUR	Systems that act like humans	Systems that act rationally
	HUMAN	RATIONAL

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SYSTEMS THAT ACT RATIONALLY: "RATIONAL AGENT"

Rational behavior: doing the right thing

The right thing: that which is expected to maximize goal achievement, given the available information

Giving answers to questions is 'acting'.

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SYSTEMS THAT ACT RATIONALLY

Logic → only *part* of a rational agent, not *all* of rationality
- Sometimes logic cannot reason a correct conclusion
- At that time, some *specific (in domain) human knowledge* or information is used

Thus, it covers more generally different situations of problems
- Compensate the incorrectly reasoned conclusion

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SYSTEMS THAT ACT RATIONALLY

Study AI as rational agent –

2 advantages:
- It is more general than using logic only
  - Because: LOGIC + Domain knowledge
- It allows extension of the approach with more scientific methodologies

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From the above definitions, we can see that AI has two major roles:

- Study the intelligent part concerned with humans.
- Represent those actions using computers.

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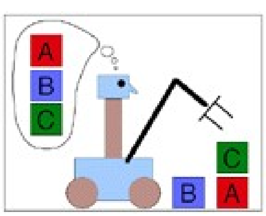
GOALS OF AI

To make computers more useful by letting them take over dangerous or tedious tasks from human

Understand principles of human intelligence



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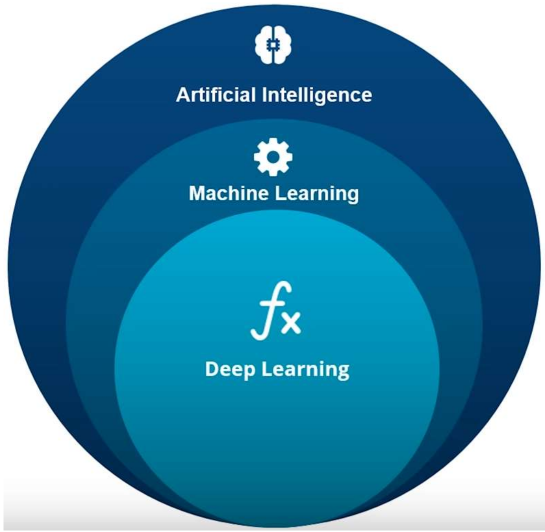
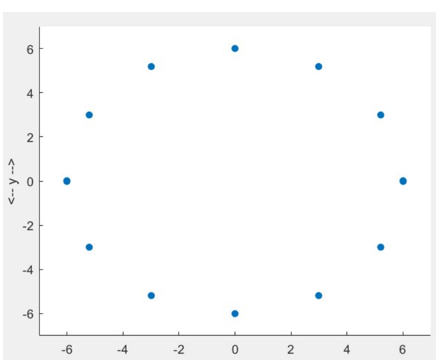
AI VS MACHINE LEARNING VS DEEP LEARNING

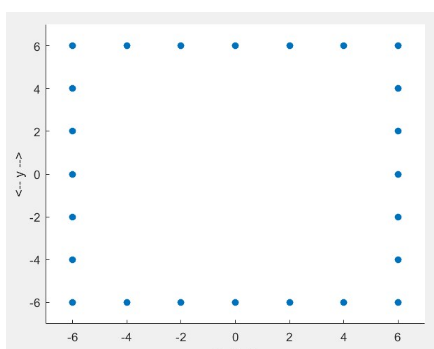


USING AI

Problem:

Given a set of connected points, find if the points form a circle or a square?





USING AI

Features

- 1) Number of corners
- 2) Number of equal Sides

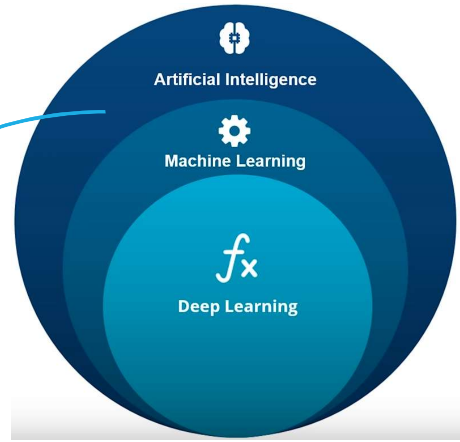
Rule base:

If (number of corners == 4) and (equal sides == 4)

points form square

Else

points form circle



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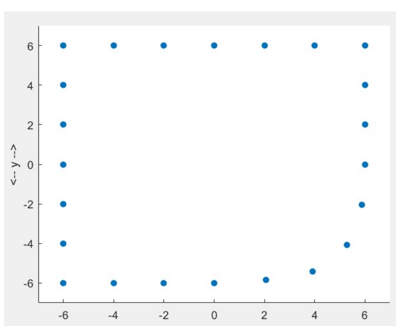
PROBLEM WITH CLASSICAL AI



Square or a circle?

