

Hybrid Intelligent Systems: Prompt Science Analysis

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ABSTRACT

Hybrid Intelligent Systems (HIS) represent a novel paradigm in artificial intelligence, synthesizing diverse AI techniques to create more powerful and adaptable systems. This abstract delves into the core attributes and applications of Hybrid Intelligent Systems, emphasizing their multidisciplinary approach. By integrating rule-based systems, expert systems, machine learning, fuzzy logic, and other AI methodologies, Hybrid Intelligent Systems harnesses the complementary strengths of different techniques. This integration enables improved problem-solving capabilities, flexibility, and performance across various domains.

Hybrid Intelligent System's adaptability is a key feature, allowing for dynamic adjustments based on the nature of tasks and evolving environments. This adaptability is facilitated by components that incorporate adaptive learning, ensuring continuous improvement over time. The versatility of Hybrid Intelligent Systems is evident in its real-world applications, spanning industries such as finance, healthcare, and manufacturing. However, the ethical dimensions of Hybrid Intelligent Systems development and deployment cannot be overstated. Transparency, fairness, user privacy protection, and accountability are paramount principles to uphold, reinforcing responsible and ethical use of these advanced technologies. As Hybrid Intelligent Systems continues to evolve, its collaborative nature, balancing artificial and human intelligence, positions it as a pivotal force in addressing complex challenges and shaping the future of AI.

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KEYWORDS: Hybrid Intelligence (HI), AI methodologies, real-world applications

I. Introduction to Hybrid Intelligence (HI)

Hybrid Intelligence (HI) represents a paradigm in artificial intelligence that amalgamates various AI techniques to create systems with enhanced capabilities. Unlike singular approaches, hybrid intelligence harnesses the strengths of different methodologies, such as rule-based systems, expert systems, machine learning, and more, to address the complexities of diverse problem domains. The synergy of these techniques results in a more adaptable and robust intelligence, allowing for improved decision-making, learning, and problem-solving.

The integration of multiple AI paradigms in hybrid intelligence systems is driven by the recognition that no single approach can comprehensively address the intricacies of all tasks. By combining rule-driven logic, which excels in explicit knowledge representation, with the learning capacities of

machine learning algorithms, hybrid intelligence systems aim to bridge gaps and overcome limitations inherent in individual methodologies. This integrative approach not only improves performance but also provides a foundation for addressing real-world challenges that often demand a multidimensional understanding.

The evolution of hybrid intelligence holds promise across diverse industries, ranging from finance and healthcare to manufacturing and beyond. As these systems continue to advance, their adaptability to dynamic environments, collaborative potential with human expertise, and ethical considerations become central pillars shaping the future of artificial intelligence. In this introduction, we embark on an exploration of the foundational principles and applications that define the transformative landscape of hybrid intelligence.

II. Knowledge-based expert systems (KBES)

Knowledge-based expert systems (KBES) are a type of artificial intelligence (AI) system that aims to emulate the decision-making abilities of a human expert in a specific domain. These systems use a knowledge base, an inference engine, and an interface to interact with users. Here are the key components and characteristics of knowledge-based expert systems:

1. Knowledge Base:

- **Facts and Rules:** The knowledge base contains information in the form of facts and rules that represent the expertise in a particular domain. Facts are statements about the domain, and rules are conditional statements that guide the reasoning process.

- **Representation:** Knowledge can be represented using various methods, such as frames, semantic networks, or production rules. The choice of representation depends on the nature of the problem domain.

2. Inference Engine:

- The inference engine is responsible for reasoning and drawing conclusions based on the information stored in the knowledge base. It uses the rules and facts to make inferences and reach decisions.

- There are different inference strategies, including forward chaining (data-driven) and backward chaining (goal-driven), which determine the order in which the system processes information to arrive at conclusions.

3. User Interface:

- The user interface enables interaction between the expert system and the end user. It may include mechanisms for querying the system, providing input, and receiving recommendations or explanations.

4. Explanation Facility:

- Expert systems often include an explanation facility to provide users with insights into the reasoning process. This helps users understand how the system arrived at a particular conclusion or recommendation.

5. Knowledge Acquisition System:

- Acquiring knowledge from human experts and converting it into a format suitable for the knowledge base is a crucial step in building a knowledge-based expert system. Knowledge acquisition tools assist in this process.

