

The Role of Ontologies in the Era of Emerging Artificial Intelligence Tools

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In the dynamic landscape of technological advancement, the fusion of ontologies and artificial intelligence (AI) heralds a paradigm shift in knowledge representation and utilization. The synergy between these two domains has unlocked unprecedented possibilities, revolutionizing how data is processed and information is accessed. As structured representations of knowledge, ontologies provide a framework for organizing information according to concepts and their relationships. They serve as a cornerstone for knowledge management, enabling a deeper understanding of complex relationships within data. As AI technologies evolve, integrating ontologies empowers AI systems to make more informed decisions and derive insights from vast datasets. One of the key benefits of incorporating ontologies into AI systems lies in enhancing awareness of contextual nuances and semantic relationships within data. By leveraging ontological frameworks, AI algorithms gain a deeper understanding of the underlying structure of information, enabling them to navigate complexities and make more nuanced decisions. Creating a heightened awareness facilitates wiser choices and more accurate predictions, ultimately enhancing the effectiveness of AI-driven solutions.

The dynamic nature of ontologies allows for continual refinement and adaptation to changing circumstances. As new information becomes available or domain-specific knowledge evolves, ontologies can be updated and refined to reflect these changes. This adaptability ensures that AI systems remain relevant and responsive to evolving needs, contributing to long-term sustainability and efficacy. Moreover, ontologies are crucial in fostering interoperability and data integration within AI systems. By providing a standardized vocabulary and conceptual framework, ontologies facilitate seamless communication and data exchange between disparate systems and domains. This interoperability enhances the scalability and versatility of AI-driven solutions, enabling them to integrate seamlessly into diverse environments and address complex

challenges. Natural language understanding (NLU) is another area where integrating ontologies and AI yields significant benefits. By leveraging ontological knowledge, AI systems can better interpret and analyze natural language inputs, enabling more accurate and contextually relevant responses. Enhancing NLU capabilities enables AI-powered interfaces like ChatGPT to interact with users more effectively and provide more personalized and insightful responses.

Furthermore, the ethical implications of AI technologies are a growing concern in today's digital age. Developers can implement ethical guidelines and constraints directly into the underlying knowledge representation by incorporating ontologies into AI systems. This ethical mitigation ensures that AI-driven solutions adhere to ethical principles and guidelines, mitigating potential risks and safeguarding against unintended consequences. Integrating ontologies and artificial intelligence represents a transformative synergy reshaping how we process, manage, and leverage information. By harnessing the power of ontological frameworks, AI systems gain a deeper understanding of the underlying structure of enhanced interoperability, Natural Language Understanding, continual learning algorithms that enable informed decision-making, and ethical mitigation frameworks. As these integrative discoveries continue to unfold, they hold the promise of digitally ameliorating the world by empowering AI-driven solutions to address complex challenges and drive innovation across diverse domains.

Data Integration and Interoperability:

In the new era of artificial intelligence tools comes a plethora of accessible data that is easy to find on multiple platforms, such as ChatGPT. These AI tools merge data from across numerous databases into integration and interoperability. One important aspect to note is that interoperability is synonymous with integration. The integration connects applications from various sources to how data is formatted for diverse datasets to be aggregated or merged in a

functional dynamic. “Data interoperability relies on metadata and data documentation, as without proper documentation, researchers would not know which datasets and variables are comparable” (Data Interoperability, 2022, p. 1). Both data integration and interoperability are used cooperatively in big corporations and businesses that depend on vast databases. As such, artificial intelligence has been incorporated into the healthcare system astoundingly. Applying new artificial intelligence technologies to the healthcare industry might be a controversial topic for many; however, when researching the capabilities of AI tools, the innovative possibilities are endless.

