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Module I

INTRODUCTION TO AI

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1.1 Foundations of AI

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Artificial Intelligence (AI) is the study in combination of disciplines and sub-disciplines and approaches.

The foundations of AI includes a combination of theoretical concepts, algorithms, and practical applications.

The key elements of AI are:

1. The Machine Learning (ML):

- ML focuses on developing algorithms and statistical models that enable systems to learn from data. It is a subset of AI.
- Supervised learning, unsupervised learning, and reinforcement learning are the paradigms within ML.

2. Data:

- High-quality, accurate, relevant, and diverse datasets are required for training models. Hence data is significant for AI systems.
- The following are the phases for cleansing data for AI systems:
 - Preprocessing,
 - cleaning, and
 - feature engineering

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3. Algorithms:

- AI algorithms that depict the functionality of AI systems are:
 - decision trees,
 - neural networks,
 - support vector machines, and
 - clustering algorithms.
- The algorithm chosen depends on the specific problem considered and the type of data available
- Neural networks are the fundamental component of deep learning. It is a subset of machine

learning. Data is the required component for AI systems.

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5. Sub categories of Deep neural networks like image recognition, natural language processing, and speech recognition Natural Language Processing (NLP) proved to be successful.

- NLP focuses on the interaction between computers and human. It is a subfield of AI that includes Human language understanding,
sentiment analysis, and
language generation.
- Another type of neural network architecture that play a pivotal role in advancing NLP is the Transformers.

6. Computer Vision:

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- Machines interpret and understand visual information from the world like images and videos that is a subtask of Computer vision.
- Convolutional Neural Networks (CNNs) is another broad subject for computer vision applications.

7. Reinforcement Learning:

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- An environment, where an agent learns to make decisions by interacting with another environment and receiving feedback in the form of rewards or penalties is called as Reinforcement learning.
- It is commonly used in robotics, game playing, and autonomous systems.

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8. Ethics and Bias:

- Ethical scenarios and bias are fundamental to the development and deployment of AI systems.
- Potential biases and ethical concerns in AI systems are concerned with Ensuring fairness,
transparency, and
accountability

9. Nature an Interdisciplinary system:

- Knowledge is deprived for AI systems from disciplines like:
Computer Science,
Mathematics,
Statistics,
Psychology, and

Linguistics.

10. Applications for AI systems:

- AI is Can be integrated in disciplines like:

healthcare,

finance,

education,

transportation, and

more.

The range covers a broad spectrum that includes:

autonomous vehicles or driverless cars and

virtual digital assistants to medical diagnosis and

fraud detection purposes.

Understanding these foundations is essential for individuals working in AI, whether they are researchers, developers, or policymakers. Additionally, staying informed about the latest advancements and ethical considerations in the field is crucial for responsible AI development and deployment.

1.1 The history of artificial intelligence

The origins of artificial intelligence (AI) may be traced back to ancient times, however, the systematic advancement of the science started in the mid-20th century. Below is a summary of the significant milestones in the history of AI:

1. Ancient Philosophy (Antiquity): The concept of developing synthetic entities possessing cognitive abilities comparable to those of humans may be traced back to ancient mythologies and philosophical teachings. Automata and artificial creatures are included in the folklore of ancient Greece, China, and Egypt.

2. Automata throughout the 17th and 18th centuries: During the 17th and 18th centuries, craftsmen constructed mechanical automata, which included clockwork figurines and dolls. These initial instances showcased basic elements of automation but were devoid of genuine intelligence.

3. The study of logic and computing during the 19th and early 20th centuries: The theoretical foundation for AI was established through the advancement of formal logic and the introduction of the notion of a universal computing machine, as demonstrated by Alan Turing's contributions in the early 20th century.

4. Electronic Computers (1940s-1950s): The introduction of electronic computers in the 139 1940s supplied the required technology for conducting computational experiments in the field of artificial intelligence. Alan Turing and John von Neumann were pivotal figures in these first advancements.

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5. The Dartmouth Conference, held in 1956,

The phrase "artificial intelligence" was first used at the Dartmouth Conference in 1956. The meeting, convened by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon, signified the formal inception of AI as an academic discipline.