6. Domain Expertise:

- The success of a knowledge-based expert system depends on the depth and accuracy of the domain-

specific knowledge it possesses. The expertise is usually provided by human experts during the development phase.

7. Examples of Applications:

- Knowledge-based expert systems have been applied in various domains, including medicine (diagnosis and treatment planning), finance (investment advice), engineering (fault diagnosis), and many others where expertise is valuable.

8. Limitations:

- KBES may struggle with uncertainty and may not handle new or unforeseen situations well. Maintenance and updating of the knowledge base can be challenging.

Despite their limitations, knowledge-based expert systems have proven to be valuable tools in certain domains where human expertise is critical. Advances in AI, including machine learning techniques, have expanded the range of applications, and hybrid systems that combine knowledge-based and data-driven approaches are becoming more common.

III. Human level intelligence to Human centric intelligence

The terms "human-level intelligence" and "human-centric intelligence" represent different perspectives on artificial intelligence and its development. Let's explore each concept:

➤ Human-Level Intelligence:

- **Definition:** Human-level intelligence refers to the ability of an artificial system to perform tasks and exhibit cognitive capabilities at a level comparable to that of a human being. This includes reasoning, problem-solving, learning, perception, language understanding, and other cognitive skills.

- **Challenges:** Achieving human-level intelligence in machines is a complex and challenging goal. While significant progress has been made in specific domains, creating a system that matches the general cognitive abilities of a human across various tasks and contexts remains a formidable task.

- **Applications:** The pursuit of human-level intelligence has implications for a wide range of applications, from robotics and autonomous systems to natural language understanding and decision-making.

➤ Human-Centric Intelligence:

- **Definition:** Human-centric intelligence emphasizes the development of AI systems that prioritize and complement human abilities, rather than attempting to replicate human cognition in

its entirety. It acknowledges the importance of collaboration between humans and AI for improved outcomes.

- **Collaboration and Interaction:** In a human-centric intelligence approach, AI is designed to enhance human capabilities, provide support, and work alongside humans in a collaborative manner. This approach recognizes the unique strengths of both humans and machines.
- **Ethical Considerations:** Human-centric intelligence places importance on ethical considerations, user experience, and the impact of AI on society. It aims to create AI systems that align with human values and promote positive interactions.
- **Applications:** Human-centric intelligence is relevant in applications such as human-computer interaction, assistive technologies, and systems that prioritize user-friendly interfaces. It seeks to address real-world problems by leveraging AI to empower and augment human capabilities.

In summary, while human-level intelligence focuses on achieving a level of AI that matches or surpasses human cognitive abilities across various domains, human-centric intelligence emphasizes the collaborative and supportive role of AI in enhancing human experiences and addressing real-world challenges. Both approaches have their own significance in the broader landscape of AI development and deployment. Achieving a balance between advancing AI capabilities and ensuring human-centric design is a key consideration for the responsible and ethical development of artificial intelligence.

IV. Collaboration among KBES and human centric intelligence

The collaboration between knowledge-based expert systems (KBES) and human-centric intelligence involves leveraging the strengths of both artificial intelligence (AI) systems and human expertise to achieve more effective and efficient outcomes. Here are some ways in which these two elements can collaborate:

1. **Augmentation of Human Expertise:**
 - Knowledge-based expert systems can augment human expertise by providing quick access to vast amounts of information, assisting in decision-making, and offering suggestions based on their knowledge base and inference engines.
2. **Assistance in Decision-Making:**
 - Expert systems can assist humans in complex decision-making processes by providing relevant

information, analyzing data, and offering recommendations. Human experts can then use this information to make informed decisions.

3. **Knowledge Sharing and Transfer:**
 - KBES can act as repositories of knowledge, capturing and preserving the expertise of human professionals. This knowledge can be shared across different contexts, locations, and time, ensuring that valuable insights are not lost when experts retire or move on.
4. **Collaborative Problem Solving:**
 - Human-centric intelligence emphasizes collaboration between humans and AI. In problem-solving scenarios, both humans and expert systems can work together, with humans providing creativity, intuition, and a broader contextual understanding, while expert systems contribute precision, consistency, and access to extensive knowledge.
5. **User-Friendly Interfaces:**
 - Designing user interfaces that facilitate smooth interaction between humans and expert systems is crucial. Human-centric design principles ensure that the collaboration is intuitive, transparent, and aligns with human users' expectations and capabilities.
6. **Continuous Learning and Adaptation:**
 - Expert systems can incorporate machine learning techniques to continuously learn from user interactions and adapt their knowledge base. This allows them to improve over time and stay relevant in dynamic environments.
7. **Explanation and Transparency:**
 - Human-centric intelligence emphasizes the need for AI systems to provide explanations for their recommendations or decisions. Expert systems can offer transparent explanations, helping human users understand the reasoning behind the system's suggestions.
8. **Ethical Considerations:**
 - Collaboration should address ethical considerations, including privacy, bias, and accountability. Both human-centric intelligence and KBES need to adhere to ethical standards to ensure responsible and fair use of AI in various applications.
9. **Human-in-the-Loop Systems:**
 - Implementing human-in-the-loop systems allows human experts to validate, refine, or override the recommendations made by expert systems. This ensures a balance between automation and human oversight.

10. Dynamic Adaptation to Context:

- Expert systems can dynamically adapt to changing contexts, but human-centric intelligence ensures that these adaptations align with human values, societal norms, and ethical guidelines.

The successful collaboration between knowledge-based expert systems and human-centric intelligence requires careful integration, thoughtful design, and an understanding of the respective strengths and limitations of both AI and human expertise. This collaborative approach aims to create synergies that result in more effective, ethical, and user-friendly solutions across various domains.

V. Hybrid intelligent systems

Hybrid intelligent systems refer to the integration of multiple artificial intelligence (AI) techniques, methodologies, or paradigms to create a more robust and effective system. The goal is to leverage the strengths of different AI approaches to compensate for each other's weaknesses, resulting in improved overall performance. Here are some key aspects of hybrid intelligent systems:

1. Combining Different AI Techniques:

- Hybrid intelligent systems integrate diverse AI techniques, such as rule-based systems, expert systems, machine learning, fuzzy logic, genetic algorithms, neural networks, and more. These techniques are combined in a way that each contributes to solving different aspects of a problem.

2. Complementary Strengths:

- Different AI techniques have distinct strengths and weaknesses. For example, rule-based systems are good at representing expert knowledge, while machine learning excels in pattern recognition and data-driven tasks. Combining these techniques allows the system to benefit from the complementary strengths of each.

3. Improved Adaptability and Flexibility:

- Hybrid systems can adapt to a wide range of problem domains and dynamic environments. The flexibility arises from the ability to switch between different AI paradigms based on the nature of the task or the characteristics of the data.

4. Optimizing Performance:

- By integrating various AI techniques, hybrid systems aim to achieve better performance compared to individual approaches. For example, a system might use machine learning for data analysis and decision-making, while incorporating rule-based systems for expert knowledge validation.

5. Handling Uncertainty:

- Fuzzy logic and probabilistic reasoning are often integrated into hybrid systems to deal with uncertainty in data and decision-making. This allows the system to make more informed and nuanced decisions, especially in situations where precise information may be lacking.

6. Adaptive Learning:

- Hybrid systems can include adaptive learning components that improve over time by adjusting their parameters based on feedback and new data. This adaptability is crucial for addressing changes in the environment or evolving requirements.

7. Real-Time Decision-Making:

- Some hybrid systems are designed for real-time decision-making by combining fast and efficient rule-based systems with learning algorithms that continuously update their models based on incoming data.

8. Applications in Various Domains:

- Hybrid intelligent systems find applications in diverse domains such as finance, healthcare, robotics, manufacturing, and more. Their ability to address complex and multifaceted problems makes them suitable for a wide range of scenarios.

9. Human-in-the-Loop Integration:

- Some hybrid systems incorporate human expertise as a key component, allowing human experts to interact with and guide the system. This human-in-the-loop integration ensures that the system benefits from human intuition and domain knowledge.

10. Cyber-Physical Systems:

In the context of cyber-physical systems, hybrid intelligent systems are used to integrate AI with physical processes, enhancing the overall performance and efficiency of systems in areas like smart cities, transportation, and energy management.

The design and implementation of hybrid intelligent systems require a deep understanding of the problem domain, the characteristics of the data, and the strengths of different AI techniques. The combination of diverse approaches contributes to creating more adaptable, efficient, and powerful intelligent systems.

VI. Ethical hybrid intelligent systems

Ethical considerations are crucial in the design, development, and deployment of hybrid intelligent systems. As these systems integrate various artificial intelligence (AI) techniques and often involve human interactions, ethical principles are essential to ensure

responsible and fair use. Here are key ethical considerations for hybrid intelligent systems:

1. **Transparency and Explainability:**
 - Ensure transparency in the decision-making process of the hybrid system. Users, especially when human-in-the-loop interactions are involved, should be able to understand how decisions are reached. Explainability helps build trust and accountability.
2. **Fairness and Bias Mitigation:**
 - Address biases in data and algorithms to ensure fair and equitable outcomes. Evaluate the training data for biases and implement strategies to mitigate them. Monitoring for bias during system operation is also important.
3. **User Privacy Protection:**
 - Implement robust privacy protection mechanisms, especially when handling sensitive personal data. Adhere to data protection regulations and ethical guidelines to safeguard user privacy throughout the system's lifecycle.
4. **Informed Consent:**
 - When human users are involved, ensure that they are adequately informed about the system's capabilities, limitations, and potential impacts. Obtain explicit consent for the use of their data and participation in the system.
5. **Human-in-the-Loop Governance:**
 - Establish clear governance and oversight mechanisms for systems that involve human-in-the-loop interactions. Ensure that human experts have the ability to intervene, override decisions, and provide input to maintain ethical standards.
6. **Security Measures:**
 - Implement robust security measures to protect the system from malicious attacks or unauthorized access. Safeguarding the integrity and confidentiality of the data and the system itself is essential for ethical operation.
7. **Accountability and Responsibility:**
 - Clearly define roles and responsibilities for developers, operators, and users of the hybrid intelligent system. Establish accountability for the system's behavior, and ensure that there are mechanisms in place to address issues or unintended consequences.
8. **Continuous Monitoring and Evaluation:**
 - Regularly monitor the system's performance and impact on users and stakeholders. Conduct ongoing ethical evaluations to identify and address any emerging ethical concerns or biases that may arise during the system's use.

9. Societal Impact Assessment:

- Assess the potential societal impact of the hybrid intelligent system, considering factors such as economic, social, and cultural implications. Be mindful of the broader consequences and work to minimize any negative effects.

10. Human Well-Being and Benefit:

- Prioritize the well-being of individuals and society. Ensure that the deployment of the hybrid system contributes to positive outcomes and societal benefits, avoiding harm and negative consequences.

11. Education and Awareness:

- Promote awareness and understanding of the ethical implications of the hybrid intelligent system among developers, operators, and users. Provide educational resources and training to foster a culture of responsible AI use.

12. Compliance with Regulations:

- Adhere to relevant laws, regulations, and ethical guidelines governing AI and data use. Stay informed about evolving legal and ethical standards and update the system accordingly.

By incorporating these ethical considerations into the design and deployment of hybrid intelligent systems, developers and organizations can create technologies that align with ethical principles, promote transparency, and contribute positively to society. Ongoing collaboration and dialogue within the AI community are essential to address emerging ethical challenges in this rapidly evolving field.

Conclusion

Hybrid intelligent systems represent a cutting-edge approach to artificial intelligence by integrating diverse AI techniques, including rule-based systems, expert systems, machine learning, and more. The key strength of these systems lies in their ability to combine the advantages of different approaches, resulting in enhanced problem-solving capabilities and improved overall performance. Their adaptability allows for dynamic switching between AI paradigms, addressing various aspects of complex tasks across different domains.

These systems find applications in sectors such as finance, healthcare, and manufacturing, showcasing their versatility in tackling multidimensional challenges. The incorporation of adaptive learning components ensures continuous improvement over time, making them well-suited for dynamic environments. However, the development and deployment of hybrid intelligent systems must prioritize ethical considerations. Transparency, fairness, user privacy protection, and accountability

are critical principles to ensure the responsible and ethical use of these technologies. Moreover, the integration of human expertise in some hybrid systems fosters collaboration between humans and AI, reinforcing the importance of a balanced approach that benefits from both artificial and human intelligence.

In conclusion, hybrid intelligent systems stand at the forefront of AI innovation, offering solutions that harness the strengths of multiple techniques. Their real-world applications, adaptability, and ethical considerations make them valuable tools in addressing complex challenges and contributing positively to various industries.

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