In the healthcare realm, the convergence of data interoperability and emerging technologies like ChatGPT is fostering the realization of a singular server to house all medical informatics. This centralized repository promises transformative healthcare delivery, research, and decision-making benefits. Data interoperability enables the seamless exchange and integration of health information across disparate systems and platforms. By consolidating this interoperable data into a unified server, healthcare providers gain unprecedented access to a comprehensive repository of medical knowledge. This repository encompasses patient health records, clinical guidelines, research findings, treatment protocols, and more. The integration of ChatGPT further amplifies the potential of this centralized server by enabling natural language interaction and analysis. ChatGPT's ability to interpret and generate human-like text facilitates intuitive querying, knowledge discovery, and decision support. Healthcare professionals can leverage this capability to access pertinent medical information, seek clinical guidance, or even engage in conversational diagnostics.

Moreover, a singular server for medical informatics promotes enhanced collaboration and knowledge sharing among healthcare stakeholders. Researchers can access diverse datasets for epidemiological studies, clinical trials, and translational research. Clinicians can tap into collective insights and best practices to inform evidence-based care decisions. Patients can benefit from personalized treatment recommendations derived from comprehensive data analysis. However, realizing this vision requires addressing significant challenges, including data privacy, security, standardization, and regulatory compliance. Nevertheless, the trajectory towards a centralized repository for medical informatics propelled by data interoperability and technologies like ChatGPT holds immense promise for revolutionizing healthcare delivery and advancing patient outcomes. A study by Maxwell Y. Jen, Oren J. Mechanic, and Dac Teoli provides legislative information regarding the integration of AI in the field of medicine in an article on informatics.

Executive Order 13335 (2004), also known as the Incentives for the Use of Health Information Technology and Establishing the Position of the National Health Information Technology Coordinator, created the Office of the National Coordinator of Health Information Technology (ONC). While this did not directly affect clinical informatics or healthcare at large, it was the United States Federal Government's first step in creating a nationwide health information exchange, a foundational system for collecting and exchanging data across hospitals, regions, and states. (Jen, 2023)

Integrating Electronic Health Records (EHRs) offers a tangible example of how artificial intelligence can revolutionize healthcare. AI algorithms can analyze vast amounts of patient data within EHRs to identify patterns, predict outcomes, and assist in clinical decision-making. For instance, AI-powered systems can flag potential medication interactions, automate administrative

tasks, and even suggest personalized treatment plans based on individual patient data. These technologies demonstrate the transformative potential of AI in enhancing efficiency, accuracy, and quality of care delivery within the healthcare field. Hospitals harness extensive metadata from individual patient charts to optimize data management in the healthcare landscape. This wealth of information facilitates the migration and exchange of data across platforms and fuels the development and deployment of clinical decision-making algorithms. By analyzing patient data, such as medical history, treatment plans, and diagnostic results, AI-driven algorithms can assist healthcare professionals in making more informed and personalized care decisions.

Nevertheless, despite the potential benefits, interoperability challenges loom large, mainly when dealing with disparate systems and software solutions. Ensuring seamless data viewing by clinical end-users across various platforms is crucial for maintaining continuity of care. Radiology departments face unique interoperability concerns due to the voluminous nature of medical images. Preserving these images in a format that ensures accessibility and fidelity for future reference is paramount. Compatibility issues between hardware and software and the complexities of migrating data across different systems add layers of complexity to achieving interoperability. Addressing these challenges requires concerted efforts from healthcare institutions, technology vendors, and regulatory bodies. Standardization of data formats, protocols, and interfaces can facilitate smoother data exchange and interoperability. Additionally, investing in robust infrastructure capable of handling diverse data types and volumes is essential. Healthcare organizations must prioritize interoperability in their procurement decisions, selecting software solutions that support seamless integration with existing systems.

Furthermore, ongoing collaboration between stakeholders is crucial for developing interoperable solutions that meet the diverse needs of healthcare providers and patients.

Incorporating enhanced operability and integration encompasses engaging high-standard development organizations, sharing best practices, and fostering a culture of innovation and interoperability within the healthcare ecosystem. In essence, while interoperability challenges are complex and multifaceted, addressing them is essential for realizing the full potential of healthcare data in improving patient outcomes and advancing care delivery.