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AI programs developed in the 1950s and 1960s.

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In the late 1950s and 1960s, early AI systems were created, such as the Logic Theorist developed by Allen Newell and Herbert A. Simon, and the General Problem Solver (GPS) created by Newell and J.C. Shaw.

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7. Symbolic AI, which emerged in the 1960s and 1970s, refers to the branch of artificial intelligence that focuses on using symbols and rules to represent knowledge and solve problems. Symbolic AI, commonly referred to as "good old-fashioned AI" (GOFAI), primarily emphasized the manipulation of symbols and the organized representation of knowledge. During this time, expert systems, rule-based systems, and early natural language processing were important.

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8. The period known as the AI Winter occurred from the 1970s to the 1980s.

The advancement of AI saw a deceleration in the late 1970s and 1980s as a result of exaggerated expectations, insufficient computer capacity, and difficulty in creating efficient algorithms. The decline in funding and interest in AI research resulted in a period sometimes referred to as the "AI winter."

9. The emergence of neural networks occurred over the period from the 1980s to the 1990s.

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During the 1980s and 1990s, there was a resurgence of interest in neural networks. The backpropagation algorithm, which was created to train artificial neural networks, has made significant contributions to the progress of machine learning.

The Machine Learning Renaissance, which began in the 2000s²⁰⁴ and continues to the present, refers to a period of significant advancements and growth in the field of machine learning.

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In the 2000s, there was a renewed interest in machine learning due to advancements in computer power, the availability of larger datasets, and the development of better algorithms. Support vector machines, decision trees, and ensemble approaches gained popularity.

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10 .The Deep Learning Revolution began in the 2010s and continues to the present day.

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In the 2010s, deep learning, which is a branch of machine learning that relies on neural networks⁹⁹ with numerous layers (known as deep neural networks), experienced significant growth. Deep learning has demonstrated exceptional accomplishments in domains such as image identification, natural language processing, and speech recognition.

11. Artificial Intelligence in Daily Life (2010s-present):

AI technology have become essential in daily life, being used in virtual assistants (such as Siri and Alexa), recommendation systems, driverless cars, healthcare diagnostics, and other areas.

AI has undergone cycles of enthusiasm, alternating with times of doubt and decreased financial support. Nevertheless, in recent years, there has been consistent expansion and improvement, as artificial intelligence has become a crucial component of technical progression and societal progress. The field's ongoing evolution has brought more attention to ethical problems and the need for responsible AI research.

Current level of technological advancement: As of my most recent knowledge update in January 2022, the current state of AI is in a constant state of evolution. It is crucial to acknowledge that there may have been breakthroughs since that time. These are the main domains that represent the most advanced and current developments in artificial intelligence:

Deep learning and neural networks: Deep learning, specifically using deep neural networks, is a leading area of focus¹⁰⁶ in AI research. Transformers and similar architectures have demonstrated great efficacy in natural language processing and other applications.

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Natural Language Processing (NLP): Natural Language Processing (NLP) is the field of study that focuses on the interaction between computers and human language. It involves developing algorithms and models that enable computers to understand, interpret, and

generate human language in a way that is similar to how humans do. Natural Language Processing (NLP) models, such as GPT-3 (Generative Pre-trained Transformer 3) and BERT (Bidirectional Encoder), have demonstrated exceptional accomplishments. Representations from Transformers have remarkable proficiency in comprehending and generating language. Computer Vision refers to the field of study that focuses on enabling computers to understand and interpret visual information from images or videos.

Computer Vision: Computer vision applications have made substantial progress. Convolutional Neural Networks (CNNs) are extensively employed for tasks such as image identification, object detection, and segmentation. Generative models such as GANs (Generative Adversarial Networks) play a significant role in the creation of images.

Reinforcement Learning: Reinforcement learning has made significant progress in teaching agents to carry out intricate tasks in several fields, such as robotics, games, and autonomous systems.

Transfer learning refers to the process of applying knowledge gained from one task to another related task. It involves using pre-trained models or features extracted from one domain to improve the performance of a model in a Transfer learning, technique in which preexisting models trained on one task are adjusted for another, has emerged as a fundamental approach in the field of artificial intelligence. This methodology facilitates the utilization of extensive datasets and pre-existing models, particularly in scenarios when there is a scarcity of annotated data.

Explainable AI:

Explainable AI, also known as XAI, refers to the field of artificial intelligence that focuses on developing systems that can provide clear and understandable explanations for their decisions and actions. There is a growing focus on the development of AI systems that can understood and clarified. Gaining insight into the decision-making mechanisms of AI models is essential for ensuring their ethical implementation, especially in sensitive fields.

Artificial Intelligence in the field of healthcare: Artificial intelligence is playing a crucial role in the field of healthcare by generating important advancements in areas like as interpreting medical images, discovering new drugs, developing customized treatment, and predicting patient outcomes using analytics.

Artificial Intelligence (AI) Ethics and Bias Mitigation: The ethical implications of artificial intelligence (AI), such as concerns regarding bias, transparency, and accountability, have become more important. Scientists and professionals are actively engaged in creating techniques to tackle biases and guarantee equitable and accountable artificial intelligence.

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Artificial Intelligence and Robotics: Artificial intelligence (AI) is playing a crucial role in the progress of robotics, with a wide range of applications including autonomous cars, drones, industrial automation, and collaboration between humans and robots.

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The intersection between Quantum Computing and AI: Research is now being conducted at the confluence of quantum computing and AI. Researchers are now exploring the possible advantages of integrating quantum algorithms into the field of artificial intelligence to solve specific challenges.

Artificial Intelligence in Edge Computing: There is an increasing trend of deploying AI models on edge devices, which are located closer to the data source. These benefits include immediate processing, less delay, and the resolution of privacy problems through the use of local data storage.

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Artificial Intelligence in the field of finance:

Artificial intelligence (AI) is extensively employed in the financial industry for several purposes, including identifying and preventing fraudulent activities, executing algorithmic trading strategies, evaluating risks, and enhancing customer support.

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Keeping abreast of the most recent research publications, conferences, and industry advancements is crucial for gaining a full grasp of the current state of the art in artificial intelligence. The discipline is characterized by its dynamism, with continuing research and advancements continually influencing its development.

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Risks and benefits of AI:

The appropriate development and deployment of Artificial Intelligence (AI) technologies necessitates thoughtful assessment of both the advantages and potential drawbacks associated with AI. Below is a summary of the potential hazards and advantages linked to artificial intelligence (AI):

Automated processes and increased efficiency: Artificial intelligence (AI) systems have the capability to mechanize monotonous and recurring processes, hence enhancing productivity and liberating human resources for more intricate and innovative pursuits.

Data analysis and pattern recognition: Artificial intelligence (AI) is very proficient in the analysis of large volumes of data, the identification of patterns, and the extraction of useful insights. This capability greatly enhances decision-making in a wide range of fields. 63

Personalization and recommendation systems: Artificial intelligence (AI) facilitates customized experiences and suggestions in domains including multimedia streaming, e-commerce, and online services, augmenting consumer happiness and involvement.

Advancements in healthcare: Artificial intelligence (AI) is essential in the field of medical image processing, drug development, personalized medicine, and forecasting patient outcomes. Its utilization in these areas results in enhanced diagnosis and therapy. 3

180 Natural Language Processing (NLP) and Language Translation: Natural Language Processing (NLP) technologies enhance the connection between humans and computers, enable language translation, and analyze sentiment, hence increasing worldwide accessibility to information.

Improved User Experience: Artificial intelligence (AI) enhances user interfaces, virtual assistants, and chatbots, hence improving the entire user experience and engagement with technology.

Self-governing Systems: Artificial intelligence (AI) enables the operation of autonomous vehicles, drones, and robots, resulting in progress in transportation, logistics, and diverse sectors.

Scientific Inquiry and Investigation: Artificial intelligence assists researchers in analyzing intricate information, conducting simulations of experiments, and uncovering breakthroughs in disciplines such as astronomy, physics, and environmental science.

6 Prejudice and Equity: AI models can acquire biases from the data they are trained on, which might result in unjust or discriminating results. Addressing prejudice in artificial intelligence is a crucial ethical concern.

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Insufficient transparency and explainability: AI models, especially deep learning models, can be intricate and opaque, posing difficulties in comprehending their decision-making mechanisms. The absence of comprehensibility gives rise to apprehensions regarding responsibility.

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Issues related to the protection and safety of something: Artificial intelligence systems are susceptible to adversarial assaults, in which malevolent individuals modify input data in order to fool the model. Ensuring the security of AI systems is crucial in order to avoid any potential misuse.

The phenomenon¹²³ of job displacement and its economic consequences: The implementation of AI-powered automation has the potential to result in employment displacement within specific sectors, which might give rise to economic and societal difficulties. It is crucial to consider the effect on the workforce.

Ethical considerations¹²⁵ Artificial intelligence (AI) presents ethical quandaries, encompassing concerns about privacy, consent, and the ethical management of AI in many contexts, such as the use of autonomous weaponry.

Excessive dependence on artificial intelligence: Excessive dependence on AI without human supervision might result in scenarios where crucial judgments are made exclusively by computers, potentially leading to unforeseen outcomes.

Concerns regarding the protection of personal information: Artificial intelligence systems sometimes need substantial quantities of data for the purpose of training. Safeguarding the confidentiality of persons' data and adhering to data protection standards is a formidable task.

Unforeseen repercussions: Artificial intelligence systems have the potential to display unforeseen behavior or unintended outcomes, particularly in situations that are dynamic and intricate.

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To effectively manage the advantages and drawbacks of AI, it is necessary to adopt a multidisciplinary strategy that includes engineers, ethicists, politicians, and the public. This method aims to set standards, legislation, and best practices to ensure the responsible development and use of AI technology.³

Intelligent agents:

Intelligent agents are beings that possess the ability to comprehend their surroundings, engage in logical thinking about it, and execute actions in order to accomplish certain objectives. Intelligent agents can vary in complexity, ranging from straightforward, rule-based systems to intricate, learning-based systems. The following are the fundamental elements and attributes of intelligent agents in the field of artificial intelligence:

Perception:

Intelligent agents require the capability to comprehend their surroundings. This entails acquiring data from sensors or input sources that enable the agent to comprehend the current condition of the world.

Justification:

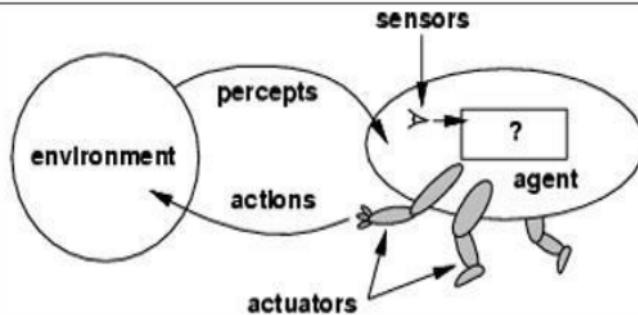
Reasoning is the cognitive process of analyzing and synthesizing the information obtained from perception in order to make informed judgments or reach logical conclusions. Cognitive processing frequently entails the formation of mental representations of the external environment and the capacity to alter such representations.

Activation:

Actuation is the capacity of an intelligent entity to carry out activities within its surroundings. These activities are derived from the agent's logical thinking and are intended to accomplish certain objectives.

Educational acquisition:

Learning refers to the capacity of an intelligent entity to enhance its performance by gaining knowledge and skills via the accumulation of experience. Learning may be categorized into three types: supervised, unsupervised, or reinforcement-based, which are determined by



the availability of feedback or data.

Key attributes of intelligent agents:

Independence:

Intelligent agents function independently, making choices and executing activities without direct human involvement. The degree of autonomy can vary, with certain agents needing greater human direction than others. Driven by specific objectives or targets. Intelligent agents are programmed to accomplish particular objectives. The establishment of these objectives can be predetermined by programmers or acquired through practical knowledge, contingent upon the agent's aptitude.

