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The Impact of "Logic" in Artificial Intelligence

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Abstract: Artificial intelligence has evolved based on many science disciplines, including but not limited to computers, math, physics, biology, law, psychology, ethics, neuroscience, engineering, economics, etc. One of these fields is logic. The study the role of logic on the building and evolution of artificial intelligence, the logic behind artificial intelligence, the impact of logic on the progress of artificial intelligence, and with the significance of logic-based artificial intelligence. Thus, responds to what is artificial intelligence logic and how it relates to other logic. The descriptive research design was employed in the current investigation through literature analysis. Study results suggest that logic has an active participation in artificial intelligence formation and development through decision-making based on logical principles and rules, complex problem solving, inference, logically processing mathematical and symbolic codes, appropriate analyzing of information data, and coping with uncertainty through logical thinking.

Keywords: Artificial intelligence, logic, logic types.

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Introduction

Artificial intelligence (AI) is a subfield of computer science concerned with building programs that allow computers to show behavior that could count as intelligent. AI studies the cognition and problem-solving capabilities of the human brain and the data serves as the basis to create intelligent software and systems (Mccarthy, 2007). It aims to build computer systems that demonstrate human-like intelligence through logic. As such, logic is an integral part of creating AI because it establishes the rules and principles for deriving valid conclusions and studies the cognition processes. Thus, the first questions arise about how and to what extent logic, as a basis supporting and creating the infrastructure of artificial intelligence, is used throughout a given process. From these questions, we can also say that the present study was structured to find how logic helps format the artificial intelligence evolution and which ways of logic are used in artificial intelligence. In line with this study objective, the literature was reviewed to investigate whether current studies on the above-mentioned objective do exist and if so, whether the contribution of logic to the section was occupied as the area of study.

Literature review demonstrated the existence of both theoretical and applied studies on the relationship between artificial intelligence and logic (Bayraktar, 2020; Güllü, 2017; Mccarthy & Hayes, 1969; Minsky, 1974; Nilsson, 2010; Pearl, 1988; Reiter, 1980; Russell & Norvig, 2020; Zadeh, 1975). Most of these studies were concerned with logical foundations in the area of artificial intelligence, knowledge representation and reasoning, The philosophical perspective on logical problems of artificial intelligence, probabilistic logic, and Bayesian networks. Moreover, there are studies on uncertainty and partial truth in artificial intelligence, navigation of an autonomous mobile robot based on artificial intelligence search and analysis functions, traffic light control systems optimization based on fuzzy logic and artificial intelligence, knowledge representation and inference, by introducing a reasoning logic into artificial intelligence and the logic structures of knowledge of the artificial intelligence, the history of development and the connection with logic. However the studies reviewed were largely focused on the relationship between logic, which is present in computer, engineering and science, and artificial intelligence. On the other hand,

recent studies have been application-oriented. While each of the above studies is not in vain, the relationship between artificial intelligence and logic is not just limited to the computer, engineering, and science fields. AI can also be related to logic and its types of informal domains. Because of that, the development will show both implications of the connection of logic with artificial intelligence and relate to how important logic is for the future development of artificial intelligence itself. To this end, the question that arises is "The impact of the logic on the formation of artificial intelligence" and a question was gained based on literature for the determination of the solution for this problem. This was followed by a discussion of the different types of logic and the effect of logical reasoning on artificial intelligence.

1. Use of Logic in Artificial Intelligence

Logic is a tool used in computer science to prove the correctness of algorithms, define the semantics of programming languages, and solve problems in fields such as artificial intelligence. Specifying a programming language via logic can characterize a mapping into itself in which computations are licensed by programs. In certain instances, logic is employed to acquire the features of a functioning system that may be elucidated by the advancement of fresh notions in logical theory. For example, one convenient aspect of artificial intelligence is the use of direct applications of ideas extracted from logic (theorems proving and model-building techniques). Some artificial intelligence theorists also apply other tools. Robert C. Moore (1994), therefore, makes a distinction among three applications of logic to artificial intelligence: as an analytic tool, as a basis for the representation of knowledge, and as a programming language. There are different fields like knowledge representation, reasoning, logical programming, and algorithms, which are very close to the overlap of logic and artificial intelligence. Below, these features which artificial intelligence symbolizes strong or weak logic are described further.

Knowledge Representation: Logic plays a key role in representing knowledge through symbols and concepts. Artificial intelligence systems often represent and process knowledge symbolically. For example, a language processing algorithm can infer meaning using logical rules by representing a sentence using symbols.

Reasoning and Inference: Logic examines the process of reasoning to reach correct conclusions using a set of rules and principles. Artificial intelligence systems similarly use logical inference to draw conclusions based on given information. For example, an expert system can use logical rules to diagnose a specific disease.

Logic Programming: In the field of artificial intelligence, languages such as the logical programming language Prolog are widely used for knowledge representation and reasoning. These languages enable the development of artificial intelligence applications by transforming logical expressions into programming constructs.

Logical Structures and Algorithms: Artificial intelligence uses various logical structures and algorithms to perform decision-making processes. For example, artificial neural networks use complex mathematical operations to perform logical operations (Huth & Ryan, 2004)

Constraint and Rule-Based Systems: Logic examines the process of thinking and drawing conclusions within the framework of constraints and rules. Applications such as artificial intelligence, constraint-based systems, and expert systems use these logical rules to solve problems.

Expert Systems: Expert systems are used to model the knowledge and experience of human experts in a specific field of expertise. These systems are typically based on "if-then" rules. For example, a medical expert system might use logical rules to make a diagnosis based on a patient's symptoms and medical history. Consider a rule set like this: "If the patient has a fever and a cough, they might have the flu."

Natural Language Processing: Natural language processing (NLP) deals with computers understanding and generating human language. Logic plays a key role in NLP because it analyzes the logical structure of language. For example, in a text understanding task, a machine might analyze a sentence expressed in natural language, derive its logical structures, and use these structures to derive the meaning of the text (Mccarthy, 2007).

Fuzzy Logic and Control Systems: Fuzzy logic is used to model systems involving uncertainty. For example, an autonomous vehicle often uses fuzzy logic when assessing traffic conditions. Terms such as "fast," "medium," and "slow" may be used to describe traffic conditions. In this case,

logical inferences can be made to adjust vehicle speed using a specific set of rules that express the vehicle's speed and traffic density.

Game Theory and Strategic Decisions: Artificial intelligence also uses logic in game theory and strategic decision-making. For example, in a strategic game like chess, an AI program can analyze the current board state, evaluate possible moves, and use logical rules to choose the most appropriate strategy (Chang & Wang, 2021)

Based on these features, studies in which artificial intelligence generally benefits from the field of logic are: studies in logical theory and computational theory (non-monotonic logic, complexity theory), studies in application areas (temporal reasoning, formalisms for reasoning about planning, action and change, meta-reasoning, reasoning about context, reasoning about values and desires, reasoning about the mental states of other agents and especially about knowledge and belief, spatial reasoning, reasoning about uncertainty), studies on application techniques (logic programming, explanation logics, theorem proving, model building), and studies on large-scale applications (cognitive robotics, combining, updating, and correcting knowledge bases) (Sipser, 2006)

2. Types of Logic Used in Artificial Intelligence Applications

Classical logic, propositional logic, first-order logic, fuzzy logic, modal logic, persuasion logic, temporal logic, and philosophical logic are the types of logic used in artificial intelligence applications. That data includes both formal types of logic as well as informal types. For that reason, logic's contribution to AI is not limited to the formal part of logic.

2.1. Classical Logic

A type of logic that focuses on whether a given set of propositions is true or false and shows how relations are naturally connected. This logic takes propositions in symbolic form and investigates the relationships between propositions with rules expressed via logical connectives (and, or, not) and quantifiers (every value of, some values of). Many applications of artificial intelligence are grounded on classical logic.

In artificial intelligence, classical logic is applied in two areas: expert systems and knowledge-based (KB) systems. Rule-Based Expert System: It is a system that solves problems in a certain domain with the assistance of knowledge and inference rules. Knowledge-based structures, conversely,

store significant information amounts using conventional logic, establishing inferences as to this information. For instance, a doctor can predict the weather if he sees certain symptoms in the body.

Rule 1: If it is cold and cloudy, then it might rain

Rule 2: No cold (hot) weather, windy situation → → humidity heavy

Rule 3: Where in a mountain region: → → mountainsides are steep.

Rule 3: In a mountain region: ⊆ high ⊆ mountains

Rule 4: In very cold outside climate, windy conditions ⊆ ⊆ windy situation → → humidity heavy

Rule 5: In a warm weather region: ⊆ 29 or 30 ⊆ ⊆ high 26 or 27 ⊆ humidity heavy.

Rule 5: In warm weather regions, ⊆ 29 or 30 ⊆ ⊆ low 26 or 27 ⊆ humidity heavy.

