Chapter: 13

NATURE OF ENVIRONMENTS & INTELLIGENT AGENTS

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ABSTRACT

Decision Support Systems need to be incorporated for the environment as well as disseminate knowledge related to the phenomena and the inter-dependencies in the disturbed natural systems, that is a model. Using an ongoing project on mangrove forest management as an example, we discuss different tasks and requirements and propose to use methods and techniques developed in research on modeling and model-based systems in Artificial Intelligence for computer support to solving the problems.

Keywords: *Knowledge Graphs, Decision Support System, Artificial Intelligence, Intelligent Agents*

INTRODUCTION

Every day, we can witness how effectively modern technology influences and change the world and our lives. The most outstanding effects, indeed, are destructive. By "destructive", we mean that human activities destroy the existing balance of complex natural systems - irreversibly, at a large and even global scale. Or is it not "impressive" that it took only a few decades to eliminate the stability of self-organizing systems that have existed and developed over thousands and millions of years: rivers, rain forests, even oceans and the atmosphere, interrelationships of species? Despite this "success", humans will not be able to destroy the system of life on earth itself. It will survive human impact as it survived the impact of a meteor 60million years ago, move to a different balance, develop new species, and eliminate others (perhaps including the human species). However, the impact of human activities has started to change and threaten the living conditions and even the lives of the originators of the disturbances.

NATURE OF ENVIRONMENTS

- **Data Environment:** AI systems heavily rely on data to make decisions and predictions. The nature of the data environment includes the type and quality of data available, data sources, data volume, and data diversity. The quality and quantity of data have a significant impact on the performance of AI algorithms.
- **Real-world Context:** AI applications are often deployed in real-world settings, such as healthcare, finance, manufacturing, and transportation. The nature of these environments includes the specific challenges and requirements of the domain in which the AI system is applied. For example, healthcare AI operates in a different context than autonomous vehicles.

- **Dynamic Nature:** Many AI environments are dynamic and can change over time. For example, market conditions, user preferences, and environmental factors can shift, and AI systems must adapt to these changes to remain effective.
- **Security and Privacy:** The nature of AI environments in terms of security and privacy concerns is essential. Protecting sensitive data, preventing cyber threats, and complying with data protection regulations are critical considerations for AI deployments.

  Hardware and Software Infrastructure: The hardware and software infrastructure on which AI systems run is a significant aspect of the environment. This includes the processing power, network connectivity, and software platforms that support AI operations.

  Human Interaction: AI systems often interact with humans, whether through user interfaces, chatbots, or other means. The nature of human interaction and user expectations is a vital part of the AI environment.
- **Ethical and Regulatory Considerations:** The ethical and regulatory environment in which AI operates is becoming increasingly important. Understanding the legal and ethical constraints and guidelines for AI development and deployment is crucial.
- **Adaptability and Learning:** Many AI systems are designed to adapt and learn from their environments. Understanding how AI systems can improve over time and how they can be fine-tuned is part of their environment.
- **Benchmarking and Evaluation:** The nature of AI environments also includes how AI systems are evaluated and benchmarked for their performance. Developing appropriate evaluation metrics and benchmarks is essential.
- **External Influences:** External factors such as market trends, competition, and public perception can influence the nature of AI environments. These factors may impact the adoption and success of AI systems.

  This test aims at fooling the tester. If the tester fails to determine machine's response from the human response, then the machine is said to be intelligent.

PROPERTIES OF ENVIRONMENT

The environment has multifold properties –

- **Observability:** The extent to which an AI agent can perceive and obtain information about its environment. An environment can be fully observable, partially observable, or unobservable. In a fully observable environment, the AI agent has complete knowledge of the environment's state. In a partially observable environment, the agent has limited or imperfect information, which may require memory and reasoning to make decisions. In an unobservable environment, the agent has no access to the environment's state.

- **Determinism:** The degree to which the outcomes of actions in the environment are predictable. In a deterministic environment, the results of actions are known with certainty. In a nondeterministic environment, there is uncertainty, and the same action can lead to different outcomes.
- **Episodic vs. Sequential:** The nature of the AI task can be episodic or sequential. In an episodic task, each action is independent, and the agent's actions do not affect future states. In a sequential task, the agent's actions have consequences that impact future states and decisions.
- **Static vs. Dynamic:** The environment can be static or dynamic. In a static environment, the state of the environment does not change while the agent is making decisions. In a dynamic environment, the environment can change, which requires the agent to adapt and make decisions in response to these changes.
- **Discrete vs. Continuous:** The properties of the state space and action space in the environment can be discrete or continuous. In a discrete environment, there is a finite number of distinct states and actions. In a continuous environment, the state and action spaces are continuous and can have infinite possibilities.
- **Adversarial:** In some AI applications, the environment may be adversarial, meaning it actively tries to thwart the agent's objectives. Adversarial environments are common in game playing and cybersecurity.
- **Stochasticity:** Stochasticity refers to randomness or probabilistic elements within the environment. The presence of stochastic elements can introduce uncertainty into the AI system's decision-making process.
- **Feedback:** The environment may provide feedback to the AI agent in the form of rewards or penalties. This feedback is essential for reinforcement learning, where the agent learns from its actions based on the consequences they yield.
- **Accessibility:** This property refers to the agent's ability to interact with the environment. An environment can be fully accessible, partially accessible, or inaccessible, depending on the agent's ability to affect or observe the environment.