Natural Language and Understanding:

Natural Language Understanding in the realm of artificial intelligence, including ChatGPT, refers to the ability of machines to comprehend and interpret human language in a meaningful way. It involves parsing, semantic analysis, entity recognition, and sentiment analysis to understand human communication's intent, context, and nuances. Regarding ChatGPT, Natural Language Understanding enables the model to process user input, grasp its meaning, and generate an appropriate, contextually relevant, and coherent response. Applying Natural Language Understanding to programs is what makes artificial intelligence human-like. These innovative technologies are fundamentally simple, yet they construct AI ontologically dependent on its function for coherency. Two key elements of Natural Language Understanding are recognizing intent and entities. Intent recognition discerns the user's purpose and sentiment in the input text, forming a critical first step in NLU to comprehend the text's meaning. Entity recognition in NLU focuses on identifying entities in a message and extracting essential details about them, including named entities like companies or places and numeric entities such as quantities and dates. Recognizing these elements is crucial for laying the foundation of ontology in Natural Language Understanding, essential for AI programming, and ensuring accurate functionality within the AI landscape.

While exploring *Allaboutai*, a leading destination for all things AI, an article authored by Dave Andre, a seasoned digital marketer with over twenty years of experience in AI and SaaS, delves into the concept of ontology. According to Andre, ontology in AI “refers to a structured framework that categorizes and organizes information” (Andre, 2023, p4). The rising utilization of AI platforms such as ChatGPT fuels the popularity of personalized chatbot experiences for business customer service interactions. Natural Language Understanding (NLU) is a branch of artificial intelligence and computational linguistics dedicated to machines' capacity to grasp and interpret human language meaningfully. It aims to empower computers to comprehend, interpret, and react to human language in a manner akin to human cognition. The significance of Natural Language Understanding lies in its ability to tackle the complexity and evolution of human language, allowing computers to comprehend it. This capability drives the development of products and tools that recognize words and extract their meaning. Natural Language Understanding facilitates human-like interactions with computers, making it invaluable for consumer products such as voice assistants, chatbots, and speech-to-text features. Notably, in the context of chatbots and their growing adoption, a survey by Drift, an AI-powered buyer engagement platform, highlights the increasing demand for personalized experiences facilitated by Natural Language Understanding. Drift conducted a survey involving over 1,000 participants to gather insights into their experiences with current online services, their opinions on traditional online customer experiences, and the potential impact of chatbots on businesses' customer satisfaction. The survey revealed participants' common frustrations with chatbots and their perceived potential. Here are the results of the study:

The most common frustrations reported by consumers included:

1. *Websites being complex to navigate (34%)*

2. *Not being able to get answers to simple questions (31%)*
3. *Basic details about a business — like address, hours of operations, and phone number — are hard to find (28%).*

The most common predicted uses for chatbots that consumers reported included (see Figure 1):

1. *Getting quick answers to questions in an emergency (37%)*
2. *Resolving a complaint or problem (35%)*
3. *Getting detailed answers or explanations (35%)*

It is also worth noting that 34% of consumers predicted that they would use chatbots to have a human conversation and interaction. (Drift, 2018)

Although not all consumers trust chatbots, many acknowledge their potential advantages to online interactions. One notable benefit consumers highlight is the rapid response time of chatbots and conversational AI. Businesses highly value immediate responses, as studies suggest a significant drop in the likelihood of engaging with potential leads when response times are delayed, with a 10x decrease after five minutes and a 400% decrease after 10 minutes (Drift, 2018, p. 1). Natural Language Understanding analyzes data to derive meaning through algorithms that organize human speech into a structured ontology. This data model encompasses semantics and pragmatics definitions. When confronted with natural language input, Natural Language Understanding breaks it into tokens and processes it through a dictionary to identify words and their parts of speech. The tokens undergo analysis for grammatical structure, including roles and potential ambiguities in meaning (Gillis, 2023, p2). Ontologies provide a structured representation of data, improving its quality and interpretability. They support

communication and data sharing between AI systems, fostering collaboration and efficiency. Adaptability to new data types and sources ensures the scalability of AI applications. The structured data approach enhances the ability of AI systems to make well-informed and accurate decisions. Natural Language Understanding is a fundamental aspect of artificial intelligence technologies and is groundbreaking for creating a functional and straightforward communication algorithm.

Continual Learning and Adaptation:

Building on the foundational advances in Natural Language Understanding and its critical role in AI technologies, the road towards continuous learning and adaptation takes on new dimensions by introducing tools such as ChatGPT. While conversational AI's quick responses are widely appreciated, it can be difficult to give AI systems the ability to learn from and adjust to changing situations continuously. In dynamic environments, traditional machine learning techniques frequently struggle to integrate new information without requiring significant retraining. Ontologies, on the other hand, offer a viable solution by offering a structured representation of knowledge. Ontologies enable AI systems to adapt and seamlessly incorporate new data by encoding domain knowledge in a formal and semantically rich format. In this regard, ontologies facilitate collaboration and efficiency among AI systems and improve the quality and understanding of data. As we continue to explore the world of ChatGPT and related technologies, ontologies play a more and more important role in facilitating continuous learning and adaptation. Ontologies improve AI tools' capacity for semantic understanding. Ontologies help artificial intelligence (AI) systems decipher natural language inputs more accurately by encoding domain-specific semantics. Continuous learning depends on this semantic understanding because it enables the AI system to identify and adjust to minute variations in

language usage over time. AI systems can produce coherent responses and make decisions that are relevant to the context because ontologies facilitate adaptive reasoning and inference.

Artificial intelligence (AI) tools such as ChatGPT can deduce implicit relationships and derive meaningful conclusions from various data sources using the structured knowledge represented in ontologies. Due to its adaptive reasoning capability, continuous learning is made feasible by the AI system's ability to refine its understanding and modify its behavior in response to changing contexts and user interactions. Ontologies must be dynamic and flexible in the age of continuous learning to consider changing domain dynamics and knowledge. Ontology learning and evolution are two methods that AI tools like ChatGPT can use to update and improve ontologies automatically based on fresh information and experiences. This dynamic evolution of the ontology guarantees that the AI system is always current and able to adjust to shifting conditions and user requirements. Human learning is distinctive to flexibility and retention, whereby new knowledge adds to prior knowledge without completely replacing it. On the other hand, AI systems frequently struggle with catastrophic forgetting, a condition in which learning new information unintentionally causes previously learned information to be lost. "The root of catastrophic forgetting lies in how neural networks update their weights. When a network learns a new task, it modifies its weights to reduce the error for that particular task. This modification can dramatically alter the knowledge representation of prior tasks, leading to the "forgetting" phenomenon." (Catastrophic Forgetting, NightFall AI). This cognitive gap is a major barrier to ongoing learning because AI systems have to manage the difficult task of integrating new information while retaining critical knowledge accumulated over time. For AI systems to successfully learn continuously, stability and plasticity must coexist in balance. Stability guarantees the preservation of essential knowledge and functionality, whereas flexibility permits

adjustment and expansion in reaction to changing conditions. It is naturally difficult to strike this balance because AI systems need to advance without jeopardizing the stability of their current body of knowledge. Should this equilibrium be lost, the AI system's judgment and response times could become less dependable and effective. The scalability of AI systems severely hampers the smooth integration of continuous learning. AI systems' memory and processing needs can blossom as they gain experience and knowledge, particularly in settings with limited resources. Finding creative solutions that maximize resource use and improve the effectiveness of knowledge acquisition and retention mechanisms is necessary to balance the practical constraints of scalability and the need for continuous learning. Memory Augmented Networks, such as Neural Turing Machines (NTMs), are critical for improving continuous learning in AI systems. These networks provide AI systems with the ability to store and retrieve prior experiences and knowledge by integrating external memory modules. Preserving past experiences guarantees the preservation of insights from the past, thereby promoting a smooth transition to new tasks. Memory-augmented networks also facilitate transfer learning by utilizing previously stored information for unique tasks. By enabling AI systems to expand on prior knowledge, this method speeds up the learning process and increases the effectiveness of ongoing learning initiatives. These networks are also very good at managing long-term dependencies in sequential data. Memory-augmented networks can make well-informed decisions based on patterns and temporal dependencies stored in external memory. Curriculum Learning is a method of enhancing continuous learning by sequentially organizing learning tasks. Curriculum learning enables AI models to build foundational knowledge before tackling more complex concepts by starting with simpler tasks and gradually increasing complexity. This methodical approach guarantees that the model gains a firm grasp of fundamental concepts,

laying a solid basis for mastering new tasks. Furthermore, curriculum learning adjusts dynamically to changing environments by modifying task difficulty in response to the model's performance. This adaptive strategy ensures the model keeps learning and improving, even as task complexity changes. Curriculum learning is made possible by maximizing learning efficiency and concentrating on tasks most pertinent to and helpful for the model's advancement. Active learning strategies are critical for increasing efficiency in continuous learning. These methods allow AI models to prioritize data samples that yield the most insightful information, allowing them to gather new data that maximizes learning efficiency selectively. Active learning maximizes the model's information gain and speeds learning by concentrating on high-value data samples. Furthermore, by selectively obtaining newly labeled data, active learning lowers the costs associated with data annotation, thereby reducing resource requirements and enabling continuous learning without substantial overhead. Furthermore, active learning improves model generalization by exposing trainees to various representative data samples. This diverse training data improves the model's ability to generalize fresh information and adjust to changing settings more effectively. Online learning methods constantly update AI models using streaming data, allowing them to adjust to evolving environments. This method makes continual learning more efficient by enabling quick adjustments to new patterns and trends. Online learning also minimizes the computational burden of retraining the model from scratch by updating it over time as new data becomes available, maximizing resource utilization. AI systems can easily manage massive amounts of streaming data and adjust to shifting distributions. This scalable and adaptable approach to continuous learning assures efficacy in dynamic environments.

Ethical and Bias Mitigation:

The ethical aspect of AI deals with the morality of utilizing and creating AI systems that use ontology methods by humans. There are two sides to this, the humans and the machines, and ensuring no abuse. A prominent criticism of AI is that the ontologies used often come from one-sided viewpoints: that of the “white, cis-gendered, middle-classed, and physically and cognitively abled.” (Elam, 2022, p. 204). Anything outside of this is considered abnormal and possibly even a threat. The absence of actual human experience denotes originality and invites bias formation. With the widening use of AI in different aspects of human life outside of the less consequential, the problematic nature will start to lead to higher-stakes issues. The AI machines depend on their sources for data, the well-built ontologies that humans must input the data. So, if we teach these machines specific methods to identify people, they must abide by the rules and data given. However, what happens when the AI uses the data given and misidentifies a person in a crime or for an animal due to skin tone, what they are wearing, or their surroundings? This question raises cause for concern because a machine has chosen a person to be guilty or mistaken for an animal that would otherwise be insulting or damaging. As Lehnert states in his article *Ontologies and Ethical AI*,

“It may seem implausible that concepts from a controlled vocabulary could be biased, but there may be bias in the concept labels themselves and, even more likely, that the relationships between these concepts create a graph of bias which is not apparent to human eyes but becomes obvious in an application (Lehnery, 2021).”

Controlled terms and structures about ontologies are essential to look at and study the data that is being input for these retrieval systems because they could be better. They work off the

knowledge people feed it. Humans and machines alike can make miscalculations and oversights. In the future, organizations may develop and offer AI ethics strategies to address bias more effectively. Making sure that the AI is accurately using the tagged data for its true purpose and not making inaccuracies that cannot be fixed once and are presumed to be fit for the rest of its lifetime, but robust vigilance is needed to keep and update systems for bias. AI is alongside it, especially as changes in the culture continue. A starting place for this action would be people using AI and those in the tech industry adapting their tech to include more diverse works. It is effortless for bias to come through with something like AI, so inputting information from marginalized communities helps to mitigate the problem. This way, even if they are not in the room, they are at least represented as an equal contributor (Elam, 2022, p. 204). However, as previously mentioned, hard work will still need to be done regarding strategies to mitigate bias.

Integrating ontologies and artificial intelligence (AI) represents a monumental shift in organizing and leveraging knowledge. Ontologies serve as structured frameworks that categorize and define concepts and their relationships, enabling AI systems to grasp complex data interconnections more comprehensively. By incorporating ontological knowledge, AI systems enhance their ability to make informed decisions and generate more accurate predictions. One of the defining features of ontologies is their adaptability. They can evolve and refine themselves in response to new information or changes in specific domains, ensuring that AI systems stay relevant and effective over time. This dynamic nature enables continual improvement and refinement, fostering interoperability and scalability within AI applications.

Moreover, ontological knowledge enhances natural language understanding (NLU) in AI systems. AI algorithms can better interpret and analyze natural language inputs by integrating ontologies, leading to more contextually relevant and insightful responses. This improved NLU

capability enables AI-powered interfaces, like ChatGPT, to engage with users more effectively and provide personalized assistance. Furthermore, integrating ontologies also addresses ethical considerations in AI development and deployment. By embedding ethical guidelines directly into the ontological framework, developers can ensure that AI systems adhere to ethical principles and mitigate potential risks. This ethical mitigation safeguards against unintended consequences and promotes responsible AI use. Overall, the synergy between ontologies and AI holds immense promise for addressing complex challenges and driving innovation across diverse domains. By leveraging ontological frameworks, AI systems can better understand data, make more informed decisions, and contribute to meaningful advancements in various fields.

In the current era dominated by ChatGPT and other prevalent AI tools, ontologies maintain their crucial role, contributing significantly to technological advancement. As technology rapidly evolves, ontologies play a vital role in facilitating information processing and decision-making processes. The benefits extend to fostering effective communication and understanding, thereby leading to improvements across industries that leverage these AI tools. The context provided by ontologies ensures comprehensibility for all industries, making information transfer and storage more seamless. This not only enhances global learning environments but also brings about the efficiency of various tasks at hand.

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Predicted Use Cases for Chatbots

What do you predict you would use a chatbot for?

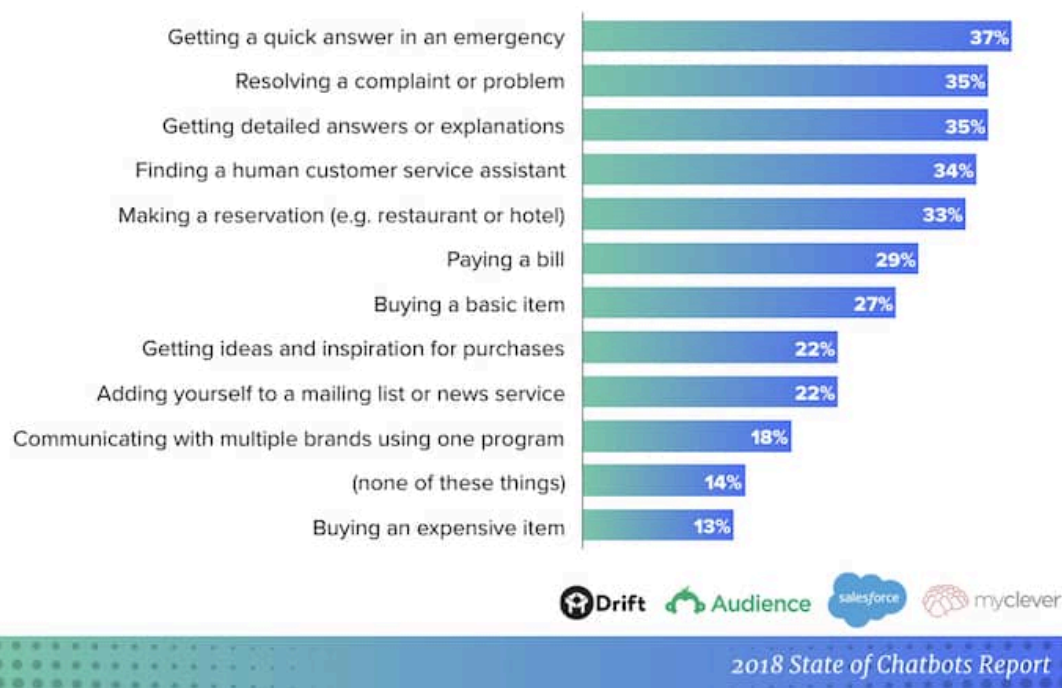


Figure 1: