Artificial Intelligence & Machine Learning Unit –I Introduction to AI & ML Course Objective ACQUAINT with fundamentals of artificial intelligence and machine learning. Course Outco…

Presentation · March 2022

DOI: 10.13140/RG.2.2.21191.98726

CITATION
1

READS
7,299

1 author:

Vishal Dhore
Guru Gobind Singh College of Engineering and Research Centre, Nashik
14 PUBLICATIONS **1** CITATION

SEE PROFILE

Artificial Intelligence & Machine Learning (302049)

TE Mechanical (2019 Course)

Unit – I

Introduction to AI & ML

By

Vishal J Dhore

Assistant Professor

Mechanical Engineering Department

Guru Gobind Singh College of Engineering and Research Centre, Nashik

Course Objective

ACQUAINT with fundamentals of artificial intelligence and machine learning.

Course Outcomes

On completion of the course, learner will be able to

CO1. DEMONSTRATE fundamentals of artificial intelligence and machine learning.

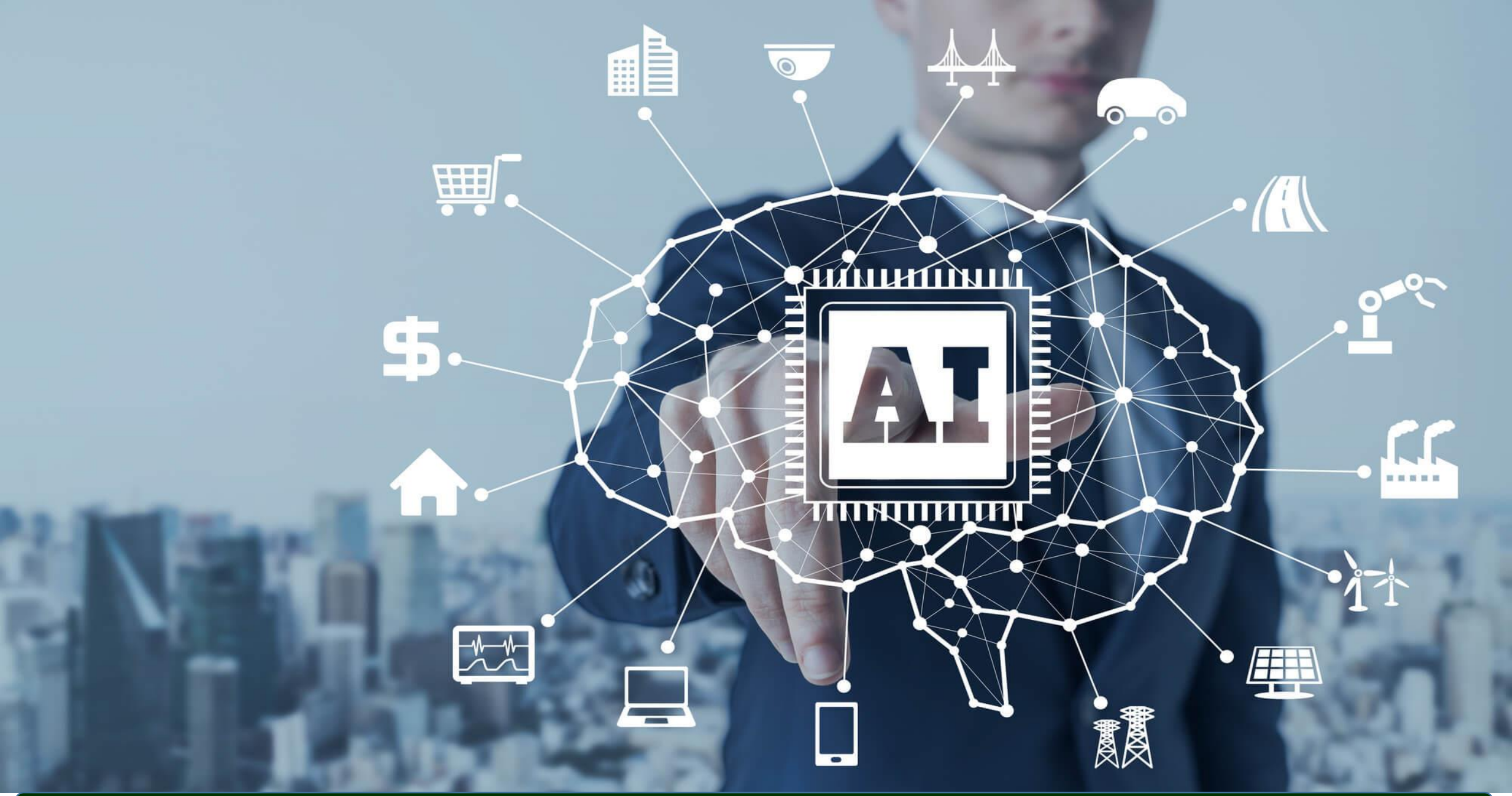
Content

History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning.

Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation.

Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical.

Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning.



Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

Why to study Artificial Intelligence (AI)?

There are 2 words: Artificial & Intelligence

Artificial

- Artificial objects, materials or processes do not occur naturally and are created by human beings, often using science and technology.
- Made by human work or art, not by nature, not natural.
- Made in imitation of or as a substitute for something natural; simulated.
- Unnatural in an affected way
- Pretended

Why to study Artificial Intelligence (AI)?

There are 2 words: Artificial & Intelligence

Intelligence

- The ability to learn or understand or to deal with new or trying situations: REASON.
- The ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (such as test).
- Mental acuteness: SHREWDNESS
- The act of understanding: COMPREHENSION
- The ability to perform computer functions

Why to study Artificial Intelligence (AI)?

- We call ourselves *Homo sapiens*—man the wise—because our **intelligence** is so important to us.
- For thousands of years, we have tried to understand *how we think*; that is, how a mere handful of matter can perceive, understand, predict, and manipulate a world far larger and more complicated than itself.
- The field of **artificial intelligence**, or AI, goes further still: it attempts not just to understand but also to *build* intelligent entities.
- AI is one of the newest fields in science and engineering.
- Work started in earnest soon after World War II, and the name itself was coined in 1956.
- Along with molecular biology, AI is regularly cited as the "field I would most like to be in" by scientists in other disciplines.

Why to study Artificial Intelligence (AI)?

- AI currently encompasses a huge variety of subfields, ranging from the general (learning and perception) to the specific, such as playing chess, proving mathematical theorems, writing poetry, driving a car on a crowded street, and diagnosing diseases and so on….
- AI is relevant to any intellectual task; it is truly a universal field.

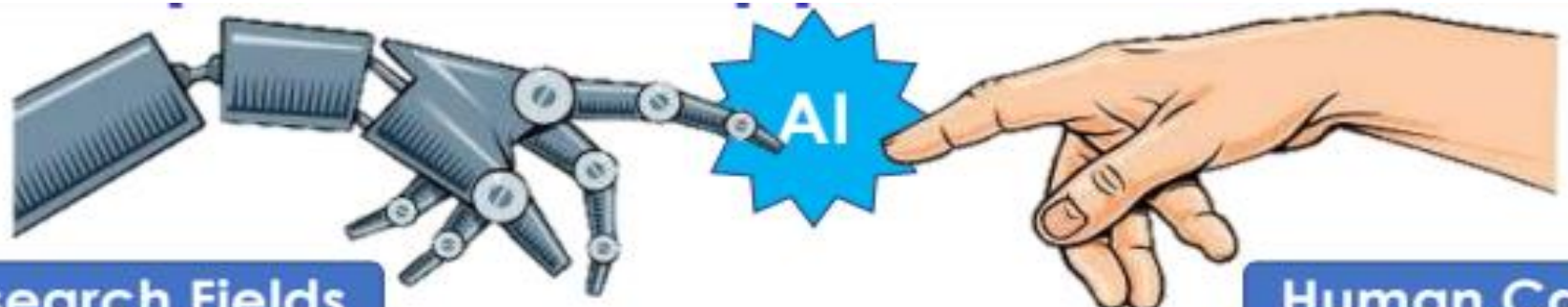
Mapping of Artificial Intelligence (AI)?

- Artificial Intelligence is quite a big umbrella term that covers all methods, algorithms and systems that exhibit some sort of intelligent behavior.
- One can mimic intelligence with coding into the system a set of heuristic rules, expressing some knowledge.
- So, it does not necessarily need to be through any kind of learning, but the knowledge can be built into the program.
- However, learning is as well one of the areas of artificial intelligence.

How human capabilities mapped to Artificial Intelligence fields?

- One of the great way to explain subareas of artificial intelligence is through human senses and capabilities.
- Human have set of senses and capabilities that make them behave intelligently.
- Artificial intelligence is trying to mimic this and therefore for each human sense or capability, there would be a field in artificial intelligence that would try to find the best way to mimic that capability.
- As shown in below figure here, the computer vision field of AI would mimic seeing, sound processing hearing, natural language processing will mimic language understanding, and so on.

How human capabilities mapped to Artificial Intelligence fields?