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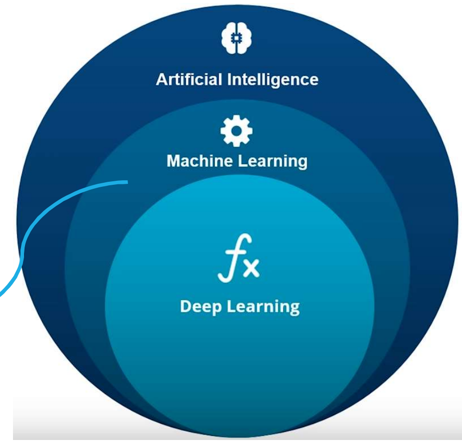
USING ML

Features

- 1) Number of corners
- 2) Equal Sides

Training Phase:

1) Take 3 examples of circles and 3 examples of squares
2) For each example, compute features (number of corners number of sides that are equal)
3) Also tell the computer that whether extracted features are taken from a circle or a square



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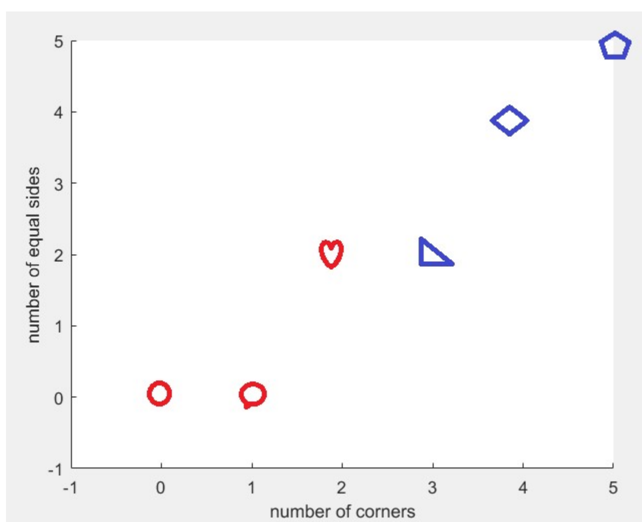
USING ML: FEATURE SPACE

During training, we give machine all examples of different shapes that look similar to a circle or square

Red ones similar to a circle, blue ones similar to a square.



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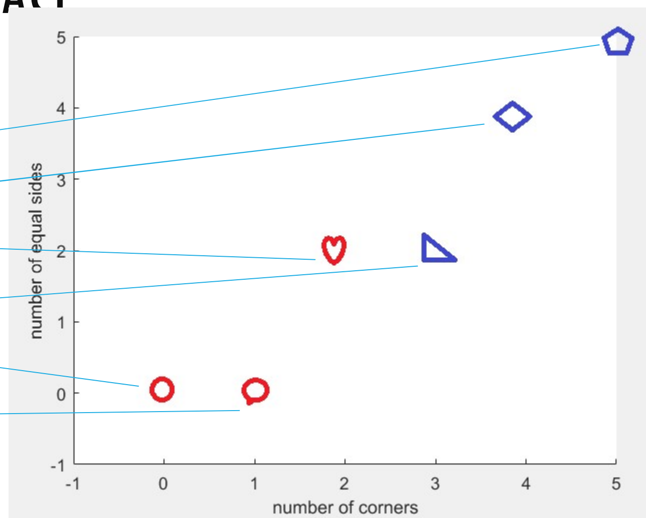
USING ML: FEATURE SPACE

Class	Number of corners	Number of equal sides
Square	5	5
Square	4	4
Circle	2	2
Square	3	2
Circle	0	0
Circle	1	0



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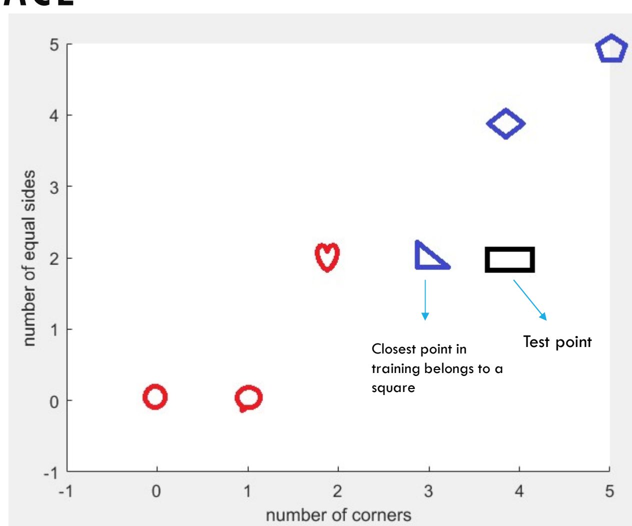
USING ML: FEATURE SPACE

Testing Phase:

Let's determine whether a set of points belonging to a rectangle is classified as a square or a circle?

Nearest Neighbor Approach:

Compute features of the test object and find that example in training the features of which is most similar to this test case.



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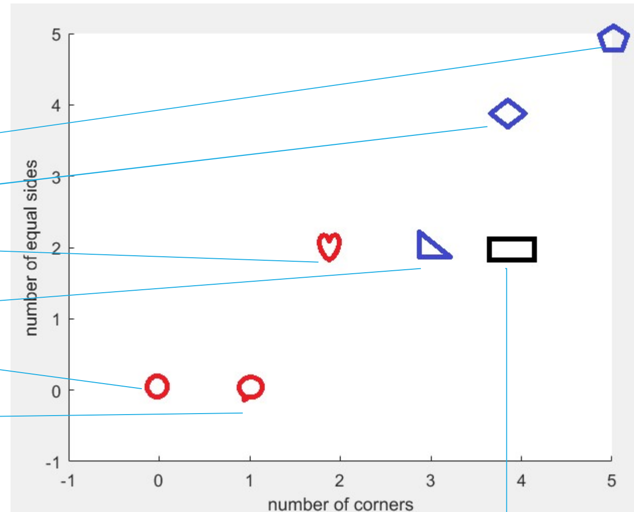
USING ML: FEATURE SPACE

Class	Number of corners	Number of equal sides
Square	5	5
Square	4	4
Circle	2	2
Square	3	2
Circle	0	0
Circle	1	0

Class	Number of corners	Number of equal sides
?	4	2



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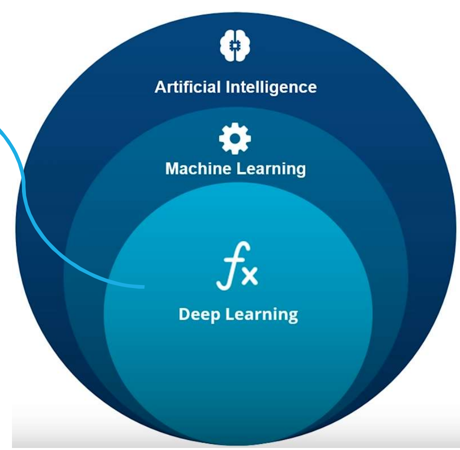
USING DL

No need of determining features

Just let an artificial neural network learn what type of features are useful for a given task.

In classical AI and ML, we don't feed all points to an algorithm directly. We first compute features and then feed those computed features only.

In DL, we don't compute features, we feed input directly to a network.



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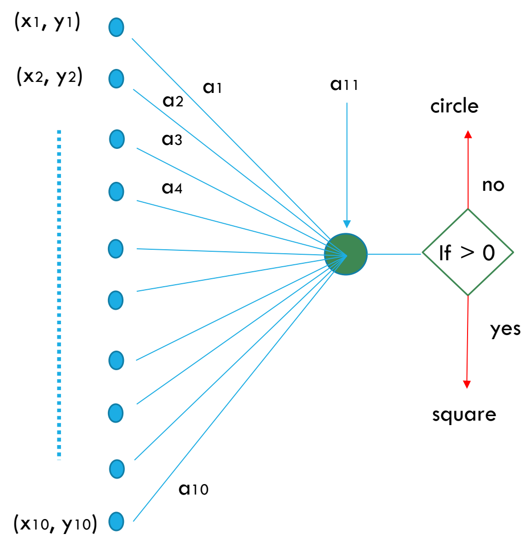
USING DL

Assume that every example contain 10 points arranged in circle or a square.

Training Phase:

1) Take 3 examples of circles and 3 examples of squares
2) Also tell the computer that whether extracted features are taken from a circle or a square
3) For each example, adjust 11 parameters such that the output for each example is +ve for circle and –ve for square.



$a_1*(x_1+y_1)+a_2*(x_2+y_2)+....+a_{10}*(x_{10}+y_{10})+a_{11} > 0$ (for all square examples in training)

$a_1*(x_1+y_1)+a_2*(x_2+y_2)+....+a_{10}*(x_{10}+y_{10})+a_{11} <= 0$ (for all circle examples in training)

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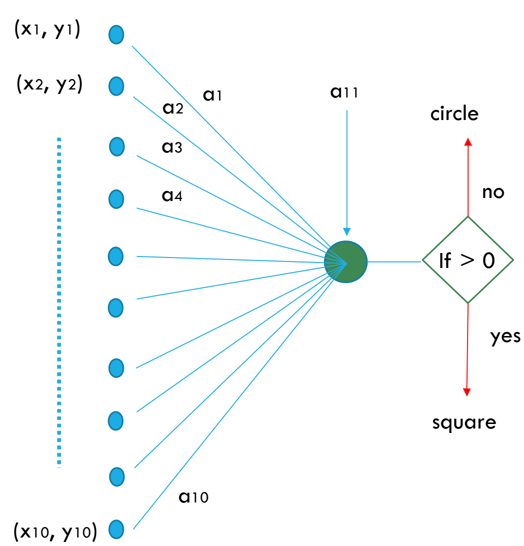
USING DL

The whole purpose of training is to calculate set of 11 parameters (a1,a2,…,a11)

Test Phase:

Multiply and add those 11 parameters with input test points to see if the output is +ve or –ve. If +ve then given test case/example is a square, otherwise a circle.

$a_1*(x_1+y_1)+a_2*(x_2+y_2)+....+a_{10}*(x_{10}+y_{10})+a_{11} = ?$



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SUMMARY

Scheme	Training Set required	Pre-Determined Features required
AI	No	Yes
ML	Yes	Yes
DL	Yes	No

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