Rule 1: Summit ⊆ high; Weather ⊆ cool; ⊆ mountains; heavy; → → humid.

Here classical logic infers that p and q are propositions (Levesque, 2012; Poole & Mackworth, 2017).

2.2. Propositional Logic

It is a branch of classical logic that studies the truth values of particular propositions. This kind of logic is also used to articulate simple propositions and their relations. Logical circuits and truth tables are examples of how propositional logic is employed in AI.

In digital circuit design and analysis logical circuits are used, in addition, there is the truth table used to determine the truth or falsity of certain scenarios. As an illustration, in a digital circuit:

If the switch is on and there is power P:

Q: If the lamp is on

Rule: The lamp is on only if the switch is on and there is power (Russell & Norvig, 2020). An example of propositional systems can arise, as some include of circuits in propositional logic.

2.3.First-Order Logic

Many fields of artificial intelligence deal with first-order logic including knowledge representation, logical inference, natural language processing, automatic theorem provers, planning & problem solving, and databases & knowledge management. By allowing you to express relationships

and attributes that exist between objects, first-order logic allows artificial intelligence systems to operate more intelligently, consistently, and smoothly. This kind of logic lays a strong foundation for designing and implementing complex systems.

Knowledge Representation and Logical Reasoning in AI Systems On: Its whole, first-order logic allows for a much richer and more expressive representation of objects, properties, and relationships.

The approach used by an expert system such as, "first-order logic", is used in making a medical diagnosis, or logical expressions are used to describe the relationships between patients' symptoms and diseases. For this:

Disease (flu) ← Symptom (fever) ∧ Symptom (cough)

Symptom (headache) ∧ Symptom (nausea) → Disease (migraine)

These statements imply which disease a patient with certain symptoms can have (Belnap & Müller, 2014).

Another application of first-order logic is found in natural language processing, where it is used to parse and understand the semantics and syntax of sentences. First-order logic is used to generate and parse the language, with grammatical rules and semantic relations defined as part of the grammarian process. To illustrate: in a text analysis system, you can apply first-order logic to deduce the structure of sentences or the meaning of words. Not all sentences have subjects and verbs.

This reads as 'All sentences have a subject and a verb' (Belnap & Müller, 2014). This example is linked to the processing and discussion of logic in the language and meaning dimension.

Another area where one can find first-order logic is in automated theorem provers that prove mathematical theorems and derive logical conclusions. They are proven automatically from first principles, via a set of rules and logical deductions. In fact, an automated theorem prover can be used to prove Pythagoras' theorem. For instance, "∀x ∀y ∀z (Triangular (x, y, z) ∧ Perpendicular (x, y, z) → x^2 + y^2 = z^2)" Thus, this says "for all x, y, z, if x, y, z is a right-angled triangle then x^2 + y^2 = z^2".

Artificial intelligence systems plan and create solutions to reach a particular objective. Most processes can be represented as rules and relations in first-order logic. A robot planning to do a specific job is an example.

To carry out the repair task, plans for going to the key and the machine must therefore be created: Task (repair) ∧ Tool (key) ∧ Place (machine) → Plan (repair with key) (Nilsson, 2010).

When it comes to more abstract concepts like classes or hierarchy of concepts, first-order logic comes into play. Without going into details, logic is used as a tool for information storage and inference in a database. Example: First-order logic can retrieve the courses that a specific student has taken in a particular database.

∀x ∀y (Student(x) ∧ Course(y) ∧ Taking (x, y) → Enrolled (x, y). This is read as∀x ∀y If Student(x) And (Course(y)∧Taking (x, y) → Enrolled (x, y) This scenario involves symbolic logic and quantification logical rules (Luger & Stubblefield, 2009).

There are also many artificial intelligence programming languages and tools capable of dealing with complex logical expressions using first-order logic. First-order logic is the basis of logical programming languages like Prolog (a fourth-generation computer programming language used widely for artificial intelligence applications) which is the most widely employed logical programming language in the artificial intelligence development life cycle. We can represent the family relationships in the Prolog program as follows:

Mother (mary, john).

Father (james, john).

Parent (X, Y) :- mother(X, Y).

Parent (X, Y) :- father(X, Y).

This program demonstrates how the relationships between parents are depicted, with Mary as John's mother and James as John's father (Luger & Stubblefield, 2009).