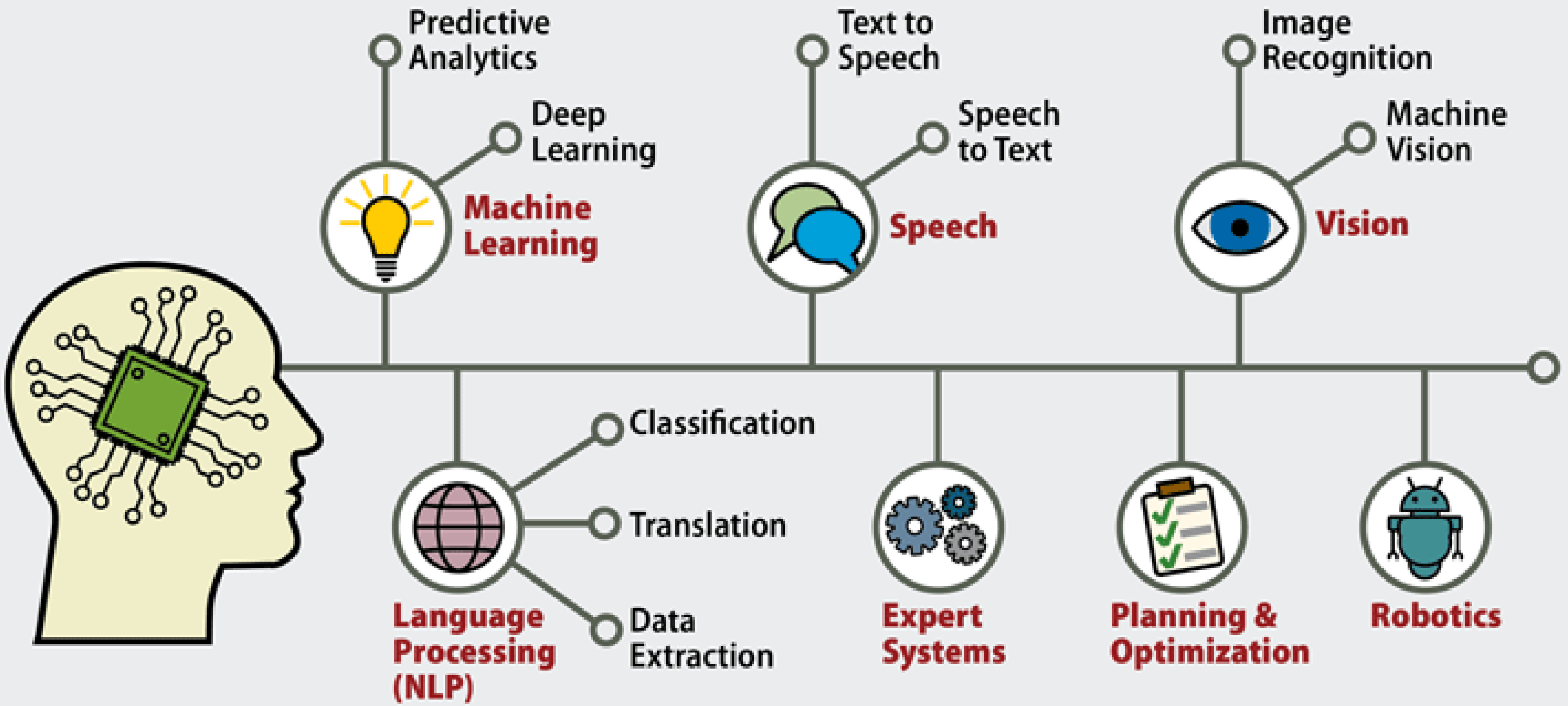
AI Research Fields	Human Capability
Computer Vision	Seeing
Sound Processing	Hearing
Sound Synthesis	Talking/Singing
Natural Language Processing	Understand language
Robotics	Movement
Automated Reasoning	Reasoning
Machine Learning	Learning

Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

How human capabilities mapped to Artificial Intelligence fields?

- Machine learning would mimic how human learns, and as we learn to understand language and recognize object, some of the machine learning concepts played a major role in the development and applications of other areas, such as computer vision, natural language processing, reasoning and so on.

What is scope of Artificial Intelligence?



Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

What is Artificial Intelligence (AI)?

- Historically some researchers have pursued several different versions of AI.
- Some have defined intelligence in terms of fidelity ***human*** performance, while others prefer an abstract, formal definition of intelligence called **rationality**- loosely speaking, doing the **"right thing"**.
- The subject matter itself also varies: some consider intelligence to be a property of internal **thought processes** and **reasoning**, while others focus on intelligent **behavior**, an external characterization.
- From these two dimensions-human vs. rational and thought vs. behavior-there are four possible combinations, and there have been adherents and research programs for all four.

What is Artificial Intelligence (AI)?

Thought	Systems that think like human	Systems that think rationally
Behavior	Systems that act like human	Systems that act rationally
	Human	**Rational**

- The methods used are necessarily different:
- The pursuit of human-like intelligence must be in part an empirical science related to psychology, involving observations and hypotheses about actual human behavior and thought processes.
- A rationalist approach, on the other hand, involves a combination of mathematics and engineering, and connects to statistics, control theory, and economics.

The Foundation of Artificial Intelligence (AI)

Philosophy: Where does knowledge come from?

Linguistics: How does language relate to thought?

Neuroscience: How do our brains process information?

Behavioral Economics: How do you make decisions to maximize utility?

Mathematics: What can be computed?

Computer Science: How can we build an efficient computer?

Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

History of Artificial Intelligence (AI)

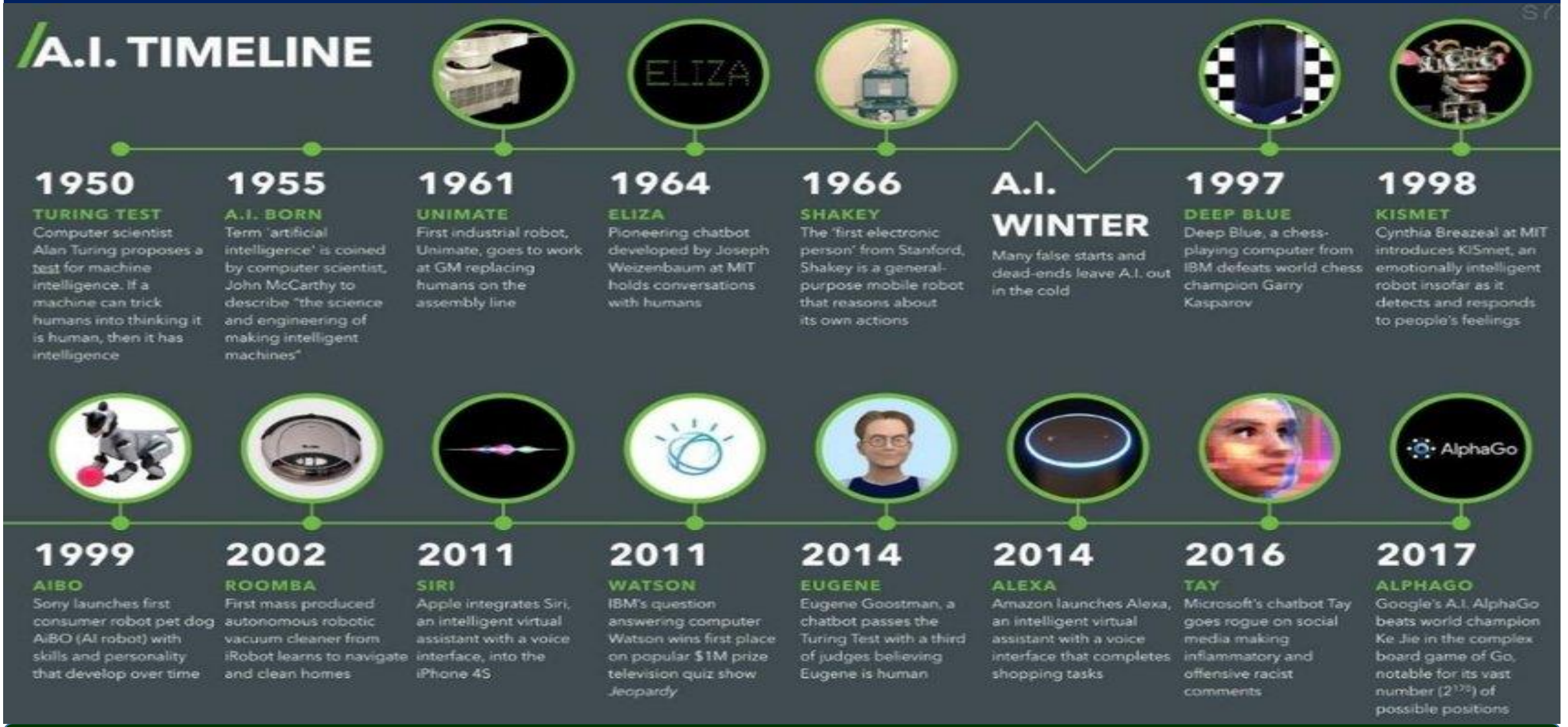
❖ The detailed phases of AI history are:

1. The inception of artificial intelligence **(1943-1953)**
2. Early enthusiasm, great expectations **(1952-1969)**
3. A dose of reality **(1966-1973)**
4. Expert systems **(1969-1986)**
5. The return of neural networks **(1986 – present)**
6. Probabilistic reasoning and machine learning **(1987 – present)**
7. Big data **(2001 – present)**
8. Deep learning **(2011 – present)**

History of Artificial Intelligence (AI)

- Everyone seems to be talking about Artificial Intelligence these days.
- It is good to remember that AI is not something new.
- Post World War-II, a variety of fields began to discuss the possibility of creating an artificial brain.
- Here is brief timeline of Artificial Intelligence history.

History of Artificial Intelligence (AI)



Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

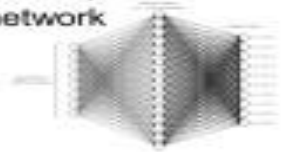
History of Artificial Intelligence (AI)

Turing test
1950

"Artificial Intelligence" term used for the first time
1956

ELIZA, natural language processing software
1965

Neocognitron, artificial neural network
1979



Neural networks widely used with the back-propagation algorithm
1986

Deep blue computer defeats Chess World Champion Gary Kasparov
1997

Amazon launches EC2 cloud computing service
2006

Apple launches the iPhone mobile revolution starts
2007

1940 1950 1960 1970 1980 1990 2000 2010 2020

Watson computer defeats quiz show Jeopardy champions
2011

Deep learning frameworks TensorFlow and Keras released
2015

AlphaGo defeats Champion Lee Sedol
2016

OpenAI's GPT3 produces language tasks almost indistinguishable from humans
2020

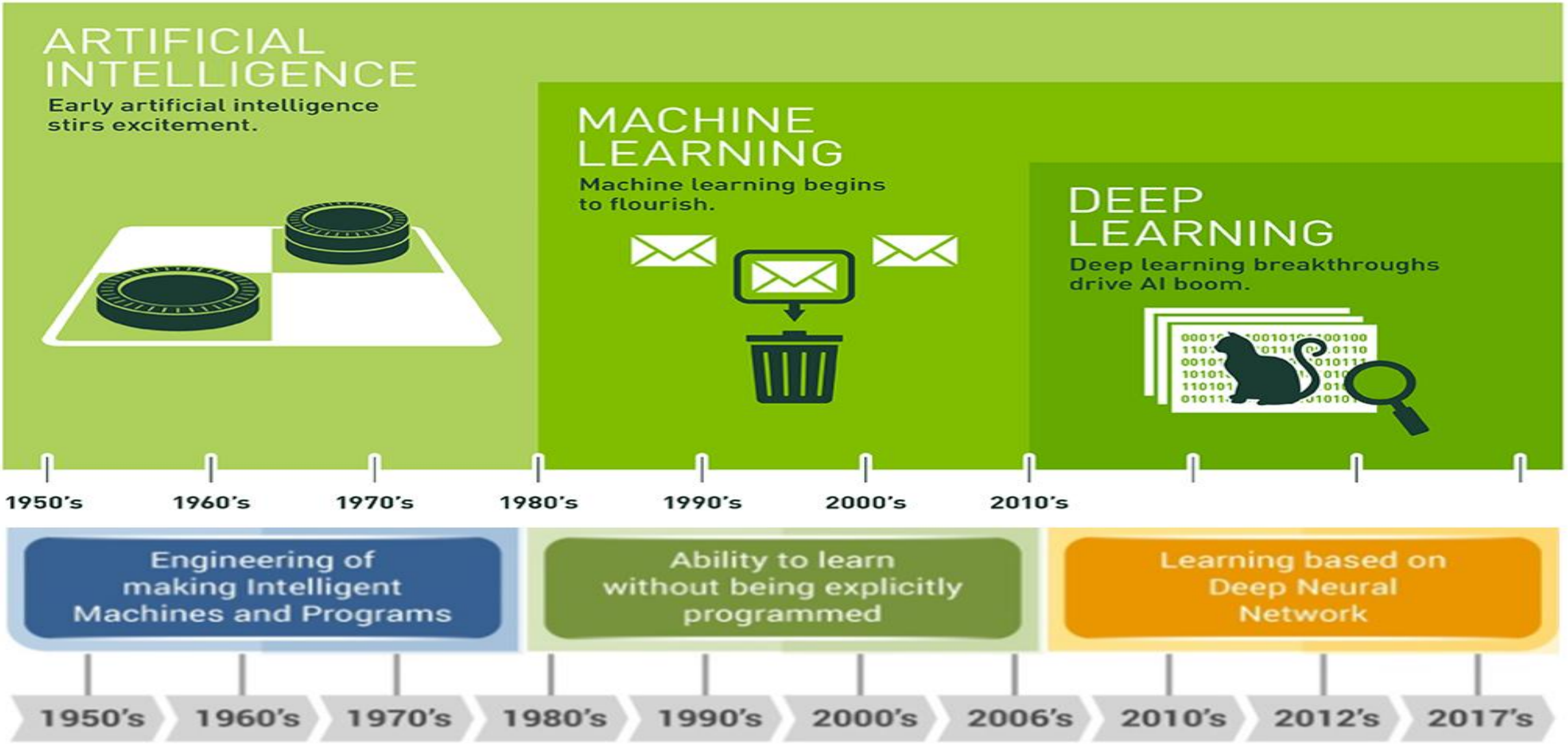
2010 2020

2011-2014
Boom virtual assistants (Siri, Google Now, Cortana, Alexa) use AI to understand natural language

2019
FDA's publishes foundation for a potential approach to premarket review for AI and ML-driven software modifications

Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

History of Artificial Intelligence (AI)



Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik

What is Data Science?

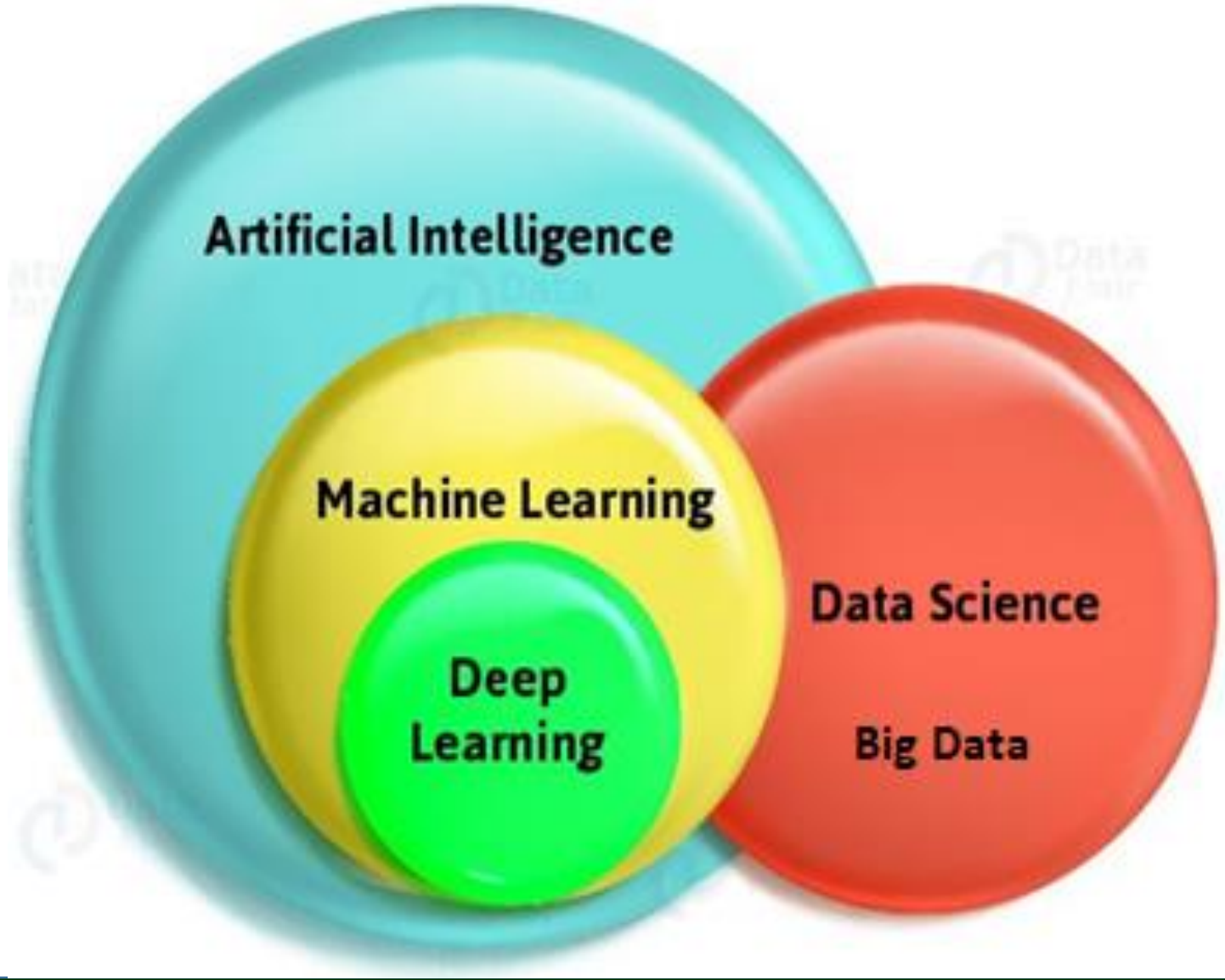
- Data science is the term for a whole set of **tools** and **techniques** by which to **analyze data** and **extract insights** from it.
- It makes use of **scientific methods, processes and algorithms** to make this happen.
- Essentially, its goal is to discover hidden patterns in raw data to help businesses improve and increase their profits.
- The term came to be buzzword when in **2012**, Harvard Business Review called it "**The sexiest job of the 21st century**".
- The data science life cycle comprises of 6 phases:

1. Discovery
2. Data preparation
3. Model planning
4. Model building
5. Communicating results
6. Operationalizing

What is Data Science?

- It is a field concerned with extracting insights from data by making use of **scientific methods** and **algorithms** so businesses can benefit.
- Data science uses **Machine Learning** to **analyze data** and make **predictions**; this can also be used in utilitarian prospects.
- Data science **combines ML with Big Data analytics and cloud computing**.
- It focuses on solving **real-world problems** and always has a **human involved** (unlike AI, where it is the AI that takes the action).
- As in apparent in diagram, it has much in common with all of Artificial Intelligence, Machine Learning and Deep Learning.

What is Data Science?



Comparison of AI with Data Science

Factors	Data Science	Artificial Intelligence
Scope	Involves various underlying data operations	Limited to the implementation of ML algorithms
Type of Data	Structured and unstructured	Standardized in the form of embeddings and vectors
Tools	R, Python, SAS, SPSS, TensorFlow, Keras, Scikit-learn	Scikit-learn, Kaffe, PyTorch, TensorFlow, Shogun, Mahout
Applications	Advertising, Marketing, Internet Search Engines	Manufacturing, Automation, Robotics, Transport, Healthcare

Need of AI in Mechanical Engineering

❖ To take the advantage of the potential of AI and Machine Learning by

- Using generative engineering
- Creating value from historical data
- Tapping into data sources
- Exploit experimental and simulation data
- Taking preventive actions before a predicted failure occurs
- Designing new from old concepts
- Optimizing existing and new products.

Need of AI in Mechanical Engineering

- Vehicle manufacturers across the world implement artificial intelligence (AI) at a rapid pace into their process.
- And with reason, Artificial Intelligence in automotive industries can help improve design processes, increase accuracy or speed up product development.
- AI and machine learning will revolutionize how business is conducted.
- By implementing AI in automotive development process, manufactures can make better use of data to recognize trends and make smarter decisions.
- The advantages of the potential of AI in automotive engineering processes are in:

- **Early Concept:** Evaluate best mechatronic design architecture using generative engineering.

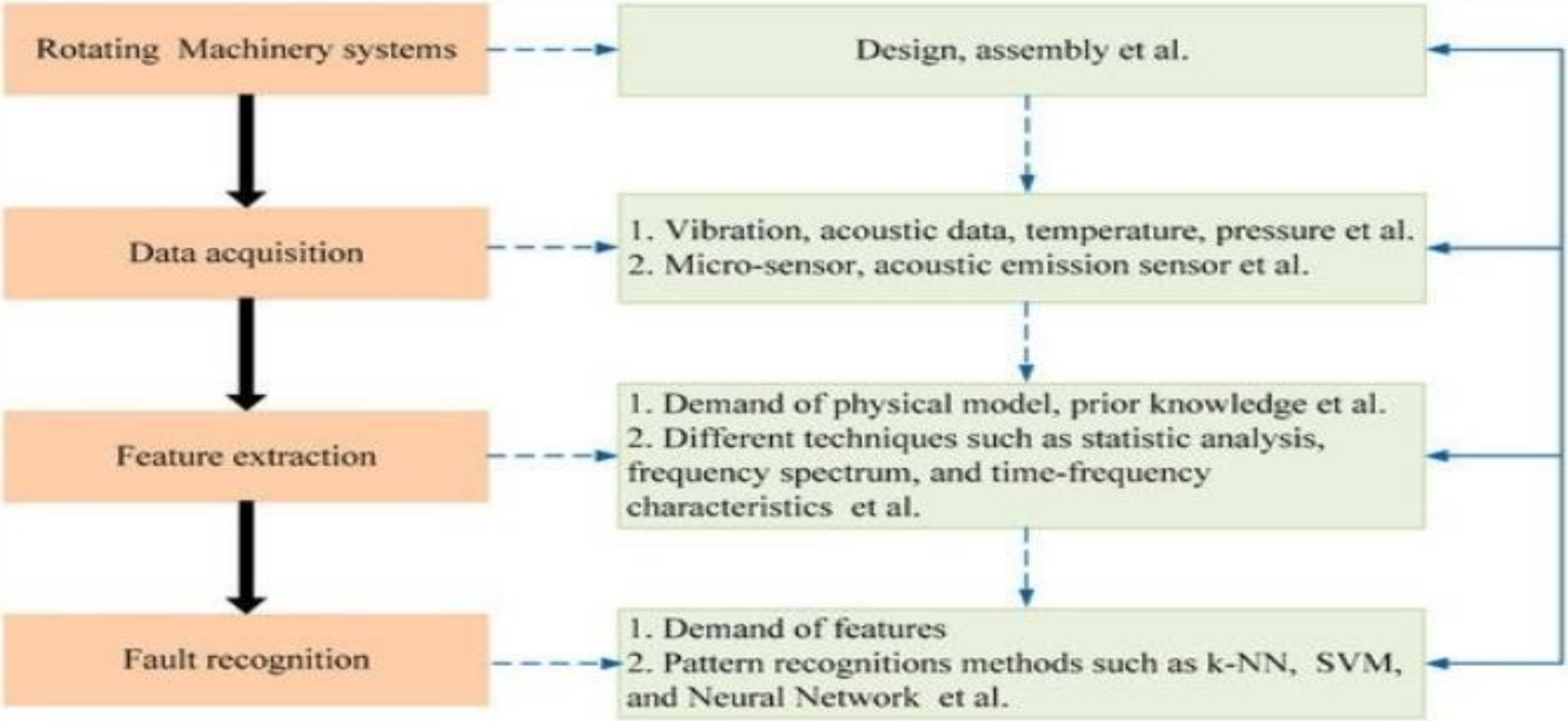
Need of AI in Mechanical Engineering

- **Target setting and benchmarking:** Create value from historical data.
- **CAE Optimization:** Tap into data sources with unlimited scalability.
- **Product validation:** Exploit experimental and simulation data for smarter scenario and product validation.
- **Predictive maintenance:** Monitor component lifetime and take preventive actions before a predicted failure occurs.
- To stop spending time to debug models, we must use the time to implement AI and machine learning to improve vehicle performance.

Need of AI in Mechanical Engineering

- **AI helping in Complex CAD:** Merging of AI and CAD is done through Model-Based Reasoning (MBR). Many new releases of software packages are using knowledge-based systems. A major field for the application of AI is Generative Design. SolidWorks gives a feature of topology optimization in its 2018 version.
- **Artificial Neural Networks in CFD:** Artificial Neural Networks(ANN) are gaining interest in academia for their potential to give approximations of flow with less computing power, time and dimensional reduction of problems.
- **IoT and Data Analysis:** 4^{th} industrial revolution is going to connect all machinery in a production plant and consumer products, so engineers can analyse, optimize and ensure quality of the product.

Need of AI in Mechanical Engineering



Introduction to Machine Learning (ML)

- Machine Learning is concerned with giving machines the ability to learn by training algorithms on a huge amount of data.
- It makes use of algorithms and statistical models to perform a task without needing explicit instructions.
- Machine Learning often deals with the following issues:

1. Collecting data 2. Filtering data 3. Analyzing data 4.Training algorithms
5. Testing algorithms 6. Using algorithms for future predictions

- Common examples of this phenomenon are virtual personal assistants, refined search engine results, image recognition, and product recommendations.

What is Machine Learning (ML)?

- University of Washington defines Machine Learning as "Machine learning algorithms can figure out how to perform important tasks by generalizing from examples."
- ML expert Tom M Mitchell states that "Machine learning is the study of computer algorithms that allow computer programs to automatically improve through experience."
- In simple words, machine learning involves algorithms that allow computers to learn automatically from previous interactions with users, without being distinctly programmed with the help of neural networks.
- It gives computers the skill to learn from previous data without an expert having to program it.
- With the help of machine learning, a system takes decisions based on previous patterns.

What are the basics of AI?

- Artificial Intelligence, fondly abbreviated as AI, is concerned with imparting human intelligence to machines.
- It focuses on the development of intelligent machines that can think and act like humans; essentially, Al is intelligence such as machines display.
- An intelligent agent is a device that can perceive its environment and act to optimize its chances of success.
- Such intelligent machines mimic human cognitive functions like learning and problem-solving.
- AI deals with the following issues/goals:

1. Reasoning and Problem solving
2. Knowledge representation
3. Planning
4. Learning
5. Perception
6. Motion and Manipulation

What are the basics of AI?

- The general problem of simulating (or creating) intelligence has been broken down into sub-problems.
- These consist of particular traits or capabilities that researchers except an intelligent system to display.
- The traits described on the following slides have received the most attention.

Reasoning and Problem Solving

- The reasoning is the mental process of deriving logical conclusion and making predictions from available knowledge, facts, and beliefs. ... In artificial intelligence, the reasoning is essential so that **the machine can also think rationally as a human brain**, and can perform like a human.
- In computer science, problem-solving refers to AI techniques, including various techniques such as forming efficient algorithms, heuristics, and performing root cause analysis to find desirable solutions. The basic crux of AI is to **solve problems just like humans**.
- Early researchers developed algorithms that imitated step-by-step reasoning that humans use when they solve puzzles or make logical deductions.
- By the late 1980s and 1990s, Al research had developed methods for dealing with uncertain or incomplete information, employing concepts from probability and economics.

Reasoning and Problem Solving

- Many of these algorithms proved to be insufficient for solving large reasoning problems because they experienced a "**combinatorial explosion**": they became exponentially slower as the problems grew larger.
- Even humans rarely use the step-by-step deduction that early Al research could model. They solve most of their problems using fast, intuitive judgments.

Knowledge Representation

- Knowledge representation is the field of artificial intelligence (AI) dedicated to representing information about the world in a form that **a computer system can use to solve complex tasks** such as diagnosing a medical condition or having a dialog in a natural language.
- Knowledge representation incorporates findings from psychology about how **humans solve problems** and **represent knowledge** in order to design formalisms that will **make complex systems easier to design and build.**
- Knowledge representation makes complex software easier to define and maintain than procedural code and can be used in expert systems.
- Knowledge representation and reasoning also incorporates findings from logic to automate various kinds of reasoning, such as the application of rules or the relations of sets and subsets.

Knowledge Representation

- Knowledge representation is not just storing data into some database, but it also **enables an intelligent machine to learn from that knowledge and experiences so that it can behave intelligently like a human.**
- Knowledge is an useful term to judge the understanding of an individual on a given subject.

Knowledge Representation

1. Declarative knowledge

- The knowledge which is based on concepts, facts and objects, is termed as 'Declarative Knowledge'.
- It provides all the necessary information about the problem in terms of simple statements, either true or false.

2. Procedural knowledge

- Procedural knowledge derives the information on the basis of rules, strategies, agendas and procedure.
- It describes how a problem can be solved.
- Procedural knowledge directs the steps on how to perform something.
- For example: Computer program.

Knowledge Representation

3. Heuristic knowledge

- Heuristic knowledge is based on thumb rule.
- It provides the information based on a thumb rule, which is useful in guiding the reasoning process.
- In this type, the knowledge representation is based on the strategies to solve the problems through the experience of past problems, compiled by an expert. Hence, it is also known as Shallow knowledge.

4. Meta-knowledge

- This type gives an idea about the other types of knowledge that are suitable for solving problem.
- Meta-knowledge is helpful in enhancing the efficiency of problem solving through proper reasoning process.

Knowledge Representation

5. Structural knowledge

- Structural knowledge is associated with the information based on rules, sets, concepts and relationships.
- It provides the information necessary for developing the knowledge structures and overall mental model of the problem.

Planning

- The planning in Artificial Intelligence is about the decision making tasks performed by the robots or computer programs to achieve a specific goal.
- Planning is the **task of finding a procedural course of action** for a declaratively described system to reach its goals while optimizing overall performance measures.
- The execution of planning is about choosing a sequence of actions with a high likelihood to complete the specific task.
- Planning can be viewed as an approach to problem solving. It **provides a systematic way of viewing problems and developing short- and long-term solutions**. It can also be viewed as a decision-making process used to help guide decisions concerning future needs.

Planning

❖ Blocks-World Planning Problem

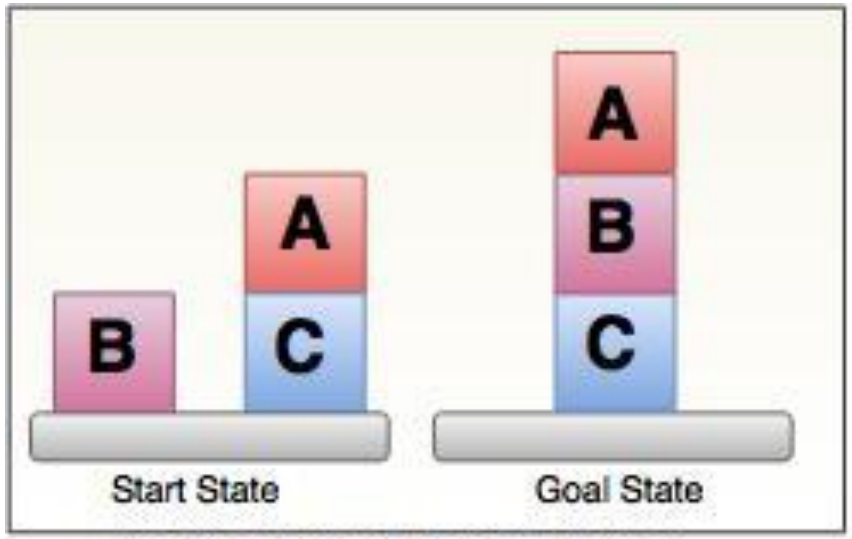


Fig: Blocks-World Planning Problem

•The blocks-world problem is known as **Sussman Anomaly.**

•Non interleaved planners of the early 1970s were unable to solve this problem, hence it is considered as anomalous.

•When two sub goals G1 and G2 are given, a non interleaved planner produces either a plan for G1 concatenated with a plan for G2, or vice-versa.

•In blocks-world problem, three blocks labeled as 'A', 'B', 'C' are allowed to rest on the flat surface. The given condition is that only one block can be moved at a time to achieve the goal.

•The start state and goal state are shown in the following diagram.

Planning

❖ Blocks-World Planning Problem

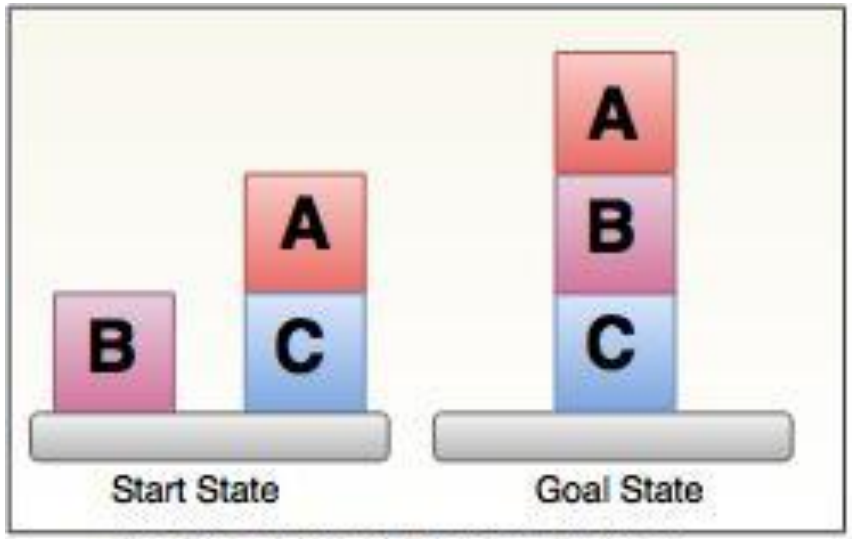


Fig: Blocks-World Planning Problem

The planning consists of following important steps:

- Choose the best rule for applying the next rule based on the best available heuristics.
- Apply the chosen rule for computing the new problem state.
- Detect when a solution has been found.
- Detect dead ends so that they can be abandoned and the system's effort is directed in more fruitful directions.
- Detect when an almost correct solution has been found.

Learning

- According to **Herbert Simon**, learning denotes changes in a system that enable a system to do the same task more efficiently the next time.
- **Arthur Samuel** stated that, "Machine learning is the subfield of computer science, that gives computers the ability to learn without being explicitly programmed ".
- In 1997, **Mitchell proposed that**, " A computer program is said to learn from experience 'E' with respect to some class of tasks 'T' and performance measure 'P', if its performance at tasks in 'T', as measured by 'P', improves with experience E ".
- The main purpose of machine learning is to study and design the algorithms that can be used to produce the predicates from the given dataset.
- Besides these, the machine learning includes the agents percepts for acting as well as to improve their future performance.

Learning

The following tasks must be learned by an agent.

- To predict or decide the result state for an action.
- To know the values for each state(understand which state has high or low vale).
- To keep record of relevant percepts.

Why do we require machine learning?

- Machine learning plays an important role in improving and understanding the efficiency of human learning.
- Machine learning is used to discover a new things not known to many human beings.

Learning

1. Rote learning

- Rote learning is possible on the basis of memorization.
- This technique mainly focuses on memorization by avoiding the inner complexities. So, it becomes possible for the learner to recall the stored knowledge.
- **For example:** When a learner learns a poem or song by reciting or repeating it, without knowing the actual meaning of the poem or song.

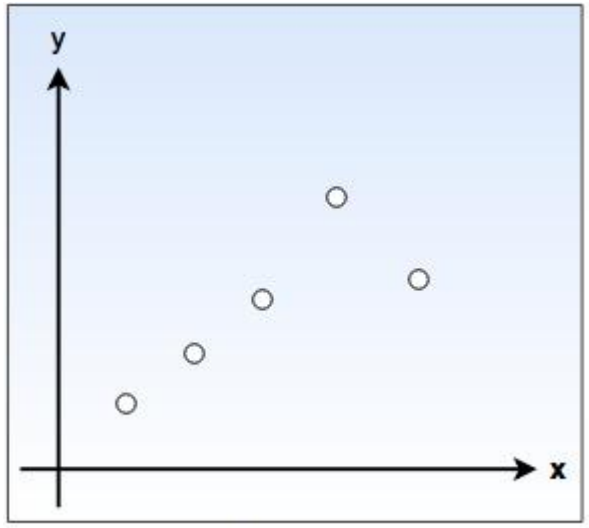
Learning

2. Induction learning (Learning by example)

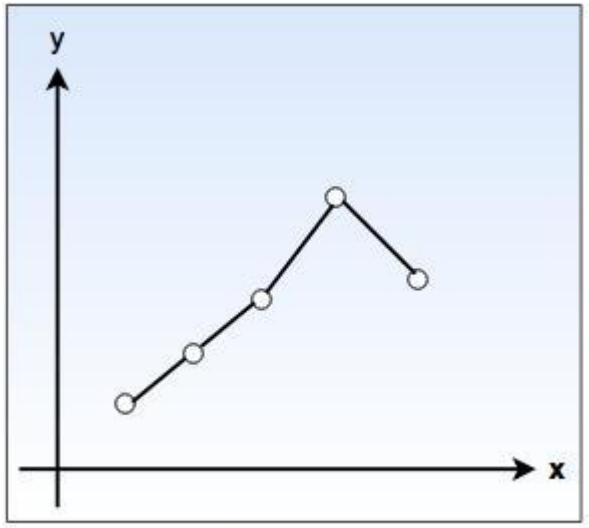
- Induction learning is carried out on the basis of supervised learning.
- In this learning process, a general rule is induced by the system from a set of observed instance.
- However, class definitions can be constructed with the help of a classification method.
- **For Example:** Consider that '***f***' is the target function and example is a pair (x f(x)), where 'x' is input and f(x) is the output function applied to 'x'. **Given problem:** Find hypothesis h such as h ≈ f

Learning

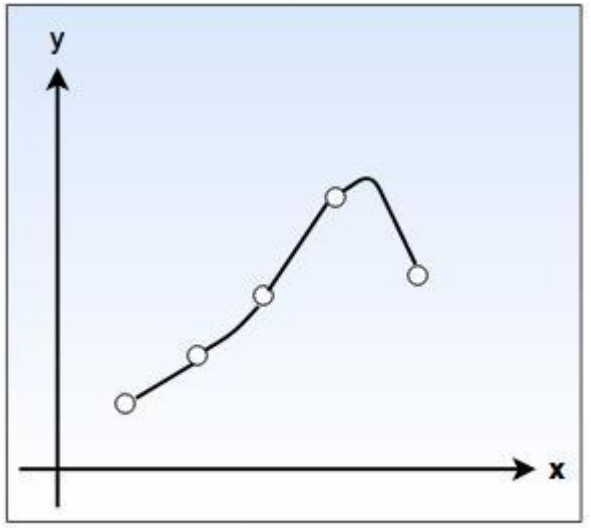
2. Induction learning (Learning by example)



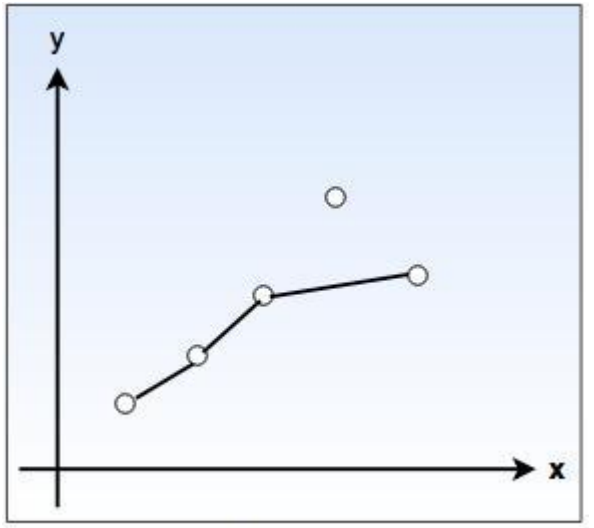
Fig(a)



Fig(b)



Fig(c)



Fig(d)

- fig-a, points (x,y) are given in plane so that y = f(x), and the task is to find a function h(x) that fits the point well.
- In fig-b, a piecewise-linear 'h' function is given, while the fig-c shows more complicated 'h' function.
- Both the functions agree with the example points, but differ with the values of 'y' assigned to other x inputs.
- As shown in fig.(d), we have a function that apparently ignores one of the example points, but fits others with a simple function. The true/ is unknown, so there are many choices for h, but without further knowledge, we have no way to prefer (b), (c), or (d).

Learning

3. Learning by taking advice

- This type is the easiest and simple way of learning.
- In this type of learning, a programmer writes a program to give some instructions to perform a task to the computer. Once it is learned (i.e. programmed), the system will be able to do new things.
- Also, there can be several sources for taking advice such as humans(experts), internet etc.
- However, this type of learning has a more necessity of inference than rote learning.
- As the stored knowledge in knowledge base gets transformed into an operational form, the reliability of the knowledge source is always taken into consideration.

Learning

Explanation based learning

- Explanation-based learning (EBL) deals with an idea of single-example learning.
- This type of learning usually requires a substantial number of training instances but there are two difficulties in this:
  I. it is difficult to have such a number of training instances
  II. Sometimes, it may help us to learn certain things effectively, specially when we have enough knowledge.
- Hence, it is clear that instance-based learning is more data-intensive, data-driven while EBL is more knowledge-intensive, knowledge-driven.
- Initially, an EBL system accepts a training example.

Learning

Explanation based learning

- On the basis of the given goal concept, an operationality criteria and domain theory, it "generalizes" the training example to describe the goal concept and to satisfy the operationality criteria (which are usually a set of rules that describe relationships between objects and actions in a domain).
- Thus, several applications are possible for the knowledge acquisition and engineering aspects.

Learning

Learning in Problem Solving

- Humans have a tendency to learn by solving various real world problems.
- The forms or representation, or the exact entity, problem solving principle is based on reinforcement learning.
- Therefore, repeating certain action results in desirable outcome while the action is avoided if it results into undesirable outcomes.
- As the outcomes have to be evaluated, this type of learning also involves the definition of a utility function. This function shows how much is a particular outcome worth?
- There are several research issues which include the identification of the learning rate, time and algorithm complexity, convergence, representation (frame and qualification problems), handling of uncertainty (ramification problem), adaptivity and "unlearning" etc.

Learning

Learning in Problem Solving

- In reinforcement learning, the system (and thus the developer) know the desirable outcomes but does not know which actions result into desirable outcomes.
- In such a problem or domain, the effects of performing the actions are usually compounded with side-effects. Thus, it becomes impossible to specify the actions to be performed in accordance to the given parameters.
- Q-Learning is the most widely used reinforcement learning algorithm.

Perception

- Perception is a process to interpret, acquire, select and then organize the sensory information that is captured from the real world.
- For example: Human beings have sensory receptors such as touch, taste, smell, sight and hearing. So, the information received from these receptors is transmitted to human brain to organize the received information.
- According to the received information, action is taken by interacting with the environment to manipulate and navigate the objects.
- Perception and action are very important concepts in the field of Robotics. The following figures show the complete autonomous robot.

Perception

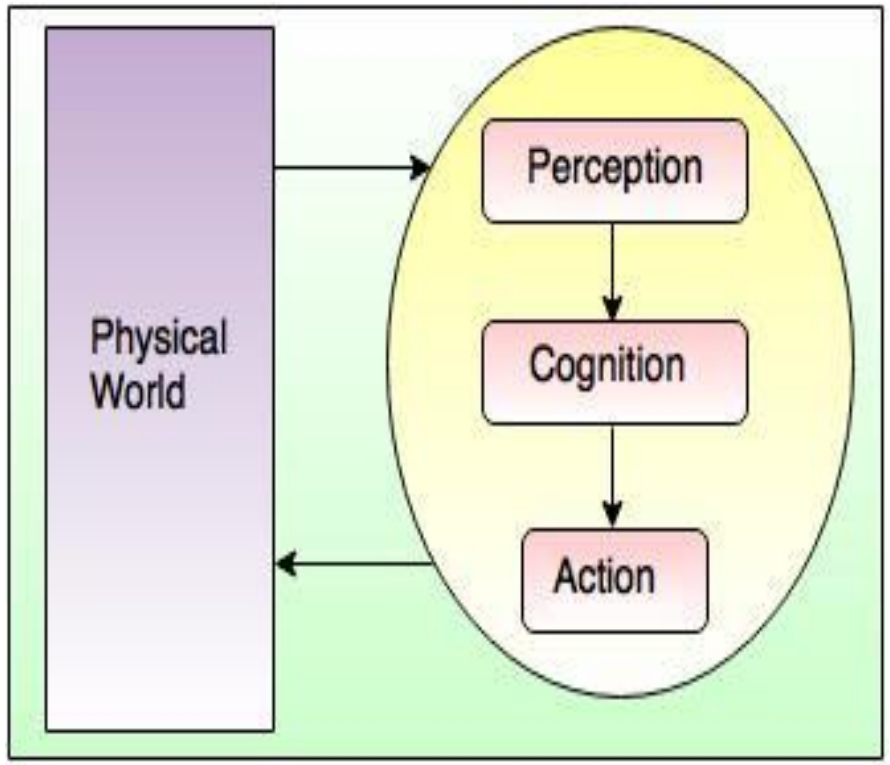


Fig: Autonomous Robot

- There is one important difference between the artificial intelligence program and robot. The AI program performs in a computer stimulated environment, while the robot performs in the physical world.
- **For example:**
  In chess, an AI program can be able to make a move by searching different nodes and has no facility to touch or sense the physical world. However, the chess playing robot can make a move and grasp the pieces by interacting with the physical world.

Motion and Manipulation

- Al is heavily used in robotics.
- Localization is how a robot knows its location and map its environment. When given a small, static, and visible environment, this is easy; however, dynamic environments, such as (in endoscopy) the interior of a patient's breathing body, pose a greater challenge.
- Motion planning is the process of breaking down a movement task into "primitives" such as individual joint movements.
- Such movement often involves compliant motion, a process where movement requires maintaining physical contact with an object.
- Robots can learn from experience how to move efficiently despite the presence of friction and gear slippage.

Approaches of AI

- Currently there is many approaches that drives Al research.
- There is no established paradigm of AI research, and researchers disagree about many issues.
- There are many questions that still are unanswered.
- One of those question is how relevant research in neurology and psychology is to research in AI and machine learning.
- For example there is little in common between biology of birds with aeronautics.
- So some scientists thinks that it is same in AI, but some also thinks that understanding of how human brain works will help us create better AI.

Approaches of AI

- Other questions are:
- Can intelligent behavior be described using simple, elegant principles (such as logic or optimization)? Or does it necessarily require solving a large number of completely unrelated problems?
- Can intelligence be reproduced using high-level symbols, similar to words and ideas? Or does it require “sub-symbolic” processing?
- Different answers to these questions gives us different approaches.
- The following four main approaches of AI:

1. Cybernetics and brain simulation
2. Symbolic
3. Sub-symbolic
4. Statistical

Cybernetics & Brain Simulation

❖ Cybernetics

- "Cybernetics" comes from a Greek word meaning "the art of steering".
- Cybernetics grew from a desire to understand and build systems that can achieve goals, whether complex human goals or just goals like maintaining the temperature of a room under changing conditions.
- Cybernetics more broadly encompasses the study of how systems regulate themselves and take action toward goals based on feedback from the environment.

❖ Brain Simulation

- **Brain simulation** is the concept of creating a functioning computer model of a brain or part of a brain.
- Brain simulation projects intend to contribute to a complete understanding of the brain, and eventually also assist the process of treating and diagnosing brain diseases.

Cybernetics & Brain Simulation

- In the 1940s and 1950s, a number of researchers explored the connection between neurology, information theory, and cybernetics.
- Some of them built machines that used electronic networks to exhibit rudimentary intelligence, such as W. Grey Walter's turtles and the Johns Hopkins Beast.
- Many of these researchers gathered for meetings of the Teleological Society at Princeton University and the Ratio Club in England.
- By 1960, this approach was largely abandoned.
- First problem was that building hardware that simulates neurological processes requires a too many components, and it would he physically hard to connect such large number of neurons as human has.
- Nowadays some scientist are getting also back to this approach.

Symbolic

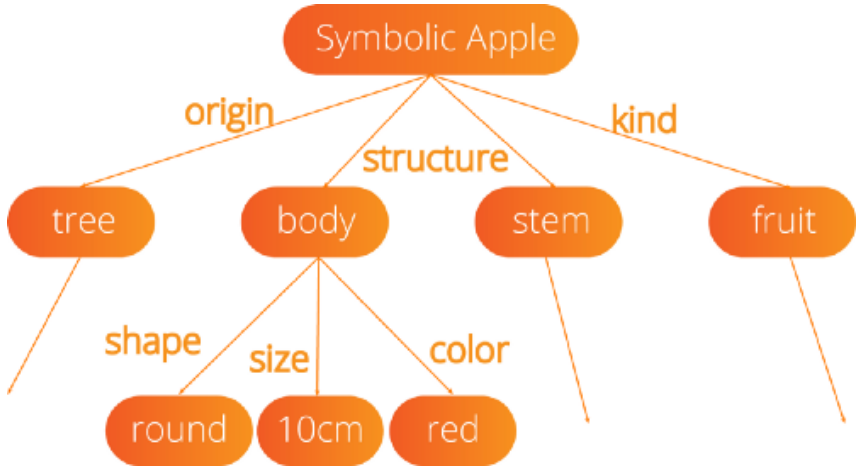
- When access to digital computers became possible in the middle 1950s, AI research began to explore the possibility that human intelligence could be reduced to symbol manipulation.
- The research was centered in three institutions: Carnegie Mellon University, Stanford and MIT, and each one developed its own style of research. John Haugeland named these approaches to AI “good old fashioned AI” or “GOFAI”.
- During the 1960s, symbolic approaches had achieved great success at simulating high-level thinking in small demonstration programs.
- Approaches based on cybernetics or neural networks were abandoned or pushed into the background.
- Researchers in the 1960s and the 1970s were convinced that symbolic approaches would eventually succeed in creating a machine with artificial general intelligence and considered this the goal of their field.

Symbolic

- Symbolic approach to knowledge representation and processing uses names to explicitly define the meaning of represented knowledge.
- Symbolic approach, introduced by Newell & Simon in 1976 describes AI as the development of models using symbolic manipulation.
- In AI applications, computers process symbols rather than numbers or letters. In the Symbolic approach, AI applications process strings of characters that represent real-world entities or concepts.
- Symbols can be arranged in structures such as lists, hierarchies, or networks and these structures show how symbols relate to each other.
- a Symbolic approach offer good performances in reasoning, is able to give explanations and can manipulate complex data structures, but it has generally serious difficulties in anchoring their symbols in the perceptive world.

Symbolic

- Symbolic AI is a sub-field of artificial intelligence that focuses on the high-level symbolic (human-readable) representation of problems, logic, and search.
- Between the 50s and the 80s, symbolic AI was the dominant AI paradigm. For instance, if you ask yourself, with the Symbolic AI paradigm in mind, “What is an apple?”, the answer will be that an apple is “a fruit,” “has red, yellow, or green color,” or “has a roundish shape.”
- These descriptions are symbolic because we utilize symbols (color, shape, kind) to describe an apple.

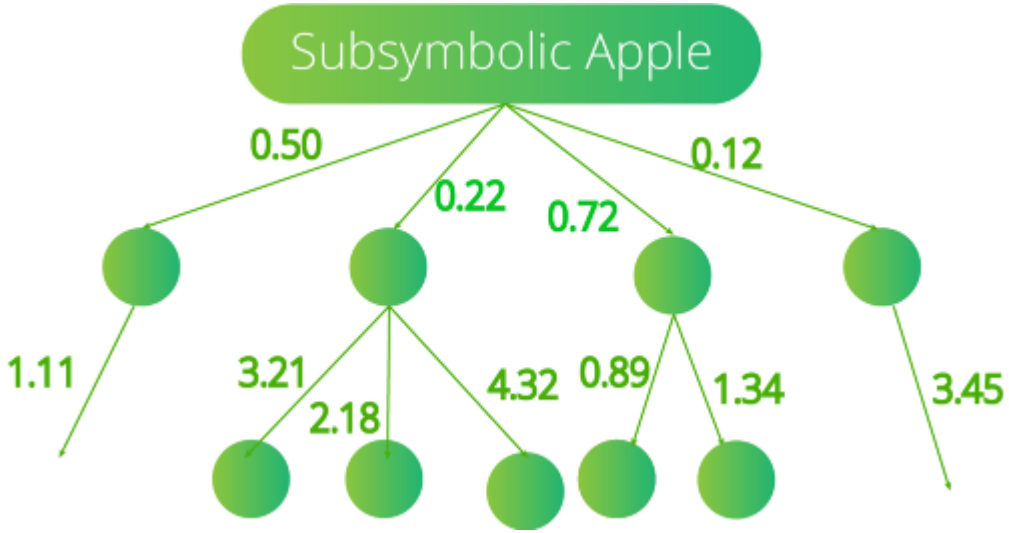


Sub-symbolic

- Subsymbolic artificial intelligence is the set of alternative approaches which do not use explicit high level symbols, such as mathematical optimization, statistical classifiers and neural networks. Symbolic AI was the dominant paradigm of AI research from the mid-1950s until the middle 1990s.
- “Subsymbolic" if it is made by constituent entities that are not representations in their turn, e.g., pixels, sound images as perceived by the ear, signal samples; subsymbolic units in neural networks can be considered particular cases of this category.
- AI models are often used to make predictions, and these models can be explicitly represented -as in symbolic AI paradigm- or implicitly represented. Implicit representation is derived from the learning from experience with no symbolic representation of rules and properties.

Sub-symbolic

- The main assumption of the subsymbolic paradigm is that the ability to extract a good model with limited experience makes a model successful. Here, instead of clearly defined human-readable relations, we design less explainable mathematical equations to solve problems.



- Neural networks, ensemble models, regression models, decision trees, support vector machines are some of the most popular Subsymbolic AI models that you can easily come across, especially if you are developing ML models.

- Starting from the 80s, the Subsymbolic AI paradigm has taken over Symbolic AI's position as the leading sub-field under Artificial Intelligence due to its high accuracy performance and flexibility.

Statistical

- The statistical approach **involves defining phenomena in terms of numbers and then using the numbers to either imply or deduce cause and effect**. Statistics are a key research tool for quantitative researchers.
- It's a process where the AI system **gather, organize, analyze and interpret numerical information from data**. More and more industries are applying AL to process improvement in the design and manufacture of their products.
- Some consider statistics to be a distinct mathematical science rather than a branch of mathematics. While many scientific investigations make use of data, statistics is concerned with the use of data in the context of uncertainty and decision making in the face of uncertainty.

Statistical

- In the 1990s, AI researchers developed sophisticated mathematical tools to solve specific subproblems.
- These tools are truly scientific, in the sense that their results are both measurable and verifiable, and they have been responsible for many of AI's recent successes.
- The shared mathematical language has also permitted a high level of collaboration with more established fields (like mathematics, economics or operations research).
- Stuart Russell and Peter Norvig describe this movement as nothing less than a "revolution" and "the victory of the neats."
- Critics argue that these techniques are too focused on particular problems and have failed to address the long term goal of general intelligence.

Approaches to ML

- Machine Learning can be approached by following types:

1. Supervised Learning
2. Unsupervised Learning
3. Reinforcement Learning

Supervised Learning

- Supervised learning is a subcategory of machine learning and artificial intelligence.
- It is defined by its use of labeled datasets to train algorithms that to classify data or predict outcomes accurately.
- As input data is fed into the model, it adjusts its weights until the model has been fitted appropriately, which occurs as part of the cross validation process.
- Supervised learning helps organizations solve for a variety of real-world problems at scale, such as classifying spam in a separate folder from your inbox.
- Supervised learning, as the name indicates, has the presence of a supervisor as a teacher.
- Basically supervised learning is when we teach or train the machine using data that is well labeled. Which means some data is already tagged with the correct answer.

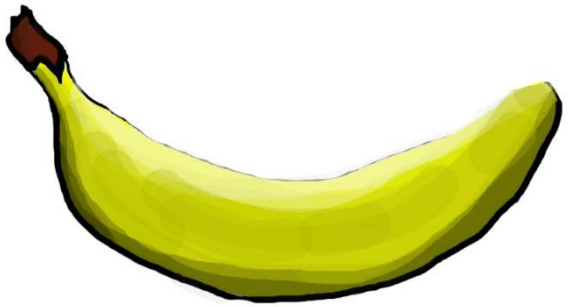
Supervised Learning

- After that, the machine is provided with a new set of examples(data) so that the supervised learning algorithm analyses the training data(set of training examples) and produces a correct outcome from labeled data.
- For instance, suppose you are given a basket filled with different kinds of fruits. Now the first step is to train the machine with all different fruits one by one like this:

- If the shape of the object is rounded and has a depression at the top, is red in color, then it will be labeled as –**Apple.**
- If the shape of the object is a long curving cylinder having Green-Yellow color, then it will be labeled as –**Banana.**

Supervised Learning

- Now suppose after training the data, you have given a new separate fruit, say Banana from the basket, and asked to identify it.



- Since the machine has already learned the things from previous data and this time has to use it wisely.
- It will first classify the fruit with its shape and color and would confirm the fruit name as BANANA and put it in the Banana category.
- Thus the machine learns the things from training data(basket containing fruits) and then applies the knowledge to test data(new fruit).

Supervised Learning

Supervised learning is classified into two categories of algorithms:

- **Classification:** A classification problem is when the output variable is a category, such as “Red” or “blue” or “disease” and “no disease”.
- **Regression:** A regression problem is when the output variable is a real value, such as “dollars” or “weight”.
- Supervised learning deals with or learns with “labeled” data. This implies that some data is already tagged with the correct answer.
- **Examples of Supervised Learning Algorithms:-**

1. Linear Regression
2. Nearest Neighbor
3. Gaussian Naive Bayes
4. Decision Trees
5. Support Vector Machine (SVM)
6. Random Forest

Supervised Learning

Advantages:-

- Supervised learning allows collecting data and produces data output from previous experiences.
- Helps to optimize performance criteria with the help of experience.
- Supervised machine learning helps to solve various types of real-world computation problems.

Disadvantages:-

- Classifying big data can be challenging.
- Training for supervised learning needs a lot of computation time. So, it requires a lot of time.

Unsupervised Learning

- Unsupervised learning is the training of a machine using information that is neither classified nor labeled and allowing the algorithm to act on that information without guidance.
- Here the task of the machine is to group unsorted information according to similarities, patterns, and differences without any prior training of data.
- Unlike supervised learning, no teacher is provided that means no training will be given to the machine. Therefore the machine is restricted to find the hidden structure in unlabeled data by itself.
- For instance, suppose it is given an image having both dogs and cats which it has never seen.

Unsupervised Learning

- Thus the machine has no idea about the features of dogs and cats so we can’t categorize it as ‘dogs and cats ‘. But it can categorize them according to their similarities, patterns, and differences, i.e., we can easily categorize the above picture into two parts. The first may contain all pics having dogs in them and the second part may contain all pics having cats in them. Here you didn’t learn anything before, which means no training data or examples.
- It allows the model to work on its own to discover patterns and information that was previously undetected. It mainly deals with unlabelled data.

Unsupervised Learning

Unsupervised learning is classified into two categories of algorithms:

- **Clustering:** A clustering problem is where you want to discover the inherent groupings in the data, such as grouping customers by purchasing behavior.
- **Association:** An association rule learning problem is where you want to discover rules that describe large portions of your data, such as people that buy X also tend to buy Y.

- Examples of unsupervised learning algorithms:

1. K-means clustering
2. KNN clustering
3. Hierarchical clustering

Unsupervised Learning

Advantages:

- Labeling of data demands a lot of manual work and expenses. Unsupervised learning solves the problem by learning the data and classifying it without any labels.
- The labels can be added after the data has been classified which is much easier.
- It is very helpful in finding patterns in data, which are not possible to find using normal methods.
- Dimensionality reduction can be easily accomplished using unsupervised learning.
- This is the perfect tool for data scientists, as unsupervised learning can help to understand raw data.
- We can also find up to what degree the data are similar. This can be accomplished with probabilistic methods.
- This type of learning is similar to human intelligence in some way as the model learns slowly and then calculates the result.

Unsupervised Learning

Disadvantages:

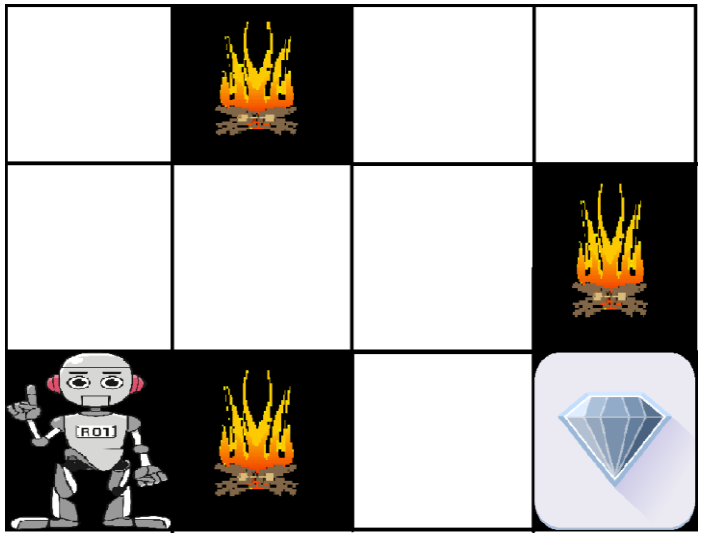
- The result might be less accurate as we do not have any input data to train from.
- The model is learning from raw data without any prior knowledge.
- It is also a time-consuming process. The learning phase of the algorithm might take a lot of time, as it analyses and calculates all possibilities.
- For some projects involving live data, it might require continuous feeding of data to the model, which will result in both inaccurate and time-consuming results.
- The more the features, the more the complexity increases.

Reinforcement Learning

- Reinforcement learning is an area of Machine Learning.
- It is about taking suitable action to maximize reward in a particular situation. It is employed by various software and machines to find the best possible behavior or path it should take in a specific situation.
- Reinforcement learning differs from supervised learning in a way that in supervised learning the training data has the answer key with it so the model is trained with the correct answer itself whereas in reinforcement learning, there is no answer but the reinforcement agent decides what to do to perform the given task.
- In the absence of a training dataset, it is bound to learn from its experience.

Reinforcement Learning

- Example: The problem is as follows: We have an agent and a reward, with many hurdles in between. The agent is supposed to find the best possible path to reach the reward. The following problem explains the problem more easily.



- The above image shows the robot, diamond, and fire. The goal of the robot is to get the reward that is the diamond and avoid the hurdles that are fired.
- The robot learns by trying all the possible paths and then choosing the path which gives him the reward with the least hurdles.
- Each right step will give the robot a reward and each wrong step will subtract the reward of the robot.
- The total reward will be calculated when it reaches the final reward that is the diamond.

Reinforcement Learning

Main points in Reinforcement learning –

- **Input:** The input should be an initial state from which the model will start
- **Output:** There are many possible outputs as there are a variety of solutions to a particular problem
- **Training:** The training is based upon the input, The model will return a state and the user will decide to reward or punish the model based on its output.
- The model keeps continues to learn.
- The best solution is decided based on the maximum reward.

Reinforcement Learning

Types of Reinforcement learning –

- **Positive –**
- Positive Reinforcement is defined as when an event, occurs due to a particular behavior, increases the strength and the frequency of the behavior. In other words, it has a positive effect on behavior.

Advantages of reinforcement learning are:

- Maximizes Performance
- Sustain Change for a long period of time
- Too much Reinforcement can lead to an overload of states which can diminish the results

Reinforcement Learning

Types of Reinforcement learning –

- **Negative –**

Negative Reinforcement is defined as strengthening of behavior because a negative condition is stopped or avoided.

Advantages of reinforcement learning:

- Increases Behavior
- Provide defiance to a minimum standard of performance
- It Only provides enough to meet up the minimum behavior

Reinforcement Learning

Various Practical applications of Reinforcement Learning –

- RL can be used in robotics for industrial automation.
- RL can be used in machine learning and data processing
- RL can be used to create training systems that provide custom instruction and materials according to the requirement of students.

RL can be used in large environments in the following situations:

- A model of the environment is known, but an analytic solution is not available;
- Only a simulation model of the environment is given (the subject of simulation-based optimization)
- The only way to collect information about the environment is to interact with it.

Thank You !!!

Vishal J Dhore, Assistant Professor, Mechanical Engineering, Guru Gobind Singh College of Engineering & Research Centre, Nashik