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- **Multi-agent:** In some AI environments, there may be multiple agents operating simultaneously, and the interactions among these agents can significantly impact the behavior and outcomes of the AI system.

STRUCTURE OF INTELLIGENT AGENTS

1. **Perception Module:** This component enables the agent to sense and collect information from its environment. It includes various sensors and data sources that provide input to the agent. These sensors can capture data such as text, images, sound, or other types of information, depending on the agent's application.

2. **Knowledge Base (KB):** The knowledge base represents the agent's internal storage of information and past experiences. It includes facts, rules, and data that the agent uses for decision-making and problem-solving. The knowledge base can be pre-programmed, learned from data, or a combination of both.

3. **Reasoning and Inference Engine:** This component allows the agent to process the information stored in its knowledge base, make logical inferences, and draw conclusions. It can include various reasoning techniques, such as deductive reasoning, inductive reasoning, or probabilistic reasoning, depending on the agent's capabilities.

4. **Decision-Making Module:** Agents use a decision-making module to determine their actions based on the information they've gathered and their goals. This module can employ algorithms like rule-based systems, expert systems, reinforcement learning, or other decision-making methods.

5. **Action Execution:** Once the agent has made a decision, it needs the ability to execute actions in the environment. These actions can be physical, such as moving a robot, or digital, such as sending a message or making a recommendation.

6. **Communication Interface:** Many intelligent agents can communicate with other agents, humans, or external systems. This communication can take the form of sending and receiving messages, sharing data, or coordinating activities with other agents.

7. **Learning Module:** Learning is the agent's ability to adapt and improve its performance over time. Agents can employ various learning techniques, such as supervised learning, unsupervised learning, reinforcement learning, or deep learning, to enhance their knowledge and decision-making abilities.

8. **Goals and Objectives:** Agents typically have predefined goals or objectives that guide their actions. These goals can be explicit tasks to accomplish, and agents often use utility functions to evaluate and prioritize different outcomes.

9. **Environment Interface:** The environment interface is the boundary through which agents interact with the external world. It allows agents to receive sensory data, perform actions, and engage with the environment. Depending on the application, this interface may include physical sensors and actuators or digital interfaces like APIs.

10. **Planning and Control:** In complex environments, agents may use planning and control algorithms to sequence actions and achieve their goals efficiently. This component is crucial for agents operating in dynamic or uncertain environments.

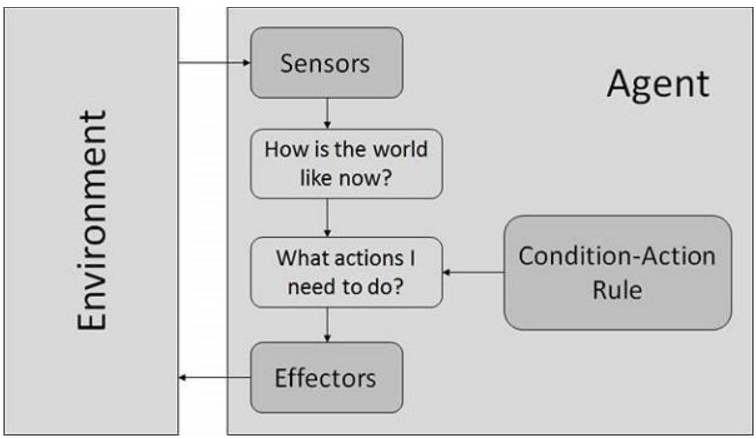

Figure-1: Intelligent Agents

MODEL BASED REFLEX AGENTS

They use a model of the world to choose their actions. They maintain an internal state.

Model − The knowledge about "how the things happen in the world".

Internal State − It is a representation of unobserved aspects of current state depending on percept history.

Updating the state requires the information about −

- How the world evolves.
- How the agent's actions affect the world.

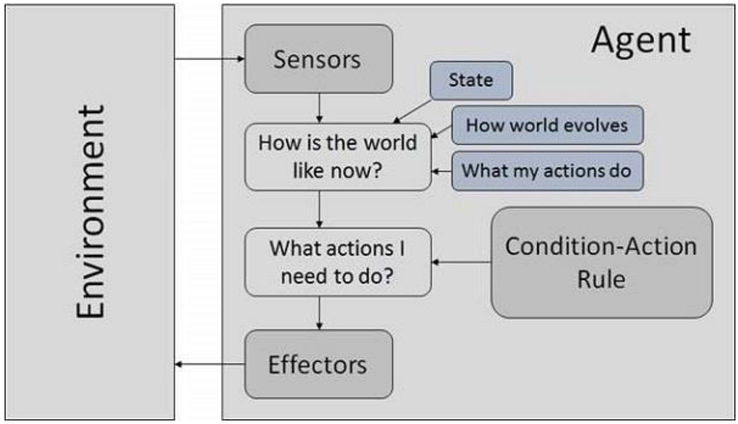

Figure-2: Model Based Reflex Agents

GOAL BASED AGENTS

Goal-based agents in the field of Artificial Intelligence (AI) are intelligent systems designed to achieve specific objectives or goals within an environment. These agents operate based on a set of predefined goals, and their primary purpose is to make decisions and take actions that maximize the likelihood of achieving those goals.

Goal − It is the description of desirable situations.

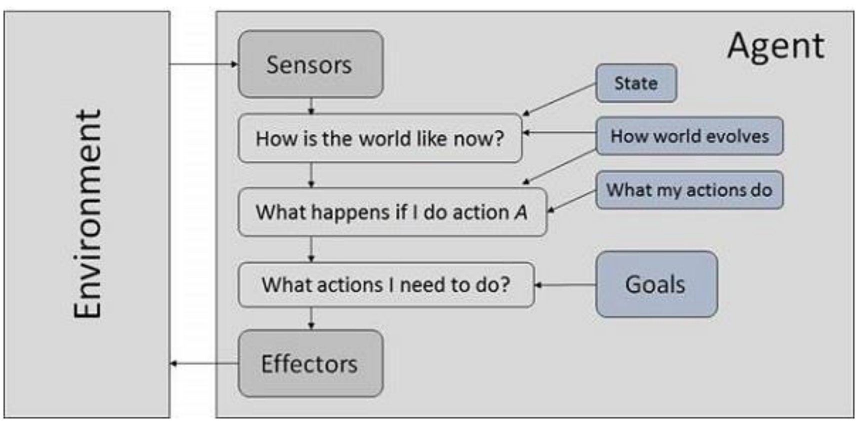

Figure-3: Goal Based Agents

UTILITY BASED AGENTS

Utility-based agents in the field of Artificial Intelligence (AI) are intelligent systems designed to make decisions and take actions based on a utility function. These agents aim to maximize their expected utility by selecting actions that lead to the most

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favorable outcomes. The utility function quantifies the desirability or preference of different states or outcomes, helping the agent make rational choices. Here are the key characteristics and components of utility-based agents in AI:

i. **Utility Function:** The utility function is a mathematical representation of the agent's preferences. It assigns a numeric value (utility) to each possible state or outcome that the agent may encounter. Higher utility values indicate more desirable states or outcomes, while lower values represent less desirable ones.

ii. **Goal Specification:** Utility-based agents typically have high-level goals or objectives. These goals are translated into a utility function that encodes the agent's preferences over different states or outcomes. The utility function reflects how well each potential state aligns with the agent's objectives.

iii. **Sensory Perception:** Agents use sensors to perceive and gather information about their environment. This sensory input is used to assess the current state or situation, allowing the agent to make decisions based on the information available.

iv. **Decision-Making:** Utility-based agents make decisions by evaluating the utility of different actions or plans. The agent selects actions that are expected to result in the highest overall utility. This process involves comparing the expected utilities associated with different choices.

v. **Uncertainty Handling:** Utility-based agents often operate in uncertain environments. To address uncertainty, they may use probability distributions or expected values to compute the expected utility of actions. This incorporates the likelihood of various outcomes when evaluating actions.

vi. **Action Execution:** Once the agent has determined the action that maximizes expected utility, it initiates the execution of the selected action in the environment.

vii. **Monitoring and Feedback:** Utility-based agents continuously monitor the environment and receive feedback regarding the outcomes of their actions. This feedback allows the agent to update its beliefs and revise its future decisions.

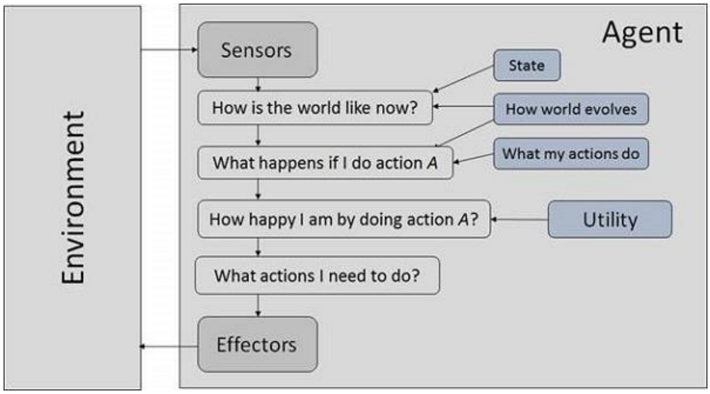

Figure-4: Utility Based Agents

PROBLEM SOLVING

Problem solving in Artificial Intelligence (AI) refers to the process of finding solutions or making decisions in complex and often dynamic situations. AI systems are designed to address a wide range of problems, from simple puzzles to intricate real-world challenges.

Problem solving in AI typically involves several key steps and techniques, including:

1. **Problem Representation:** The first step in AI problem solving is to represent the problem in a format that the AI system can understand. This involves defining the initial state, the goal state, the set of actions or operations that can be performed, and the constraints that govern the problem. Problem representation can vary depending on the nature of the problem, such as using state spaces, graphs, or mathematical models.

2. **Search Algorithms:** Many AI problem-solving approaches involve searching through a space of possible solutions to find the best one. Various search algorithms, such as depth-first search, breadth-first search, A* search, and heuristic search, can be employed to explore the solution space efficiently. These algorithms help identify a sequence of actions that lead from the initial state to the goal state.

3. **Knowledge Representation:** In many problem-solving tasks, AI systems use knowledge representations to encode domain-specific information and constraints. Knowledge can be structured using symbolic logic, semantic networks, frames, or other knowledge representation formalisms. This knowledge helps AI systems reason about the problem and make informed decisions.

4. **Inference and Reasoning:** AI systems use inference and reasoning mechanisms to draw conclusions, make predictions, and generate new information based on the problem's representation and domain knowledge. Logical reasoning, probabilistic reasoning, and rule-based reasoning are examples of techniques used in problem-solving tasks.

5. **Heuristics and Domain Knowledge:** Heuristics are rules of thumb or problem-solving strategies that provide shortcuts to quickly assess the desirability of different states or actions. Domain knowledge, acquired through training or expert input, helps AI systems make more informed and context-specific decisions.

6. **Constraint Satisfaction:** Many problems involve satisfying a set of constraints while optimizing a particular objective. Constraint satisfaction problems (CSPs) involve finding assignments to variables that meet all specified constraints. AI systems use techniques like constraint propagation and backtracking to solve CSPs.

7. **Optimization Techniques:** In optimization problems, AI systems aim to find the best solution or configuration among a set of possible alternatives. Optimization algorithms, such as linear programming, genetic algorithms, and simulated annealing, are employed to identify the optimal solution.

8. **Machine Learning:** In certain problem-solving scenarios, machine learning techniques are used to train AI systems to make decisions based on historical data. Supervised learning, reinforcement learning, and unsupervised learning are employed to create models that can generalize from data and make predictions.

PROBLEM SOLVING AGENT

An intelligent **agent** act to increase their performance measure. Some do this by adopting a goal. **Problem Solving Agent** – Special type of goal-based **agent**. observable initial state and current state is known discrete – more than one solution possible deterministic – the solution, when executed will work!!

EXAMPLE PROBLEM

Smart Car- car project and Tesla's "autopilot" feature. The AI detailed in this article learned to play simple video games, and Google will be testing that same intelligence in driving games before moving onto the road. The idea is that, eventually, the car will be able to "look" at the road ahead of it and make decisions based on what it

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sees, helping it learn in the process. While Tesla's autopilot feature isn't quite this advanced, it's already being used on the road, indicating that these technologies are certainly on their way in.

CONCLUSIONS

In this paper, we argued that solving our "environmental problems" requires to gain more insight in the complex interactions in ecosystems of which human activities are only a small part, i.e. develop and use better models of such systems, computer systems should be designed and implemented that support this task and, hence, have to support conceptual modeling and problem solving based on such models, theories, methods, and techniques developed in Artificial Intelligence research on knowledge representation and reasoning and, in particular, qualitative modeling and model-based systems are a promising starting point to pursue this goal.

This is why, although the goals are rather ambitious, there can be accomplishments,even in the short term. This is not the claim that we believe to have solved allfundamental problems. On the contrary, a lot of research and development of tools as qualitative spatial and temporal reasoning. But there exists a strong basis in terms of theory, methods, and implemented tools and systems for tackling the tasks mentioned above in real applications.

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