Flexibility:

Intelligent agents frequently demonstrate adaptability, which refers to their capacity to modify their actions in accordance with alterations in the surroundings or the acquisition of new data. Learning processes play a role in this ability to adapt.

Perception of one's surroundings and understanding of the current situation:

Effective intelligent agents possess a high degree of situational awareness, comprehending the specific circumstances in which they function. This level of consciousness aids in making judgments that are more informed. Interpersonal exchange of information, ideas, or thoughts. Certain sophisticated agents possess the ability to engage in communication with other agents or individuals. Communication includes the transmission of information, soliciting feedback, and cooperating with other entities to accomplish shared objectives.

Agents and environments:

Artificial Intelligence Agents:

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An intelligent agent is a discerning creature that uses sensors to detect its surroundings, analyzes information, and executes actions in order to accomplish predetermined objectives. Intelligent beings can vary in complexity, transitioning from rule-based systems to more sophisticated learning-based systems. The essential elements of intelligent agents encompass:

Perception (Sensors):

Agents possess sensors or perceptual processes that enable them to view and collect information on their surroundings. Sensors encompass a variety of devices such as cameras, microphones, temperature sensors, and so on.

Logical thinking and the process of making choices:

Agents employ cognitive processes to analyze the information acquired through perception. Individuals make judgments or form conclusions based on their own cognition and mental representations of the environment. Actuation refers to the process of causing a mechanical device or system to move or operate. In the context of robotics, actuation refers to the effectors, which are the components responsible for producing Agents possess effectors or actuators that allow them to execute activities inside the environment. These acts are intended to accomplish certain objectives or adapt to changes in the surroundings.

Educational acquisition: A multitude of intelligent agents possess the ability to acquire knowledge through firsthand encounters. Learning mechanisms, such as algorithms for machine learning, empower agents to adjust and enhance their performance as time progresses.

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Characteristics of Environments: under the field of artificial intelligence, the term "environment" pertains to the external circumstances and conditions under which an intelligent agent functions. It encompasses all external factors that have the capacity to influence or be influenced by the activities of the agent. Environments can vary in their level of complexity, ranging from simple to complicated. They can also differ in their nature, being either static or dynamic. Additionally, environments can be categorized as either deterministic or stochastic.

Comparison between Fully Observable and Partially Observable: In an environment that is completely viewable, the sensors of the agent offer comprehensive information on the current state of the environment. Within a partially viewable environment, the agent's knowledge or understanding of the situation may be limited or unclear.

Deterministic versus stochastic: In a deterministic setting, the result of an action may be accurately anticipated. In a stochastic setting, results are subject to random or unknown factors.

Comparison between Episodic and Sequential: In a setting characterized by episodic structure, the agent's encounters are separated into discrete episodes, with each episode being self-contained and separate from the others. Within a sequential context, the activities of the agent have an accumulative impact, and the present action can influence subsequent states.

Comparison between Static and Dynamic: In a static environment, the elements remain constant and do not undergo any changes throughout time. In a dynamic context, the agent may need to adjust and revise its knowledge of the world due to changes in external causes.

Dichotomy between Discrete and Continuous: In a discrete setting, there exists a limited collection of unique states and activities. In a continuous environment, states and behaviors are not separate and distinct, but rather occur on a continuous spectrum.

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Interaction between an agent and its environment: An intelligent agent's interaction with its surroundings is commonly represented as a continuous loop

Perception: The agent acquires²⁶ input from the environment via its sensors, gathering information on the present state. Process of making choices or reaching conclusions based on careful consideration of available options and relevant information. The agent analyzes the perceptual information, engages in logical thinking, and determines the most suitable course of action.

Task: The agent carries out the selected action via its effectors, so exerting an influence on the environment.

Environmental Response: The environment reacts to the actions of the agent, which may result in a modification of its current condition.

The loop persists in an iterative manner as the agent adjusts to variations in the environment and strives to accomplish its objectives.

The notion of rationality

The fundamental components of the notion of rationality encompass the following:

1. **Goals and Objectives:** Rationality presupposes that the actor possesses clearly stated goals or purposes. The agent might get these goals either through explicit provision or through experiential learning.

2. **Facts and convictions:** Rational decision-making relies on the agent's knowledge and convictions regarding the world. This encompasses information on the present condition of the environment, potential courses of action, and the resulting outcomes of those activities.

3. Consistency: Rational agents exhibit decision-making that is characterized by logical consistency. Assuming the agent's preferences and beliefs stay unchanged, its decisions should demonstrate logical consistency and avoid any conflicts.

4. Optimization of utility: Rationality sometimes incorporates the notion of utility, which signifies the attractiveness or worth of certain outcomes. Rational agents aim to optimize their anticipated utility while making decisions.

5. Flexibility: Adaptable rational agents. Individuals modify their views and adapt their behavior based on new knowledge or shifts in the surroundings, with the goal of preserving or enhancing their anticipated usefulness.

6. Decision theory: Decision theory offers a structured framework for representing logical decision-making. It entails evaluating the likelihoods, values, and compromises to create choices that are in line with an individual's objectives.

6. Bounded rationality: Although the ideal notion of rationality involves flawless knowledge and computing powers, in reality, agents frequently function with restricted information and computational resources. Bounded rationality recognizes and accepts these limitations.

Context dependence refers to the concept that the interpretation or meaning of something can vary depending on the context in which it is presented or observed. Rationality is contingent upon the specific circumstances or conditions. The rationality of an action might vary depending on the context, taking into account the agent's objectives and the condition of the environment.

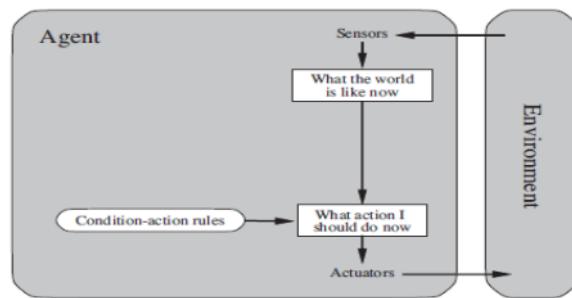
7. Comparison between Normative and Descriptive Rationality: Normative rationality pertains to the theoretical notion of how an individual ought to make decisions, whereas descriptive rationality examines the actual decision-making processes of individuals, taking into account their cognitive constraints.

8. Multi-Agent Systems: In the context of multi-agent systems, the notion of rationality encompasses the interactions that occur between several agents. In this particular setting, rational actors take into account the prospective behaviors of others and the potential consequence of those acts on their own objectives.

Structure of agents

The architecture of agents pertains to the arrangement and layout of elements within an intelligent agent. A₁₈ agent's structure has many components that facilitate its perception of the environment, its ability to process information, and its capacity to execute actions in order to accomplish its objectives. The structure of intelligent agents often consists of the following basic components:

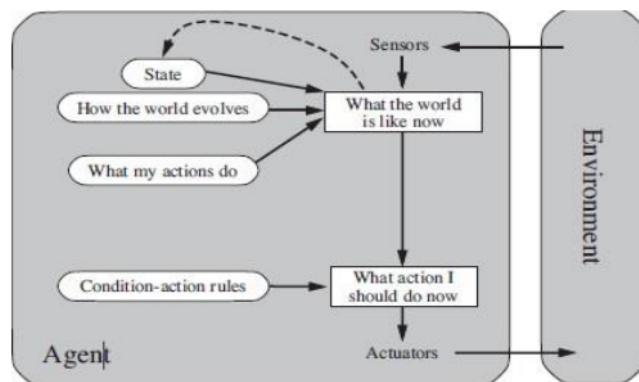
3 Simple Reflex Agents: These agents make judgments exclusively based on the current percept, disregarding the past sequence of events. They adhere to predetermined



guidelines for their actions. Reflex agents that rely on models to make decisions and do actions.

117 Model-Based Reflex Agents:

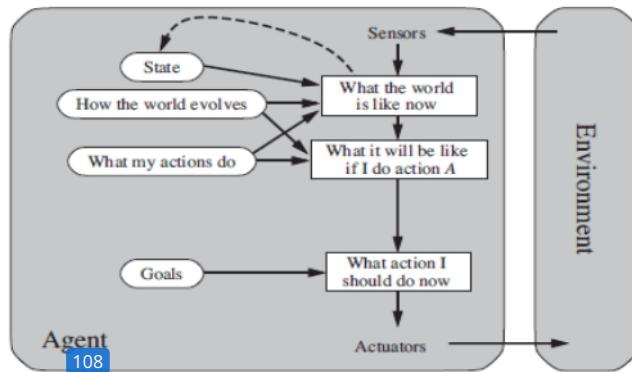
These agents possess an internal representation of the world, enabling them to make



decisions by considering both present and previous sensory information.

Goal-based agents :

Goal-oriented agents possess well defined objectives and employ decision-making processes to accomplish those objectives. They carefully contemplate the repercussions of their acts and strategize accordingly. Agents that are designed to maximize utility or optimize

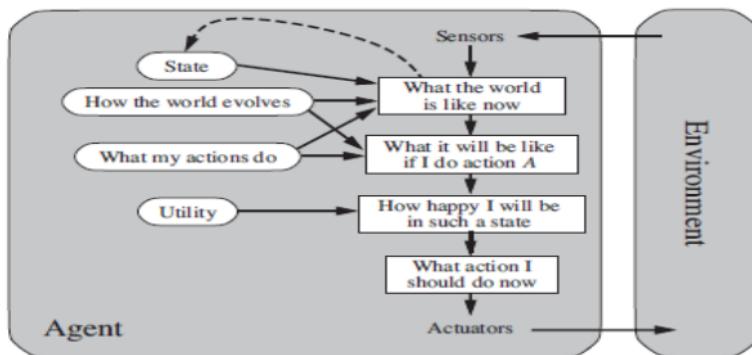


outcomes based on a set of preferences or goals.

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Utility-based agents:

Utility-based agents make decisions by evaluating the predicted usefulness of various actions. They evaluate the attractiveness of potential results and select activities that optimize anticipated usefulness.

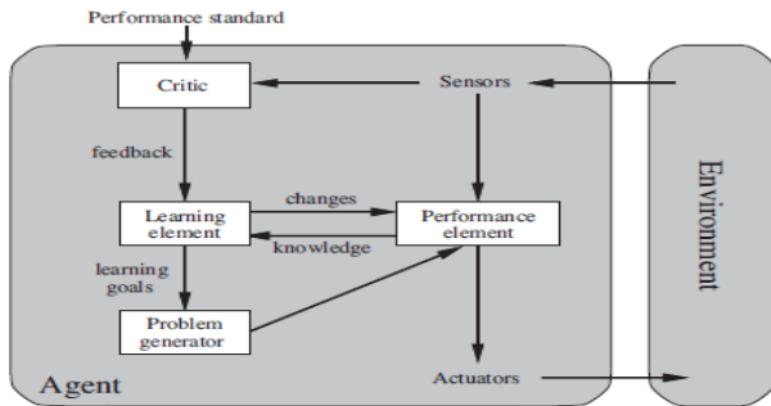


Learning agents:

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Intelligent agents that acquire knowledge and skills through the process of learning:

Learning agents have the ability to modify their behavior by drawing on past experiences. They utilize learning algorithms to enhance their performance progressively.



Multi-Agent Systems:

In situations with several intelligent agents, they have the option to work together or compete with each other in order to accomplish their own or shared objectives. Effective coordination and communication among agents is of utmost importance.

Intelligent agents play a crucial role in a wide range of AI applications, including as robotics, autonomous systems, recommendation systems, and others. The development and execution of intelligent agents need the integration of algorithms, models, and technologies that are customized to meet the unique needs of the application.

Module 2

64 Problem-solving by searching

Problem-solving by searching is a fundamental concept in artificial intelligence (AI) that involves finding a sequence of actions or steps to reach a goal state from an initial state. This process is modeled as a search problem, where the system explores possible states and actions in a systematic manner until a solution is found.

In artificial intelligence, a well-defined problem typically exhibits the following characteristics: