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Advanced AI

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About the Course

Name of the subject:Advanced AI
Course Code:MCA 301
Programme:Master in Computer Applications
Year of study:Second Year
Semester :III
Specialization:Artificial Intelligence and Data Science
Course Type:Specialization Course
Academic Year:2023-24

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Syllabus

Module-I: Introduction

Introduction to Artificial Intelligence, Foundations of Artificial Intelligence, History of Artificial Intelligence, State of the Art, Risks and Benefits of AI, Intelligent Agents, Production systems in AI.

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Module-II:Problem Solving

Solving Problems by Searching, Problem-Solving Agents, Search Algorithms: Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Heuristic Functions, Local Search and Optimization Problems.

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Module-III:Knowledge Representation and Reasoning

Propositional Logic: Propositional Theorem Proving, Effective Propositional Model Checking, Agents Based on Propositional Logic, First-Order Logic, Syntax and Semantics of First-Order Logic, Using First-Order Logic, Knowledge Engineering in First-Order Logic, knowledge representation using propositional and predicate logic, comparison of propositional and predicate logic, reasoning and Types of reasoning

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Module-IV:Advanced AI Models

Transformer-based Language Models:GPT-3 (Generative Pre-trained Transformer 3)

Generative Models: GAN ,HMM, Auto regressive model, Applications, Evaluation and challenges of generative models

Deep Generative Models :Deep Learning, Advanced DNN, Recurrent Neural Networks (RNNs) ,CNN,LSTM, GRU, GAN

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Module-V:Emerging Trends in AI

- Introduction to Computer Vision and its Applications
- Introduction to Natural Language Processing and its Applications
- Introduction to Explainable AI and Interpretability
- Introduction to Quantum AI and its potential impact
- Introduction to Edge AI and Federated Learning

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Books

Sr.No.	Text Books	Name of the Author
1	“Artificial Intelligence: A Modern Approach”	Stuart Russell and Peter Norvig
2	“A First Course in Artificial Intelligence”	Deepak Khemani
3	“Artificial Intelligence”	Elaine Rich, Kevin Knight and Nair
4	“Deep Learning”	Ian Goodfellow The MIT Press
Sr.No.	**Reference Books**	**Name of the Author**
1	“Artificial Intelligence: A new Synthesis”	Nilsson Nils J
2	“Artificial Intelligence”	Patrick Henry Winston
3	“Computational Intelligence: An Introduction”	Andries P. Engelbrecht
4	“Artificial Intelligence: Concepts and Applications”	Dr. Lavika Goel

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Advanced Artificial Intelligence

Module 01.Introduction

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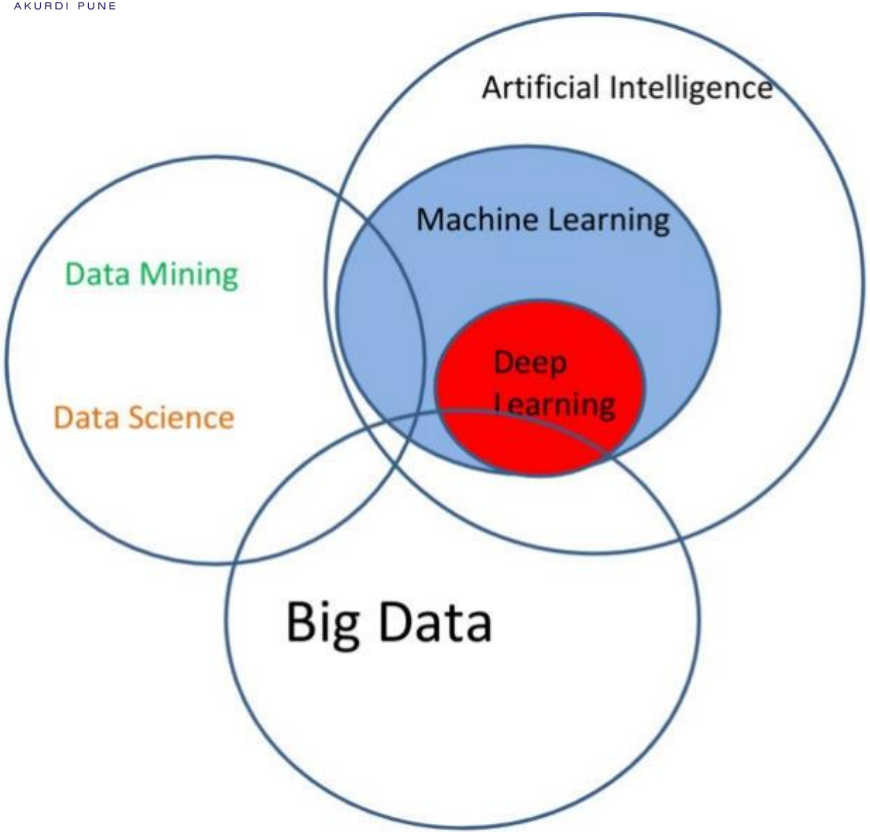
Introduction



Data Science:

- Based on strict analytical evidence
- Deal with structured & unstructured data
- Includes various data operations
- Extracts meaningful insights

Data Mining:

- Key part of data analytics
- Process of sorting through large data sets to identify patterns and relationships

Big Data:

- It is larger, more complex data sets, especially from new data sources

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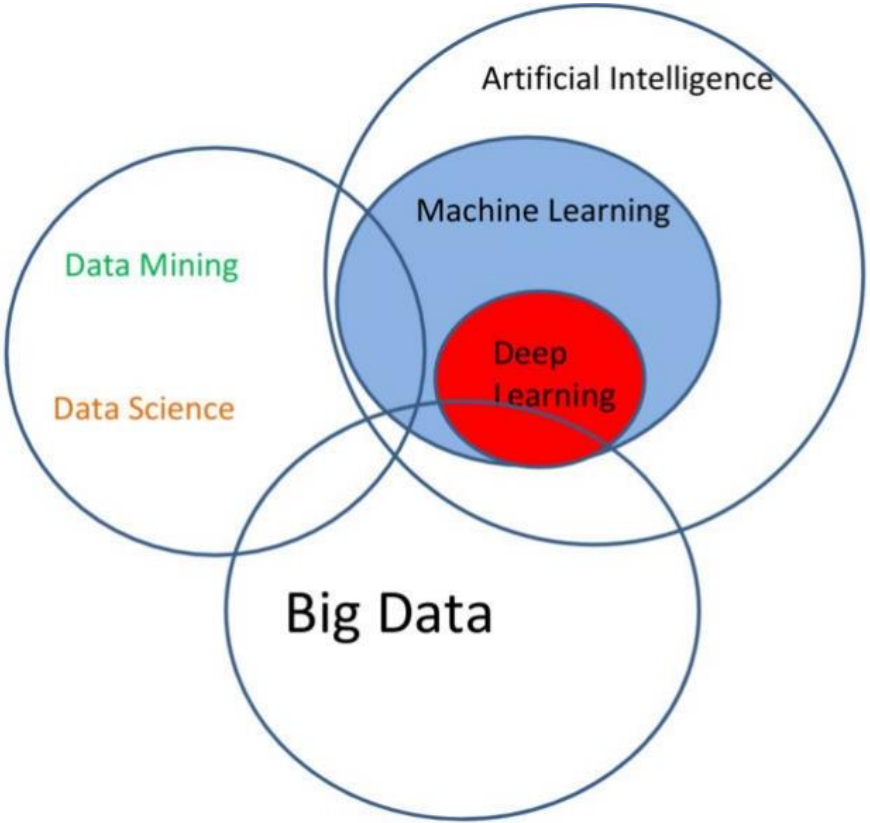

Deep Learning

- Deep learning is a machine learning technique that teaches computers to do what comes naturally to humans: learn by example.

Machine Learning

- Uses Statistical models
- Learns automatically with past data
- Machines improved with experience

Artificial Intelligence

- Imparts human intellects to machine
- Uses logic and decision trees

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Introduction to AI

Artificial:

- Produced by human beings rather than occurring naturally, especially as a copy of something natural.

Intelligence:

- The ability to understand, learn and think

Artificial Intelligence:

- Artificial intelligence (AI) is a wide-ranging branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence.

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Goals of AI

- To Create Expert Systems − Systems which exhibit intelligent behavior, learn, demonstrate, explain, and advice its users.
- To Implement Human Intelligence in Machines − Creating systems that understand, think, learn, and behave like humans.
- The central scientific goal of AI is to understand the principles that make intelligent behavior possible in natural or artificial systems. This is done by

  1. The analysis of natural and artificial agents;

  2. Formulating and testing hypotheses about what it takes to construct intelligent agents; and

  3. Designing, building, and experimenting with computational systems that perform tasks commonly viewed as requiring intelligence.

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Programming

Sr. No.	Programming Without AI	Programming With AI
1	A computer program without AI can answer the **specific** questions it is meant to solve.	A computer program with AI can answer the **generic** questions it is meant to solve.
2	Modification in the program leads to change in its structure.	AI programs can absorb new modifications by putting highly independent pieces of information together. Hence you can modify even a minute piece of information of program without affecting its structure.
3	Modification is not quick and easy. It may lead to affecting the program adversely.	Quick and Easy program modification.

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Foundations of AI

1. Philosophy

- It is the very basic foundation of AI. The foundation provides the disciplines that contributes ideas, viewpoints and techniques to AI.
- The study of fundamental nature of knowledge, reality and existence are considered for solving specific problem is a basic thing in AI.
- Philosophy defines how can the formal rules be used to draw a valid conclusions.

2.Mathematics & statistics

- AI required formal logic and probability for planning and learning.
- Computation required for analyzing relations and implementation.
- Knowledge in formal representation are most required for writing actions for agents.
- In AI the mathematics and statistics are most important for Proving theorems, writing algorithms, computations, decidability, tractability, modeling uncertainty, learning from data

Foundations of AI

3.Economics

- Deals with investing the amount of money, and maximization of utility with minimal investment.
- While developing AI product we should make decisions for when to invest, how to invest, how much to invest and where to invest.
- To answer these questions one should have the knowledge about Decision theory, game theory, operation research etc.

4.Neuroscience

- It is the study of nervous system, particularly of human brain.
- Human brains are somehow different when compared to the other creatures.
- Man has largest brain in proportion to his size.
- The brain consists of nerve cells or neurons and the observation of individual neurons can lead to thought, action and consciousness of one's brain.

Foundations of AI

5.Psychology/cognitive science

- The scientific method to the study of human vision, problem solving skills, how do people behave, perceive, process cognitive information and represent knowledge.

6.Computer science and Engineering

- Logic and inference theory, algorithms, programming languages and system building are important parts of computer science.
- Computer hardware gradually is changing from AI applications such as GPU(Graphics processing unit),TPU(Tensor Processing Unit) and WSE(Wafer Scale Engine).
- The amount of computing power used to train machine learning applications and utilizations doubled every 100 days.

Foundations of AI

6.Computer science and Engineering

- Super computers and Quantum computers can solve very complicated AI problems.
- AI has founded many ideas in modern and main stream computer science including time sharing, interactive interpreters, rapid development environments, link list data type, automatic storage management and key concepts of symbolic , functional, declarative and object oriented programming.

Foundations of AI

7.Control theory and Cybernetics

- Control theory helps the system to analyze, define, debug and fix errors by itself.
- Developing self controlling machines, self regulating feedback control systems and the submarine are some examples of control theory.
- Calculus and matrix algebra and tools of control theory provides themselves to systems that are describable by fixed set of continuous variables are foundation of AI.

8.Linguistics

- Speech recognition is the technology which enables the machine to understand the spoken language and translate into machine readable format.
- It is the way to talk with computer and on the basis of that command a computer can perform a specific task.
- It includes speech to text and text to speech.

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Processing Units

1)A Graphics Processing Unit (GPU) is a specialized electronic circuit designed to manipulate and alter memory to accelerate the creation of images in a frame buffer intended for output to a display device.

2)An Associative Processing Unit (APU) is a type of AI accelerator that focuses on identification tasks. It is designed to identify patterns in large amounts of data.

3)A Tensor Processing Unit (TPU) is an AI accelerator application-specific integrated circuit (ASIC) developed by Google for neural network machine learning, using Google's own Tensorflow software1.

4)A Vision Processing Unit (VPU) is a type of microprocessor designed to accelerate machine vision tasks. It is a specific type of AI accelerator, aimed at accelerating machine learning and artificial intelligence technologies.

5)A Neuromorphic Chip is an electronic system that imitates the function of the human brain or parts of it. They contain artificial neurons and synapses that mimic the activity spikes and the learning process of the brain.

6)A Quantum Processing Unit (QPU) is the central component of a quantum computer or quantum simulator. It is a physical or simulated processor that contains a number of interconnected qubits that can be manipulated to compute quantum algorithms.

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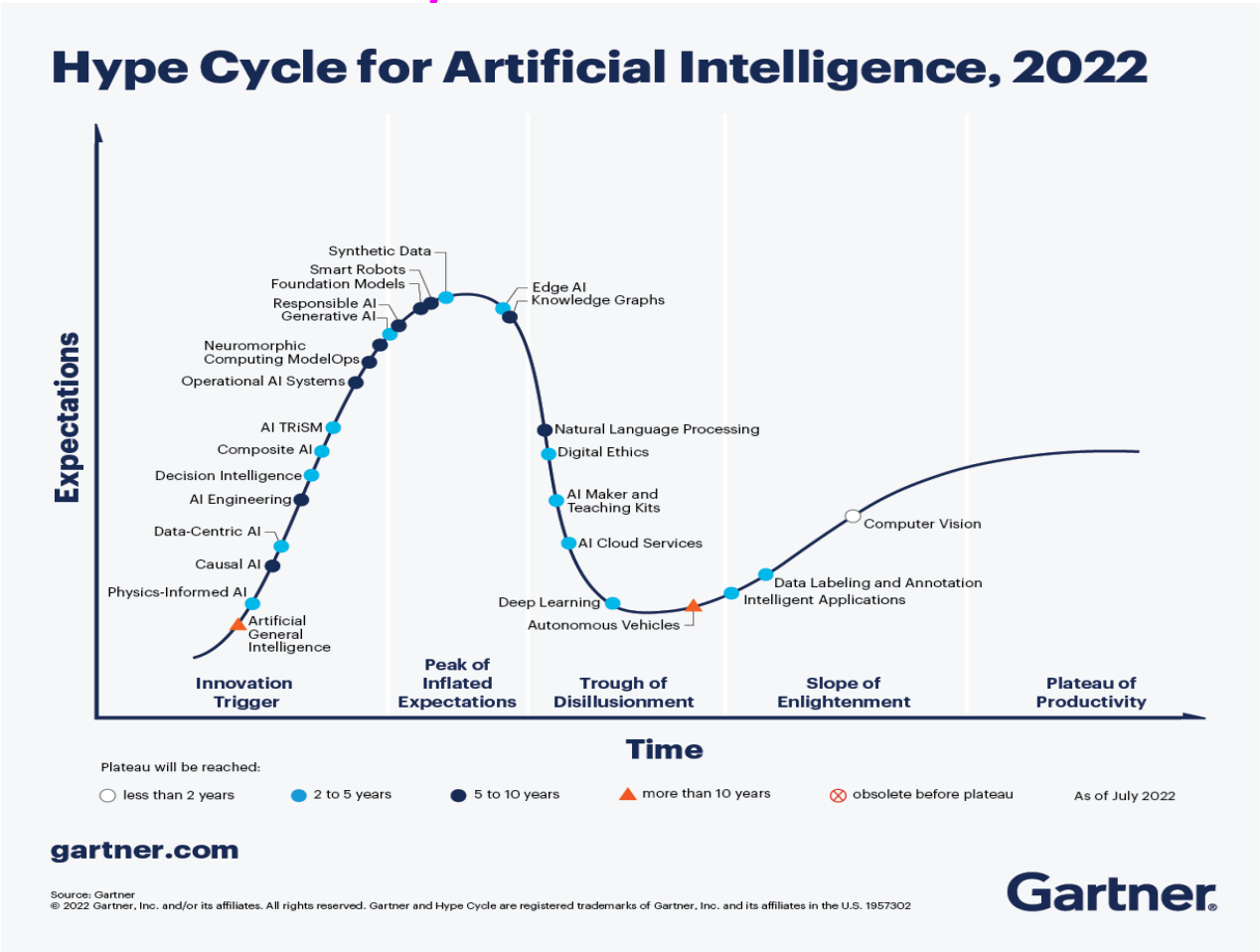
Cycle for AI



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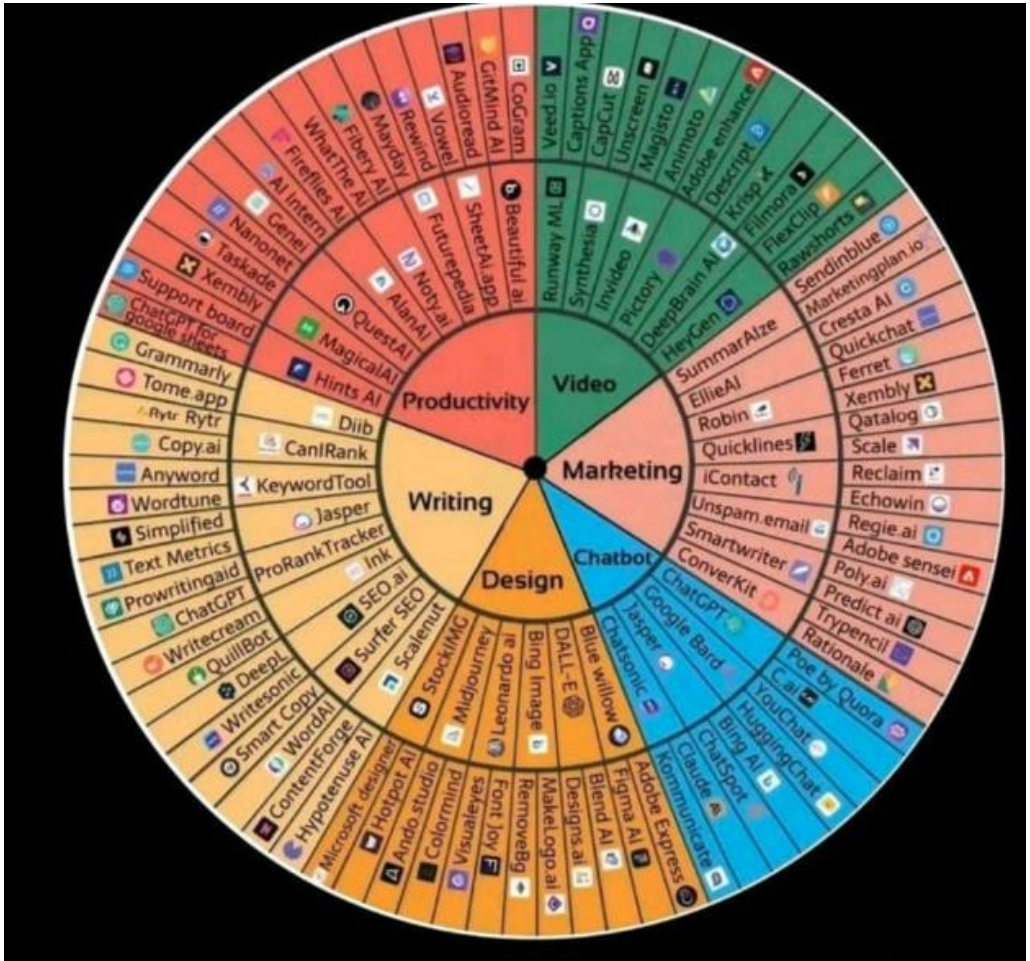
AI Tools



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History of AI

1956 - John McCarthy coined the term ‘artificial intelligence’ and had the first AI conference.

1969 - Shakey was the first general-purpose mobile robot built. It is now able to do things with a purpose vs. just a list of instructions.

1997 - Supercomputer ‘Deep Blue’ was designed, and it defeated the world champion chess player in a match. It was a massive milestone by IBM to create this large computer.

2002 - The first commercially successful robotic vacuum cleaner was created.

2005 - 2019 - Today, we have speech recognition, robotic process automation (RPA), a dancing robot, smart homes, and other innovations make their debut.

2020 - Baidu releases the LinearFold AI algorithm to medical and scientific and medical teams developing a vaccine during the early stages of the SARS-CoV-2 (COVID-19) pandemic.

The algorithm can predict the RNA sequence of the virus in only 27 seconds, which is 120 times faster than other methods

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State of Art for AI

1) **Deep Learning:**

- Deep learning continued to dominate the AI landscape, enabling breakthroughs in various fields such as
  - ❖ Computer vision,
  - ❖ Natural language processing (NLP),
  - ❖ Speech recognition, and more.
  - ❖ Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) are widely used architectures, and
  - ❖ Attention mechanisms (e.g., Transformer) are gaining traction.

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State of Art for AI

2) Generative Models:

- Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) were leading the way in generating realistic images, videos, and other data.
- GANs could produce highly detailed and coherent images, while VAEs were effective for learning latent representations of data.

3) Natural Language Processing (NLP):

- NLP has significant advancements, with models like OpenAI's GPT (Generative Pre-trained Transformer) series gaining attention.
- These models demonstrated impressive language understanding and generation capabilities, enabling applications like language translation, text summarization, and even creative writing.

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State of Art for AI

4) Transfer Learning:

- Transfer learning became a cornerstone of AI research, where pre-trained models were fine-tuned for specific tasks.
- This approach dramatically reduced the amount of data and computation required for training task-specific models.

5) Reinforcement Learning:

- Reinforcement learning continued to make strides, achieving impressive results in areas such as game playing (e.g., AlphaGo, AlphaZero), robotics, and autonomous systems.

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State of Art for AI

6) Healthcare:

- AI was being applied to various healthcare tasks, including medical image analysis, disease diagnosis, drug discovery, and personalized treatment recommendations.

7) Ethics and Bias:

- There was a growing emphasis on addressing ethical concerns and biases in AI systems.
- Researchers and organizations are working to develop fairness, transparency, and accountability in AI algorithms.

8) AI and Creativity:

- AI-driven creative applications were emerging, including generating art, music, and literature, as well as assisting in design and creative processes.

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Benefits of AI

1) Automation and Efficiency:

- AI can automate repetitive tasks, leading to increased efficiency and productivity across various industries.

2) Data Analysis and Insights:

- AI algorithms can analyze large amounts of data quickly and identify patterns, trends, and insights that may be difficult for humans to discover.
- This is particularly valuable in fields such as healthcare, finance, and marketing.

3) Enhanced Decision-Making:

- AI systems can assist in complex decision-making by providing data-driven recommendations and insights based on analysis of vast amounts of information.

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Benefits of AI

4) Personalization:

- AI can personalize experiences for users by analyzing their preferences and behaviors, leading to more relevant recommendations and content.

5) Innovation and Creativity:

- AI has the potential to enhance human creativity by generating new ideas, designs, art, and music.

6) Healthcare Advancements:

- AI can improve medical diagnostics, drug discovery, and treatment planning by analyzing medical images, patient data, and genomic information.

7) Autonomous Systems:

- AI powers autonomous vehicles, drones, and robots, which can perform tasks in dangerous or inaccessible environments without human intervention.

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Benefits of AI

8) Language Translation and Communication:

- AI-powered language translation tools enable effective communication between people who speak different languages, fostering global collaboration.

9) Environmental Impact:

- AI can contribute to environmental sustainability by optimizing energy consumption, predicting natural disasters, and monitoring environmental changes.

10) Assistive Technology:

- AI can be used to develop assistive technologies for people with disabilities, enhancing their quality of life and enabling greater independence.

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Risks of AI

1) **Job Losses**
2) **Data Discrimination**
3) **Privacy Concerns**
4) **Security Risks**
5) **Potential for AI to exceed human capabilities**
6) **Economic Disparity**
7) **Loss of human skills**: Example critical thinking, problem-solving, and emotional intelligence.
8) **Threat to Humanity**: In the long term, there are concerns about AI systems becoming superintelligent and potentially posing existential risks to humanity if not properly controlled.
9) **No Emotions**

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Agents

- According to the father of Artificial Intelligence, John McCarthy, it is *"The science and engineering of making intelligent machines, especially intelligent computer programs"*.
- Artificial intelligence, or AI, is the field that studies the synthesis and analysis of computational agents that act intelligently.
- An agent is something that acts in an environment – it does something.

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Agents

- We judge an agent by its actions. An agent acts intelligently when

  1. What it does is appropriate for its circumstances and its goals,
  2. It is flexible to changing environments and changing goals,
  3. It learns from experience, and
  4. It makes appropriate choices given its perceptual and computational limitations.

  An agent typically cannot observe the state of the world directly; it has only a finite memory and it does not have unlimited time to act.

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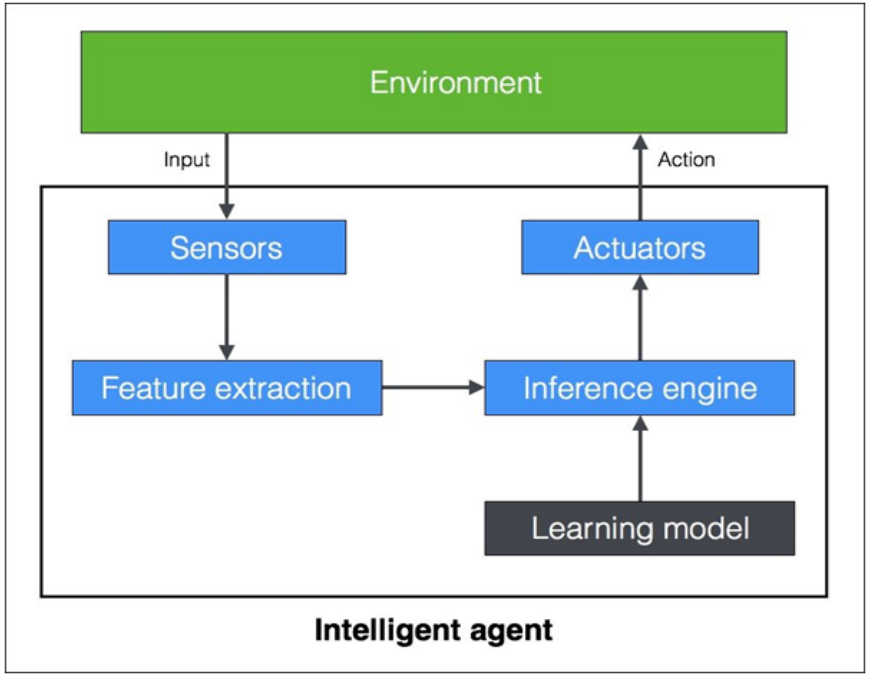
Intelligent Agent

- An intelligent agent is a computer system with autonomous action in some environment.
- An intelligent agent (or simply an agent) is a program that gathers information or performs some other service without your immediate presence and on some regular schedule.
- An agent is sometimes called a bot (short for robot).



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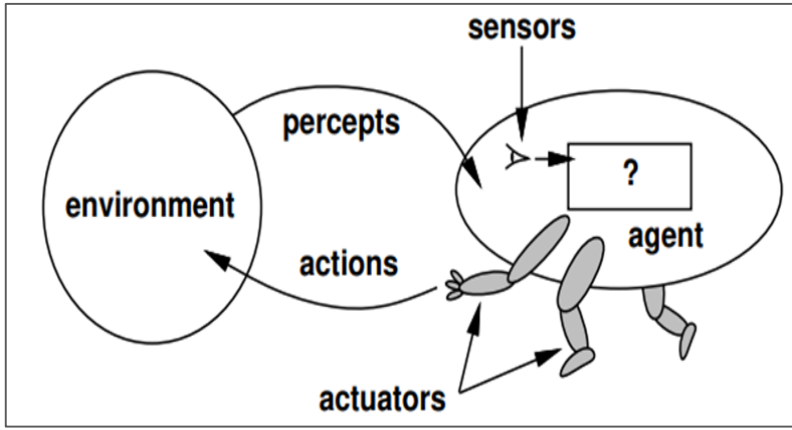
Intelligent Agent

- An intelligent agent is a component of software (or hardware) that it perceives and it acts autonomously in an open and dynamic environment, learning and cooperating with other agents (the same user) to offer a benefit to their user.
- Agents are software entities that encapsulate a number of attributes including autonomy, mobility, sociability, reactivity and proactivity amongst others.
- An **agent** is anything that can be viewed as perceiving its **environment** through **sensors** and acting upon that environment through **actuators**.



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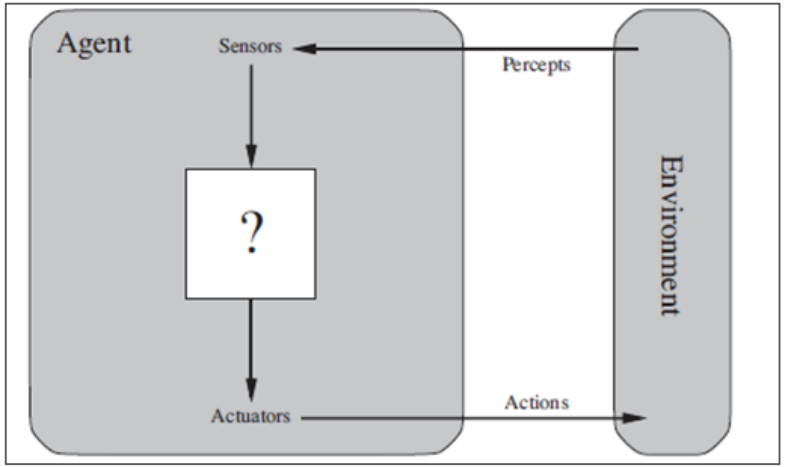
Intelligent Agent

- A sensor measures some aspect of the environment in a form that can be used as input by an agent
- Perception provides agents with information about the world they inhabit by interpreting the response of sensors
- A human agent has eyes, ears, and other organs for sensors and hands, legs, vocal tract, and so on for actuators.
- A robotic agent might have cameras and infrared range finders for sensors and various motors for actuators.
- A software agent receives keystrokes, file contents, and network packets as sensory inputs and acts on the environment by displaying on the screen, writing files, and sending network packets.



Agents interact with environments through sensors and actuators

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Intelligent Agent

To perform the mapping task five types of agent programs are there. They are:

1. Reactive agents

2. Deliberative agents

3. Goal-based agents

4. Utility-based agents

5. Learning agents

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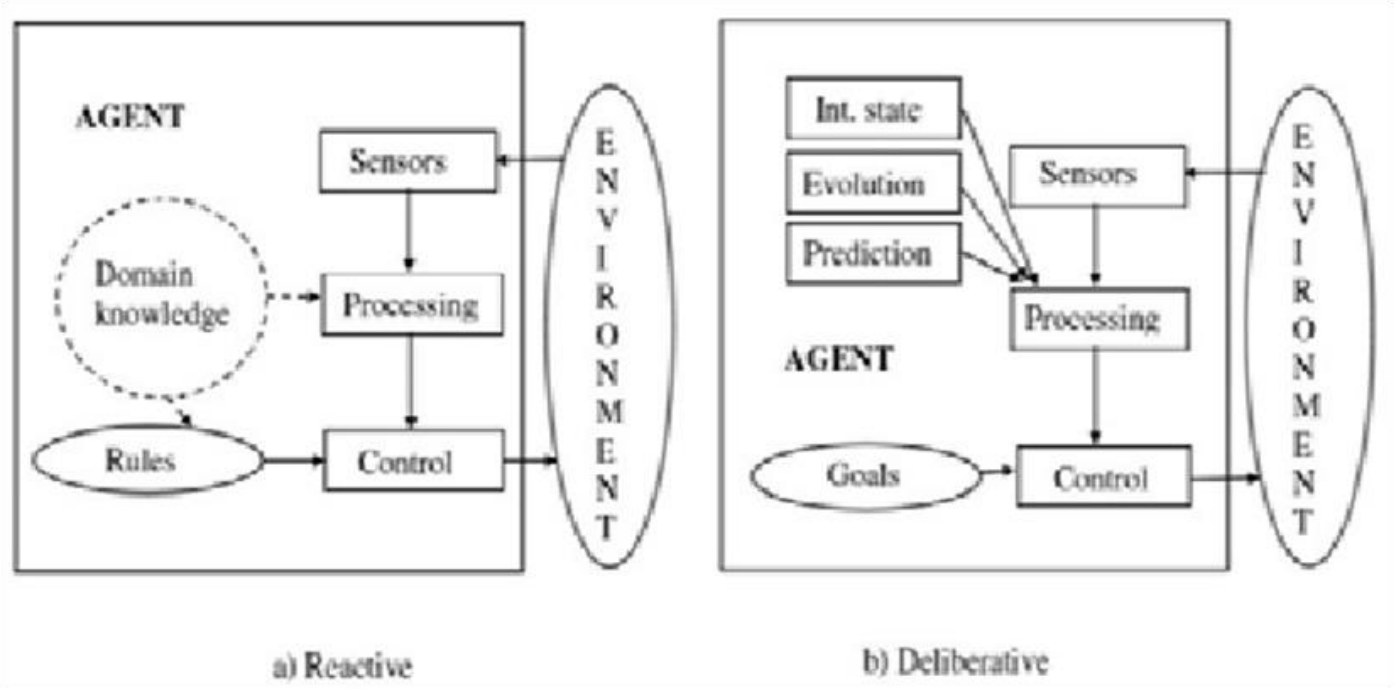
Intelligent Agent

Comparison between Reactive and Deliberative agents



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Comparison between Reactive and Deliberative agents

- Reactive agents has no internal state
- They cannot just react automatically on the basis of information from the external environment
- Reactive agents must have enough data available in the local or internal environment to figure out a satisfactory action.
- In the decision-making process, it is difficult for reactive agents to take into account the external or non-local information.
- Reactive agents do not understand the relationship between environmental and individual behavior.
- Reactive agents sense and act through various means.
- A deliberative agent maintains its internal state and predicts the effects of actions.
- Deliberative agents act more like thinking agents and search through a space of behaviors while maintaining their internal state.

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Intelligent Agent

3.Goal Driven Agents

- Knowing something about the current state of the environment is not always enough to decide what to do.
- For example, at a road junction, the taxi can turn left, turn right, or go straight on. The correct decision depends on where the taxi is trying to get to. In other words, as well as a current state description, the agent needs some sort of **goal** information that describes situations that are desirable—for example, being at the passenger's destination. The agent program can combine this with the model.
- Sometimes goal-based action selection is straightforward—for example, when goal satisfaction results immediately from a single action.
- Sometimes it will be trickier—for example, when the agent has to consider long sequences of twists and turns in order to find a way to achieve the goal.

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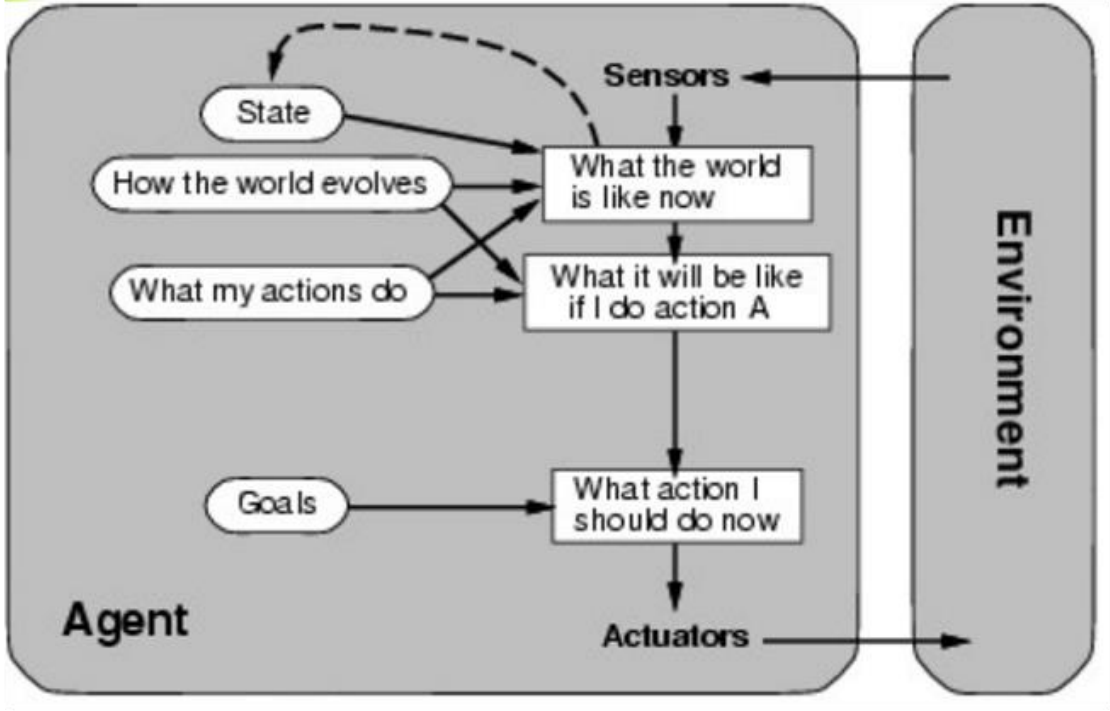
Intelligent Agent

3.Goal Driven Agents



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Intelligent Agent

3.Goal Driven Agents

- A goal-based agent, in principle, could reason that if the car in front has its brake lights on, it will slow down. Given the way the world usually evolves, the only action that will achieve the goal of not hitting other cars is to brake.
- Although the goal-based agent appears less efficient, it is more flexible because the knowledge that supports its decisions is represented explicitly and can be modified. If it starts to rain, the agent can update its knowledge of how effectively its brakes will operate; this will automatically cause all of the relevant behaviors to be altered to suit the new conditions.
- The goal-based agent's behavior can easily be changed to go to a different destination, simply by specifying that destination as the goal.

Intelligent Agent

4.Utility Driven Agents

- Goals alone are not enough to generate high-quality behavior in most environments.
- For example, many action sequences will get the taxi to its destination (thereby achieving the goal) but some are quicker, safer, more reliable, or cheaper than others. Goals just provide a crude binary distinction between “happy” and “unhappy” states. A more general performance measure should allow a comparison of different world states according to exactly how happy they would make the agent. Because “happy” does not sound very scientific, economists and computer scientists use the term utility instead.
- A utility-based agent has many advantages in terms of flexibility and learning.

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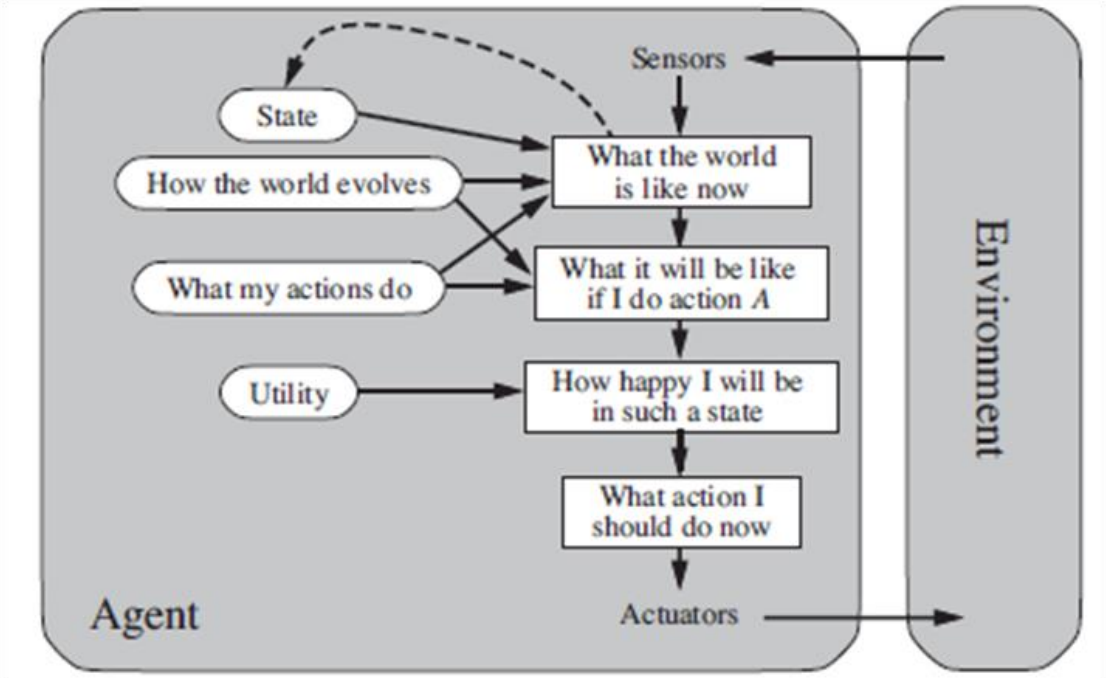
Intelligent Agent

4.Utility Driven Agents



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4.Utility Driven Agents

- Furthermore, in two kinds of cases, goals are inadequate but a utility-based agent can still make rational decisions. First, when there are conflicting goals, only some of which can be achieved (for example, speed and safety) .Second, when there are several goals that the agent can aim for, none of which can be achieved with certainty, utility provides a way in which the likelihood of success can be weighed against the importance of the goals.
- A utility-based agent has to model and keep track of its environment, tasks that have involved a great deal of research on perception, representation, reasoning, and learning
- Choosing the utility-maximizing course of action is also a difficult task, requiring ingenious algorithms.·Even with these algorithms, perfect rationality is usually unachievable in practice because of computational complexity.

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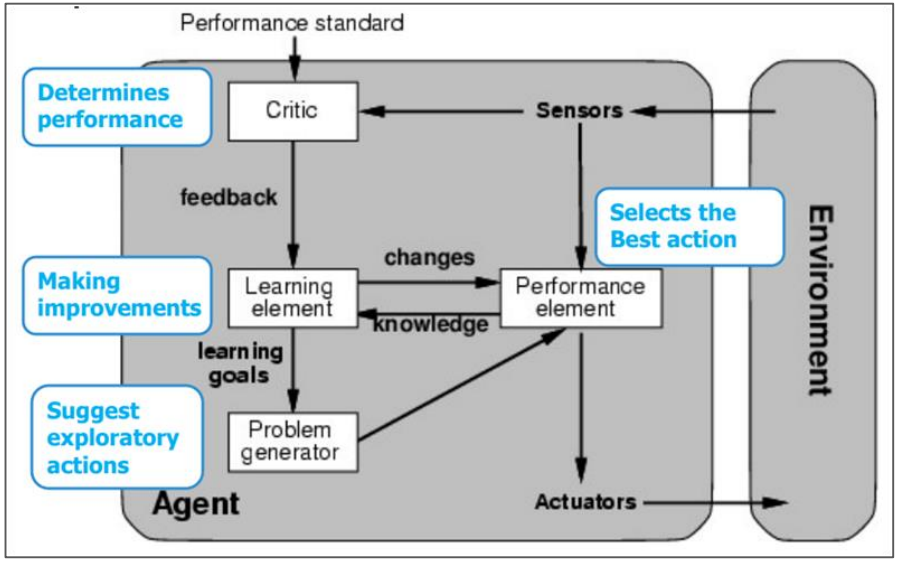
5.Learning Agents

- Learning has another advantage: it allows the agent to operate in initially unknown environments and to become more competent than its initial knowledge alone might allow.
- A learning agent can be divided into four conceptual components
- Learning elements is responsible for making improvements and performance elements is responsible for selecting external actions



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5.Learning Agents

- The performance element is what we have previously considered to be the entire agent: it takes in percepts and decides on actions.
- The learning element uses the feedback from the **critic** on how the agent is doing and determines how the performance element should be modified to do better in the future.
- The design of the learning element depends very much on the design of the performance element. When trying to design an agent that learns a certain capability, the first question is not “How am I going to get it to learn this?” but “What kind of performance element will my agent need to do this once it has learned how?” Given an agent design, learning mechanisms can be constructed to improve every part of the agent.
- The critic tells the learning element how well the agent is doing with respect to a fixed performance standard. The critic is necessary because the percepts themselves provide no indication of the agent’s success.

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Intelligent Agent

5.Learning Agents

- The last component of the learning agent is the **problem generator**.
- It is responsible for suggesting actions that will lead to new and informative experiences.
- The point is that if the performance element had its way, it would keep doing the actions that are best, given what it knows.
- But if the agent is willing to explore a little and do some perhaps sub optimal actions in the short run, it might discover much better actions for the long run.
- The problem generator’s job is to suggest these exploratory actions.

Intelligent Agent

5.Learning Agents

- The taxi goes out on the road and drives, using this performance element.
- The critic observes the world and passes information along to the learning element.
- For example, after the taxi makes a quick left turn across three lanes of traffic, the critic observes the shocking language used by other drivers.
- From this experience, the learning element is able to formulate a rule saying this was a bad action, and the performance element is modified by installation of the new rule.
- The problem generator might identify certain areas of behavior in need of improvement and suggest experiments, such as trying out the brakes on different road surfaces under different conditions.

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Production systems in AI

- Production system or production rule system is a computer program typically used to provide some form of artificial intelligence, which consists primarily of a set of rules about behavior but it also includes the mechanism necessary to follow those rules as the system responds to states of the world.

The major components of Production System in Artificial Intelligence are:

1) Global Database:

- The global database is the central data structure used by the production system in Artificial Intelligence.

2) Set of Production Rules:

- The production rules operate on the global database.
- Each rule usually has a precondition that is either satisfied or not by the global database.
- If the precondition is satisfied, the rule is usually be applied.
- The application of the rule changes the database.

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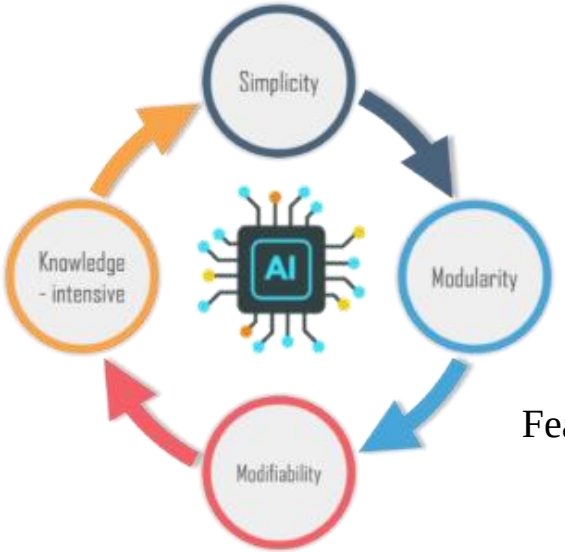
Production systems in AI

3) A Control System:

- The control system then chooses which applicable rule should be applied and ceases computation when a termination condition on the database is satisfied.
- If multiple rules are to fire at the same time, the control system resolves the conflicts.



Features of production system

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Production systems in AI

1. Simplicity:

- The structure of each sentence is unique and uniform as they use the “IF-THEN” structure.
- This structure provides simplicity in knowledge representation.
- This feature of the production system improves the readability of production rules.

2. Modularity:

- This means the production rule code the knowledge available in discrete pieces.
- Information can be treated as a collection of independent facts which may be added or deleted from the system with essentially no deleterious side effects.

3. Modifiability:

- This means the facility for modifying rules.
- It allows the development of production rules in a skeletal form first and then it is accurate to suit a specific application.

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4. Knowledge-intensive:

- The knowledge base of the production system stores pure knowledge.
- This part does not contain any type of control or programming information

5. Adaptability:

- The system can adapt to situations accordingly.
- It implements pattern-directed control, which enhances the hierarchical control of search in the event of complexities.

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Production systems in AI

Control or search strategies

1.It should cause motion

2.It should be systematic

3.Finally, it must be efficient in order to find a good answer.

- Represent the knowledge in a production system as a set of rules along with a control system and database. It can be written as:

If(Condition) Then (Condition)

The production rules are also known as condition-action, antecedent-consequent, pattern-action, situation-response, feedback-result pairs.

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Production systems in AI

Advantages

- Provides excellent tools for structuring AI programs
- The system is highly modular because individual rules can be added, removed or modified independently
- Separation of knowledge and Control-Recognises Act Cycle
- A natural mapping onto state-space research data or goal-driven
- The system uses pattern directed control which is more flexible than algorithmic control
- Provides opportunities for heuristic control of the search
- A good way to model the state-driven nature of intelligent machines
- Quite helpful in a real-time environment and applications.

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Production systems in AI

Disadvantages

- It is very difficult to analyze the flow of control within a production system
- There is an absence of learning due to a rule-based production system that does not store the result of the problem for future use.
- The rules in the production system should not have any type of conflict resolution as when a new rule is added to the database it should ensure that it does not have any conflict with any existing rule.

Thank you!

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