2.4. Fuzzy Logic

Fuzzy logic is a specific logic used for modeling problems of probabilities and uncertainty (Zadeh, 1975). Fuzzy logic deals with uncertain situations by considering the statistical information and probability distributions and integrates with probability theory. Typically this is used in sectors such as risk analysis, forecasting, and decision making. Although classical logic only accepts true or false (1 or 0) values, fuzzy logic accounts for imprecise and uncertain values. This enables better modeling and solving of

real-world problems. On the other hand, fuzzy logic is a logic type well able to model uncertainty and fuzziness.

Fuzzy logic finds application in two fields of the artificial intelligence system, one is control systems and the other is pattern recognition. Common applications include air conditioners and automated control systems for control systems and pattern recognition for image processing and data analysis. This can apply to an air conditioning control system for example. The air conditioner runs fast when the temperature is high and the humidity is high. If the temperature and humidity levels are moderate, the air conditioner runs at medium speed. It is such a common method that Fuzzy logic is used widely, particularly in systems such as control systems (Zadeh, 1975).

2.5. Modal Logic

In artificial intelligence, modal logic is frequently used to represent how propositions, knowledge statements, or realities can transform based on specific modes, arrowed through the nodes in the graph. This kind of logic employs specific expressions called "modal operators". The core modal operators are as follows:

Necessity: This operator declares a proposition as always true. E.g., in "A circle is a ring", the necessity operator here specifies a condition that holds on every ring.

Option: This operator indicates that a proposition could be true. In the statement "It may rain today", for example, the condition expressed by the possibility operator may be true, but not certain.

Certainty: This operator tells us that a proposition is definitely true. For example, when it says "2+2=4", the condition established by the certainty operator is always true and cannot be refuted.

These operators are what is used in modal logic to express relations between propositional statements and their levels of truth. Modal logic is especially suitable for representing and reasoning about problems with uncertainty and vagueness in artificial intelligence applications. An application usage of modal logic is in robotics in which it can be utilized to identify and compare a continuum of options for actions (Bueno & French, 2018; Lindström & Segerberg, 2007).

2.6. Persuasion Logic

One type of logic, persuasion logic, is concerned with the structures and relations of persuasive arguments. This logic gives the rules and criteria to know how strong an argument is compared to others. It is employed in AI systems, most prominently in argumentation-based decision-making systems and new approaches to dealing with uncertainty. This sort of logic is designed to mimic how these types of strategies are employed to sway or convince others. Basic elements of persuasion logic often include (Brachman & Levesque, 2004):

Evidence and Arguments: These arguments are typically both logically and emotionally constructed.

Emotional and Social Persuasion: The persuasion logic not only cares about logical arguments, but emotional and social ones as well. This matters when modeling the process of how we persuade other people emotionally or socially.

Artificial intelligence applications: Application of thought logic in artificial intelligence applications such as virtual assistants, sales robotics, or marketing software. Such systems play on persuasion logic to seek certain actions or a purchase (Fisher, 2004). Example: A virtual or personal assistant (Siri, Google Assistant, Amazon Alexa, etc) application can apply persuasion logic by convincing the users to perform a specific action. They can argue with the user to purchase some commodity or make use of some service. For instance, they could argue whether a user should eat at a restaurant, or they could explain the benefits of a service to encourage them to use it. A marketing or salesbot, as well, can leverage persuasion logic to seduce users into purchasing a given product or service. For instance, if a user visits an e-commerce site, a bot can inform them that discounts are about to expire or stocks are low, creating a feeling of urgency and prompting them to make a purchase. For instance, in artificial intelligence applications used for education or training purposes, the third step will be trying to persuade students to study or learn more about a certain topic. For instance, a language learning app may provide motivational messages or progress incentives to encourage users to practice a new language daily. Persuasive logic can also be employed through AI applications for health and well-being to provide health coaching to users to plan health-friendly

lifestyles. This could be through giving users some information about the health benefits of regular exercise or motivating them to go on a particular diet program (Fogg, 2002).

2.7. Temporal Logic

Example forms of temporal logic will help to validate time-varying system dynamics. This logic gives special quantifiers and operators to express what happens in the time intervals of past, present, and future. Temporal logic is often used in artificial intelligence and computer science, particularly when systems must represent temporally changing states and account for many time-specific and time-dependent conditions. It is used in various domains including automation, model checking, and temporal decision-making (Euzenat & Montanari, 2005).

A large number of methods and applications observe the use of temporal logic in artificial intelligence, which can be grouped into: software and system verification, automated vehicles and robots, advanced planning and decision making, and explorers of time-based data. Temporal logic expressions can specify if a software system has a certain state or behavior at some moment in time. This gives system designers and test engineers a good blueprint of how their systems are expected to behave over time. From building automated vehicles or robots, temporal logic can assist in accurately maintaining certain conditions or timers in such systems, as well. For time-related conditions, these can be modeled using temporal logic so that an automated vehicle can sense the surrounding traffic and safely maneuver at certain times (Goranko & Rumberg, 2020). Moreover, it is also used in higher-level planning as well as decision-making operations in AI systems using temporal logic. Example: If you are creating an AI-based planning system then temporal logic expressions can be used to represent the availability of resources during certain time epochs or to represent the sequence of actions to be performed. Temporal logic can be applied to such scenarios, it helps them to comprehend and analyze the change in data across timelines. The Dinge logics introduced in are a family of linguistically inspired logic frameworks that allow them to specify strict temporal aspects of the underlying processes and time regularities they apply to, e.g., with the help of temporal logic, one can say that stock prices

have to increase or decrease, some number of times, over several time intervals (Lamport, 1983).

2.8. Philosophical Logic

Philosophical logic is an area of logic that uses a philosophical perspective; philosophically motivated logic, especially modal logic, falls on this side. This discipline encompasses the formal analysis of language and thought, ideas of a structure of logical systems, and the application of those systems in relation to philosophical questions. Philosophical logic extends far beyond classical logic and deals with more theoretical and far-reaching problems in logic. It played an important role in shaping the philosophical underpinnings of those types of logic. The philosophical logic topics in the data as well as the types of logic we have discussed are described more content-wise and described in bullet points shown below with references (Chang & Wang, 2021):

2.8.1. Branches of Philosophical Logic

Inductive logic, modal logic, deontic logic, quantum logic, temporal logic, free logic, question logic, command logic, choice logic, and conditional logic are branches of logical theory that are directly related to philosophical concerns. These areas of interest are listed below :

Inductive Logic

Philosophical Concerns: Inductive logic seeks to move from particular to general. Philosophically, the reliability and limitations of induction are questionable.

Use of Artificial Intelligence: Machine learning algorithms identifies general patterns in data based on inductive logic. The best example would be an AI system that makes predictions about consumer behavior by analyzing the behavior of specific customers.

Modal Logic

Philosophical Concerns: Modal logic studies necessity, probability and other modal concepts. Everything from philosophically possible worlds to modal actualities.

Use of Artificial Intelligence: Modal logic is employed in planning and decision-making systems in artificial intelligence. A robot, for instance — based on probability — analyzes the impact of a particular action.

Deontic Logic

Philosophical Concerns: Deontic logic addresses questions of moral and legal norms. It even follows philosophical imperatives and the logical DNA of laws.

Use of Artificial Intelligence: Deontic logic lets AI make ethical choices. For instance, To help an automated vehicle to comply with traffic rules, it is used or to take ethical decisions in a situation of an emergency (Garcia & Rodriguez, 2022; Sider, 2010).

Quantum Logic

Philosophical Concerns: Quantum logic goes beyond classical logic and examines features of quantum mechanics, such as uncertainty and superposition. Philosophically, this system of logic is used to understand the nature of reality.

Use of Artificial Intelligence: Used in quantum computing. Quantum computers solve problems at a much greater complexity using quantum logic than classical computers.

Temporal Logic

Philosophical Concerns: Temporal logic examines the accuracy of statements over time. Philosophically, it examines the nature of time and the changing circumstances that occur over time.

Use of Artificial Intelligence: It is applied in time series analysis and planning systems. An example of this: an AI system is used to predict the weather (Lamport, 1983).

Free Logic

Philosophical Concerns: Free logic is a logical analysis of undefined terms and empty sets. It philosophically explores the nature of being and not being.

Use of Artificial Intelligence: Free logic is used with knowledge bases to deal with incomplete or uncertain information. An information system, for instance, can help with unknown or uncertain information.

Question Logic

Philosophical Concerns: The logic of questions looks at the logical structures behind the act of asking and answering questions. Philosophically, it concerns the methods of gaining knowledge.

Use of Artificial Intelligence: Question logic is used for natural language processing and chatbots. This is also the logic that an artificial intelligence model applies to understand what users are asking and answer logically (Nilsson, 2010).

Command Logic

Philosophical Concerns: Command logic examines the logical structure of commands and instructions. Philosophically, the concepts of action and volition are discussed.

Use of Artificial Intelligence: Command logic is useful in robotic systems. An example is a robot's ability to perceive and respond to a few instructions to accomplish some tasks.

Preference Logic

Philosophical Concerns: Preference logic is the logical study of individuals' preferences and choices. Philosophically, it reflects on the theory of rational choice.

Use of Artificial Intelligence: Preference logic is employed in different artificial intelligence systems such as decision support systems and recommendation engines. For instance, an e-commerce website that recommends products to its users (Mccarthy, 2007).

Conditional Logic

Philosophical Considerations: Conditional logic investigates the logical apprehension of "if...then" statements. Philosophically, it treats conditional propositions and causality.

Use in Artificial Intelligence: Used for conditional decision making and scenario analysis. For example, a financial analysis system might evaluate scenarios such as, 'If interest rates increase, how will the market react?' (Poole & Mackworth, 2017)

2.8.2. Philosophical Discussions That Use The Mechanism of Formal Logic

Formal logic forges economy and exactness in philosophical taste and argument. This is especially true in matters concerning the rationale of language and logic. For instance, philosophers like Bertrand Russell and Ludwig Wittgenstein engage in deep conversations about what meaning is by examining the logical structure of language. In the realm of artificial

intelligence, such analysis helps natural language processing systems operate better and more accurately (Mccarthy, 2007).

2.8.3. Discussion of Some Philosophical Problems Regarding Logic and The Logical Structure of Language

It encompasses the logical form of language and of logic, of meaning and of truth and of cognition. So you have a discussion about, philosophically speaking, how language works and how meaning is conveyed. In AI these conversations are utilized in language processing and meaning extraction. For example, the capacity of a language model to comprehend texts and generate sensible responses is thus founded on philosophical analysis.

2.8.4. Philosophical Studies on Special Sciences

Specialized sciences also rely on logic to understand the principles, models, and methodologies associated with their fields. For instance, mathematical logic, used to prove mathematical theorems, the philosophy of science: this is the philosophical study of the assumptions, foundations, and implications of science. In AI, this kind of reasoning is used for processing and analyzing scientific data. Artificial intelligence could be applied to new drug discoveries by studying their biological data (Schulte & Placek, 2011).

Different segments of philosophical logic play a major role in the creation of more intelligent, ethical, and rational systems of AI. Such logical theories underpin the processes of decision-making, planning, knowledge representation, and ethical evaluation in artificial intelligence. Since theoretical studies in logical artificial intelligence are often based in a certain overlap with philosophical logic, it is possible to develop systems more secure and responsive to human utility by employing the same philosophical and logical principles outlined above in AI. It's equally interested in applications of logic that are non-meta-mathematical and its foundational subjects are much the same. This overlap is a function of common interests as well as the direct influence of philosophical logic on logical artificial intelligence. These are the kinds of logic in different contexts to solve the various problems in the AI application. However, which logic type is preferred depends on data structuring and how complex is the problem (Garcia & Rodriguez, 2022; Sider, 2010).

3. The Challenges Faced By AI Systems Equipped With Logical Reasoning Capabilities

Improving logical reasoning in AI systems requires integrating tools and techniques that will enable machines to process and interpret information logically and consistently.

• Some commonly used approaches that can help improve logical reasoning in AI systems include:

Rule-Based Systems: These systems are based on a set of well-defined rules to reach conclusions or make decisions. Such rules are typically structured in terms of "if-then" statements and serve as a guiding mechanism during the reasoning activities of the AI system. Developers use logical rules to train the system to infer new information from the existing data.

Information Representation: Representing knowledge in a structured manner is crucial for logical reasoning. Techniques such as ontologies, semantic networks in AI, or knowledge graphs can organize knowledge hierarchically and establish relationships between different entities. This allows an AI system to navigate and reason over the knowledge it possesses.

Verification and Reasoning Tools: Some of the theorem provers and reasoning tools can be used to automate logical inferences, including solution-based theorem provers and model-checking tools. These tools offer methods to validate the soundness of logical propositions, conduct consistency checks, and generate new logical inferences. These engines help AI systems do a better job at logical reasoning (Mccarthy, 2007).

Deduction: Deduction is the process of reasoning from one or more general premises or principles to reach a logically certain conclusion. It is based on the use of logical rules and formal logic to draw valid conclusions. Propositions, predicates and first order logic are some of the techniques that help to implement deductive reasoning in AI systems. Such methods enable the system to generate new knowledge based on background knowledge and rules.

Inductive Reasoning: Inductive reasoning involves generalizing from specific observations to draw broader conclusions. Machine learning algorithms such as decision trees, Bayesian networks or neural networks can be used to perform inductive reasoning. By analyzing patterns in existing data,

an AI system can learn to make probabilistic predictions and logical inferences. (Pearl, 1988) .

Abductive Reasoning: Abductive reasoning involves deriving the best explanation or hypothesis from a set of observations. It is often used when existing information needs to be supplemented or clarified. Bayesian networks and probabilistic graphical models can be used to implement abductive reasoning in artificial intelligence systems. The system can arrive at the most plausible solution by considering various possible explanations and their probabilities (Levesque, 2012; Poole & Mackworth, 2017).

Another shared challenge in developing AI systems that can reason is that they create many common AI systems.

• Some of the main challenges for getting AI to reason logically include the following:

Knowledge Representation: AI systems need an effective way to represent and store knowledge in logical reasoning. Choosing the appropriate representation to capture the complexities of real-world scenarios can be challenging. Knowledge representation must account for uncertainty, ambiguity, and context, often requiring sophisticated techniques such as ontologies or probability models.

Incomplete or Ambiguous Knowledge: Logical reasoning relies on complete and accurate information. However, real-world data can be incomplete, noisy or ambiguous. AI systems also need to handle incomplete or contradictory information, which makes logical inference difficult. Probabilistic reasoning or fuzzy logic is used to address this uncertainty and approximate reasoning (Pearl, 1988) .

Scalability and Efficiency: As the complexity of the problem increases, logical reasoning can become computationally demanding. Searching large knowledge bases or making comprehensive logical inferences can be time-consuming and demanding. Developing effective algorithms and reasoning mechanisms for complex problems is crucial for practical application (Poole & Mackworth, 2010).

Dealing with Complexity and Abstraction: Logical reasoning often involves dealing with complex and abstract concepts. AI systems must understand and reason about high-level concepts, relationships, and

generalizations. Accurately capturing and representing these abstract concepts within an AI system can pose a significant challenge.

Contextual Understanding: Reasoning logically requires understanding the context in which information is presented. Context plays a crucial role in interpreting statements, determining relevance, and resolving ambiguities. AI systems should, but are not required to, be able to grasp contextual cues and adapt their logic accordingly.

Acquiring Domain-Specific Knowledge: Logical reasoning in AI systems often requires domain-specific knowledge. Building a knowledge base encompassing a wide range of domains can be time-consuming and labor-intensive. Extracting relevant expertise from various sources and ensuring its accuracy and completeness are significant challenges in developing logical reasoning capabilities (Brachman & Levesque, 2004).

Logical thinking is a fundamental aspect of human intelligence, and incorporating it into AI systems opens up new possibilities for solving complex problems, making informed decisions, and increasing transparency. By leveraging tools and techniques such as knowledge representation, rule-based systems, formal logic, and NLP, AI systems that reason logically and provide reliable and explainable results can be developed. While challenges exist in acquiring knowledge, coping with uncertainty, and interpreting it, advances in AI that utilize logical thinking promise to revolutionize diverse fields, including healthcare, autonomous systems, and fraud detection. As we continue to explore the potential of logical thinking in AI, we are moving closer to developing intelligent machines that not only mimic human reasoning but also augment human capabilities. Thus, humans will usher in a future where AI becomes a powerful ally in solving the world's most complex problems (Nilsson, 2010).

4. Conclusion

Logic has a mathematical and symbolic structure and is the one behind AI systems decision and problem-solving. One approach to artificial intelligence systems is something called “logic processing,” or “symbolic computation.” The game is economically symmetrical (the income is not). Logic works by assessing the truth of these expressions of symbols or letters, thus making us be able to draw inferences and arrive at conclusions about them. But it seeks to draw accurate inferences, not just from the

logical formal field, that is, from symbols and algorithms alone, but also from the logic of the informal, philosophical, and classical varieties. In this context, it becomes apparent that logic is at the heart of artificial intelligence. So that the present study was planned to demonstrate the form of logic-based artificial intelligence, the role of logic in artificial intelligence, and the role and logic in the way that non-logic in the non-formal areas of artificial intelligence other than its formal keeper. With the descriptive approach, its study overviewed the logic on which basis is artificial intelligence, the relationship between artificial intelligence and logic, the role logic has in the establishment and development of artificial intelligence, types of logic, examples through which these types are implemented in artificial intelligence and its relationship with logical inferring. In the study results, logic is one of the factors lying behind artificial intelligence, utilized for the development and improvement of artificial intelligence, and thus has a significant correlation with artificial intelligence. Accordingly, the study made the following conclusions:

• Logic supports artificial intelligence systems using propositions (statements that can be true or false) and conjunctions (e.g. "and", "or", "not"): Generally, these systems have rule bases. Those bases are logical rule sets in which specified actions are performed under specified conditions.

• Logic lets someone conclude something based on certain premises: Often their inferences are based on predefined rules and logical structures. In Logic, logical operators are used to combine or evaluate premises. These operators are simple ones like "and", "or" and "not".

• Logic is a basic foundation of the decision-making processes of the algorithms of artificial intelligence: Logical rule bases are used to act in some way under some conditions. An example would be a set of logical rules that can be established to decide which direction an autonomous vehicle would turn.

• Logic also underpins the problem-solving abilities of AI systems: Logic-based algorithms can break down complex problems, generate solutions that satisfy relevant criteria, and derive output.

• AI systems improve logical reasoning: Various methods and techniques allow artificial intelligence systems to improve logical reasoning. These systems could make better, more consistent, rational, and intelligent

decisions, particularly if they adopt key principles/structures from the basic principles of (philosophical) logic, which is the informal side of logic. This enables A.I. to better serve human needs and develop more dependable systems.

• Logic influences various domains in artificial intelligence systems, which are knowledge representation, inference, planning, NLP, information verification, ethical decision-making, and uncertainty management: The reasoning ability of artificial intelligence systems makes these systems more intelligent, reliable, and consistent. Artificial intelligence can be successful and effective in multiple application areas due to the application of logical methods and techniques.

• Logic serves as the foundation of AI wherein the decision-making processes and the intelligent behaviors of AI systems are modeled.

Artificial intelligence is defined as a system that creates algorithms and models that perform various complex processes such as processing information, making certain decisions, and reasoning using rules and logical algorithms to achieve a defined objective. The present study concluded that AI can think, almost similarly to the human brain, perform tasks that are human-like, logical reasoning and thinking, solve complicated problems, facilitate clear, precise, rational and clever decision-making, deal with unpredictability, develop credible systems, however, the system of AI does not think like the human brain.

While logic carries out and contributes to the development of artificial intelligence, it must also be considered that sophisticated artificial intelligence studies can have undesirable outcomes due to improper and unreliable utilization. Similarly, artificial Intelligence is purely based on science, as without technology, we cannot allow for using Artificial Intelligence in any fashion, however, unless Artificial Intelligence is used appropriately and positively, it might result in a generation that neither tries to think logically nor requires to use their minds, cannot even use reasoning against any problem and gives up the mind which they should use to Machines. So as not to fall into this, artificial intelligence must be logical and based on rules, and principles of reasoning and not endanger reliability while serving humanity positively (information transfer, making work easier, providing quality and effective applications in education and training,

and having accurate and appropriate studies in different sectors such as health, justice, economy, etc. Thus, "logic", which works as a useful tool for the information management formation and processes of artificial intelligence, will give correct and positive contributions to the sequences of studies of artificial intelligence.

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Öz: Yapay zekâ, bilgisayarlar, matematik, fizik, biyoloji, hukuk, psikoloji, etik, sinirbilim, mühendislik, ekonomi vb. dahil ancak bunlarla sınırlı olmamak üzere birçok bilim disiplinine dayalı olarak gelişmiştir. Bu alanlardan biri de mantıktır. Çalışma, mantığın yapay zekanın inşası ve evrimindeki rolünü, yapay zekanın arkasındaki mantığı, mantığın yapay zekanın ilerlemesi üzerindeki etkisini ve mantık tabanlı yapay zekanın önemini ele almaktadır. Bu nedenle, yapay zekâ mantığının ne olduğu ve diğer mantıklarla nasıl ilişkili olduğu sorusuna yanıt verir. Mevcut araştırmada literatür analizi yoluyla tanımlayıcı araştırma tasarımı kullanılmıştır. Çalışma sonuçları, mantığın mantıksal ilkelere ve kurallara dayalı karar alma, karmaşık problem çözme, çıkarım, matematiksel ve sembolik kodları mantıksal olarak işleme, bilgi verilerinin uygun şekilde analiz edilmesi ve mantıksal düşünme yoluyla belirsizlikle başa çıkma yoluyla yapay zekâ oluşumunda ve gelişiminde aktif bir rol oynadığını göstermektedir.

Anahtar Kelimeler: Yapay zekâ, mantık, mantık türleri.