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A Systematic Review on Augmented Intelligence: A Relation between Human Intelligence and Artificial Intelligence

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ABSTRACT :

Augmented Intelligence (AuI) represents the integration of human intelligence (HI) and artificial intelligence (AI), combining their strengths to mitigate their individual weaknesses and achieve superior performance. This survey reviews the literature on AuI, examining the roles of HI and AI, various AI approaches, features, and applications across sectors like sales, business, healthcare, military, decision-making, remote assistance, and logistics. Highlighting the journey of Telecom Argentina from data analytics and machine learning to AuI, the paper contrasts AuI with traditional AI, showcasing its enhancement of human judgment, handling of large datasets, and routine decision-making. The paper also explores collaboration models such as human-in-the-loop AI and cognitive computing, and discusses emerging models like Hybrid Augmented Intelligence (HAI), emphasizing AI's potential to complement human capabilities and drive innovation responsibly across industries.

Keywords : Augmented intelligence, blood glucose monitoring, cognitive computing, digital transformation, hybrid augmented intelligence, human-AI collaboration, human-in-the-loop, innovation responsibly across industries.

1. INTRODUCTION :

What is Augmented Intelligence and why?

Augmented intelligence (AI) is a form of artificial intelligence designed to augment human intelligence rather than replace it. We use machine learning and predictive analytics to improve human decisions and the actions taken in response to those decisions. This technology is called artificial intelligence (AI) or cognitive augmentation. The concept of augmented intelligence is not new. It has been integrated into our lives for many years. Early examples of this were servers and servers, which enabled faster data processing and better decision-making based on that data. As technology advances, especially the Internet of Things (IoT) and the connectivity of smart objects, mindfulness becomes part of our daily lives.

Augmented Intelligence = Human + Computer

Augmented intelligence systems can use advanced algorithms and large data sets to provide insights and recommendations that humans cannot access. This landmark link between human intelligence and machine precision aims to improve many aspects of life, from personal productivity to solving complex problems in professional settings.
The future of artificial intelligence will be more integrated into our daily lives, providing analytical tools and intelligent systems to support human activities, potentially changing industries such as healthcare, finance and education.

Background

In the 1960s, pioneers such as Engelbart and Licklider laid the groundwork for the concept of "human-computer symbiosis," emphasizing the different capabilities of computers and the human brain. This led to the development of Intelligence Augmentation (AI), which aims to optimize the computing power of humans and computers [3]. One aspect of AI, human-computer interaction (HCI), emphasizes a design approach that focuses on interpretation, human behaviour, and experimentation, as opposed to some aspects of traditional artificial intelligence (AI) that aim to model humans as machines smart[5].
However, HCI is only one view of human-computer architecture. Another area is dealing with large-scale computing problems, called "human computing problems," that cannot be solved efficiently by computers or humans alone. Crowdsourcing strategies, often using gamification, use human processing power to solve these problems.

As AI technology develops rapidly, it will have a significant impact on human interaction and social structure. [1] AI will solve complex problems in various fields, promote social and economic development, and promote innovation. Deep learning techniques, driven by advances in computing power, have ushered in a new era of AI development, especially in high-demand areas such as cloud computing, big data, wearables, and intelligent machines.

The advancement of AI can be thought of in the three-dimensional space of power, scale, and efficiency. Capability refers to the knowledge level capabilities of the AI system, the expansion of the range of problems it can solve, and the quality of the solutions it provides. Although AI systems such as DeepBlue, Watson, and AlphaGo have achieved great success, their high-level self-learning capabilities are still lacking compared to general AI.

Intelligent machines are becoming an increasingly integral part of human society, and human-machine interaction is shaping our future. However, many human problems are complex and uncertain, thus requiring human intervention in the decision-making process of intelligent systems. Despite the abundance of data, human monitoring remains important, especially in critical applications such as industrial risk management and pharmaceutical monitoring.

Human-In-The-Loop Hybrid Augmented Intelligence is essential to meet these challenges. This approach combines human knowledge and experience with AI capabilities to increase the reliability of intelligent systems and optimize human-machine collaboration.

In short, the evolution of AI from traditional AI to Augmented Intelligence (AuI) shows the importance of human-computer symbiosis. AuI aims to use the capabilities of humans and machines to enhance human potential, solve complex problems and promote social development. But it also shows the need to develop and deploy responsible AI to ensure oversight and human involvement to minimize risks and maximize benefits.

Difference between Human Intelligence and Artificial Intelligence

Human intelligence (HI) and artificial intelligence (AI) differ significantly in their origins, nature and capabilities, and both have unique strengths and limitations.

Human intelligence is an inherent human cognitive ability based on the complex activity of neural networks in the brain. This form of intelligence encompasses a wide range of abilities, including reasoning, problem solving, creativity, emotional understanding, and social skills. These skills enable people to learn from experience, adapt to new situations and gain knowledge through observation, teaching and reflection. Human intelligence is characterized by its flexibility, adaptability and lifelong learning ability. Humans can process complex data, understand nuanced contexts, and apply intuition in ways that are currently beyond the reach of AI systems.

In contrast, artificial intelligence is the intelligence displayed by machines designed with algorithms and computer models to perform tasks that usually require human cognitive functions. Artificial intelligence excels at performing specific, well-defined tasks, recognizing patterns and making predictions based on large data sets. For example, AI can process massive amounts of data at speeds that exceed human capabilities, making it highly effective in areas such as data analysis, pattern recognition, and automating repetitive tasks. AI systems are trained to perform these tasks with high accuracy, but their learning is limited by the quality and scope of the data they are trained on. Unlike humans, AI does not have the ability to intuitively understand context or flexibly adapt to completely new situations without reprogramming or retraining.

A major difference between HI and AI is emotional intelligence. Humans have the ability to recognize, understand and manage their own and others' emotions, which is essential for social interaction, empathy and effective communication. Emotional intelligence plays a crucial role in human relationships and decision-making, enabling nuanced responses to complex social situations. However, AI lacks true emotional intelligence. Although efforts are being made to develop artificial intelligence capable of simulating emotional reactions or recognizing human emotions, these systems do not experience emotions in the same way as humans, and their ability to empathically communicate is limited.

Creativity is another area where human intelligence excels. Humans have an innate ability to think creatively, generate new ideas and innovate beyond existing knowledge and limitations. This creativity is driven by imagination and the ability to think abstractly, characteristics that are currently difficult for artificial intelligence to reproduce. While AI can produce creative results within given parameters, such as creating art or music based on certain styles, it lacks the true creativity and originality that humans bring to these processes.

Ethical and moral reasoning further differentiates HI from AI. People can engage in ethical debate and consider values, principles, and consequences to resolve moral dilemmas. This requires a deep understanding of social norms, cultural contexts and individual values. However, AI operates based on ethical frameworks and rules programmed by humans. It has no inherent understanding of morality and can only follow predefined ethical guidelines. This limitation raises serious concerns about bias, fairness, and accountability in AI decision-making processes.

Although artificial intelligence is excellent at certain tasks and can significantly improve efficiency in various areas, it cannot match the versatile capabilities of human intelligence. The adaptability, creativity, emotional understanding and ethical reasoning of human intelligence make it indispensable for complex decision-making, social interaction and innovative problem-solving. The synergy between HI and AI, especially in the context of augmented intelligence, offers an opportunity to combine the strengths of both, which enhances human capabilities and fosters collaborative innovation.

2. Roles of Human Intelligence and Artificial Intelligence in Augmented Intelligence

The relationship between artificial intelligence (AI) and human intelligence (HI) is crucial in the development of modern technology.

Human intelligence (HI) and artificial intelligence (AI) each have unique strengths and weaknesses, making them highly complementary. HI is creative, complex and dynamic in nature, characterized by the ability to learn, speak, think and interact with the environment. The self-adaptive capacity of the human brain allows it to transcend experience and infer knowledge, making humans highly skilled at abstract thinking, reasoning and innovation. Human intelligence evolves due to the structural complexity and neuroplasticity of the brain in processing irregular and unstructured information. This complexity facilitates advanced cognitive processes such as intuition, conscious thought, and dynamic knowledge development, allowing humans to function in learning, reasoning, collaboration, and other advanced intelligence functions.

On the other hand, artificial intelligence is characterized by its normalization, repeatability and logic. Normalization refers to artificial intelligence's reliance on structured data; Inputs to AI systems must conform to certain standards and formats. AI excels at repeatability, as its mechanical nature

ensures that repetitive tasks do not degrade efficiency or accuracy. This is due to the powerful computational capabilities and abiotic characteristics of computers that allow them to tirelessly handle large amounts of repetitive work. AI's logic gives it an advantage in solving symbolic problems, making it particularly effective at discrete tasks that require precise calculations and logical operations. However, AI's strength in processing structured information and performing repetitive tasks is also a limitation. Artificial intelligence systems struggle with unstructured and unethical data where human intelligence excels. AI's ability to handle repetitive tasks without making mistakes differs from the human tendency to tire and make mistakes in repetitive work. However, humans bring intuition, creativity and the ability to break and create new rules that AI currently lacks.

The synergy between HI and AI has significant potential across sectors and industries. Using the strengths of both, we can achieve great results. For example, in creative fields, AI can quickly generate a variety of ideas, providing inspiration and saving time for human experts who can refine those ideas into their own vision. In healthcare, AI can analyze huge data sets and medical images to help doctors diagnose diseases more accurately and faster, allowing healthcare professionals to focus on patient care and empathy. In addition, AI can facilitate information discovery and synthesis by sifting through vast amounts of data, extracting relevant information and producing summaries or reports. This ability is invaluable in research and data-intensive fields, speeding up processes such as literature review and hypothesis generation. However, human

supervision is necessary to ensure the quality, relevance and ethical consistency of content produced with the help of artificial intelligence. Human experts provide the necessary context, judgment and ethical considerations that AI lacks.

Integrative Intelligence System:

To fully exploit the potential of both HI and AI, we propose the development of IIS (Integrative Intelligence System). This system would combine the strengths of human creativity, intuition and complex decision-making with the computer power, efficiency and logical processing of artificial intelligence. IIS would work through three main collaborations:

1. HI-AI Cascade: In this approach, human intelligence initiates the decision-making process by providing contextual inputs and insights to AI. AI then processes those inputs and produces preliminary analysis and recommendations that are passed on to human experts for refinement. This ensures that AI results are based on human context and judgment, reducing bias and improving the quality of decisions.
2. AI-HI Cascade: This is where AI starts by analyzing large data sets and generating initial findings or recommendations. These results are evaluated by human experts who use their experience, intuition and ethical considerations to make final decisions. This approach leverages AI's ability to quickly process massive amounts of data and ensures that final decisions are based on human expertise.
3. Parallel HI-AI Decision-Making: Both HI and AI participate in the decision-making process at the same time. Human experts and artificial intelligence systems independently analyze the same problem, and their observations are combined into a complete solution. This parallel approach maximizes the strengths of both intelligences and creates a solid framework for solving complex problems.

By implementing these collaborative approaches in IIS, organizations can improve creativity, efficiency and decision-making across industries. This system allows for continuous feedback and learning, ensuring that both human and AI evolve and improve over time. IIS represents a balanced integration of HI and AI that promotes innovation, ethical considerations and excellence in various applications.

Comparison of Augmented Intelligence and Artificial Intelligence

Artificial intelligence is designed to automate routine and everyday tasks, freeing people from these responsibilities, while intelligent augmentation (IA) seeks to increase human capabilities, allowing people to perform tasks more intelligently and efficiently.

AI Vs. IA:

AI primarily aims to replace human labor in repetitive or routine tasks, improving efficiency and reducing human error. AI works independently, makes decisions and completes tasks without human input. This technology excels at quickly processing large amounts of data, recognizing patterns and accurately performing predefined **tasks**.

IA, on the other hand, aims to improve human decisions and performance by enhancing, not replacing, human capabilities. IA acts as a partner, providing analytics and recommendations that help people make decisions faster, more efficiently and more informed. Unlike artificial intelligence, AI focuses on enhancing human intelligence and helping people use technology to improve their abilities.

Intelligence enhancement: -

AI works independently, makes decisions and completes tasks without human intervention. It is ideal for scenarios where consistency and speed are paramount, such as data analysis, automation of repetitive processes and large-scale data processing.-

IA acts as a partner providing analysis and recommendations to enable faster, more efficient and more informed decision making. IA systems support humans by processing complex data and providing insights, but still rely on human judgment and creativity to make final decisions.

Research and the Digital Revolution:

Extensive research has been conducted to understand the implications of advanced intelligence for digital transformation. These studies explore how AI can be applied in various industries to drive efficiency and innovation.

Research findings show how impact assessment can improve decision-making processes, increase productivity and stimulate innovation, transforming industries. For example, in healthcare, AI can help doctors by providing data insights that improve diagnostic accuracy and treatment plans.

Research Gaps highlight the need for more specialized research, especially in areas such as manufacturing, health and medicine. These areas present unique opportunities and challenges for IA that require focused research to fully exploit the potential of IA.

Barriers to adoption:

Integrating AI and IA technologies into existing systems presents several challenges: -

- **Technology Adaptation:** Ensuring the seamless integration of future AI and IA -technologies with current systems is a major obstacle. Compatibility and interoperability are critical to successful implementation. -
- **Employee Training:** The employees must be given the necessary skills to effectively use these advanced tools. Training programs must be developed to equip employees with the knowledge to effectively use IA and AI technologies.
- **Ethical Considerations:** Addressing issues related to security, privacy and the ethical implementation of AI and IA is critical. It is very important to ensure that these technologies are used responsibly and that they do not infringe on individual rights.

The combination of artificial intelligence and human intelligence can transform many industries. Artificial intelligence takes care of repetitive tasks, while AI improves human skills and facilitates faster and smarter decision making. Further research and targeted research are needed to fully exploit this symbiotic relationship, especially in regions with unique opportunities and challenges. Successful integration of AI and IA technologies depends on overcoming barriers related to technology adaptation, workforce training and ethical considerations. By addressing these challenges, companies and organizations can leverage artificial intelligence and AI to drive innovation, increase productivity and create new growth opportunities.

3. Issues faces Augmented Intelligence

Recent advances in hardware, sensor and network technologies and the proliferation of Internet of Things (IoT) devices have generated significant interest in the development of fully autonomous systems such as driverless cars. These inventions raise unique technical, organizational, social and ethical issues. Human-computer symbiosis can potentially solve some of these challenges. Information systems (IS) researchers have embraced both the artificial intelligence (AI) and artificial intelligence (IA) traditions. Recent research in information systems research (ISR) has revived both design and rational thinking. However, there is still a lack of coherent discussion and integrated literature on how AI and AI research can advance organizational and societal applications and influence the future of work. This special issue of Information Systems Research aims to foster a new dialogue on the synergy between IA and AI in IS research by highlighting current knowledge and research initiatives.

The main topics of interest in this special issue are:

- Designs to effectively combine human and computer cognitive power.
- Applications and evaluations of human-computer symbiosis in various industries including healthcare, education, finance, cyber security and transportation.
- Generalizable modelling innovations that combine concepts from IA and AI.
- Evaluation of theoretical predictions about human-computer cooperation in solving large-scale computing problems.
- Social, behavioural and economic impacts of AI and IA, including their impact on work, productivity, jobs and industry.
- Theoretical predictions and assessments of legal, policy, governance and business models related to AI and IA systems.
- Human control issues in the design of IA systems.
- This special issue aims to attract high quality submissions that highlight existing knowledge and research and showcase the best research in the field.

4. The Future of Augmented Intelligence

4.1. Augmented Intelligence

The future of augmented intelligence, which is currently in the hype cycle of technological triggers according to Gartner, represents the early stages of AI and machine learning and raises the important question of whether or not human-machine collaboration will lead to a decline in employment opportunities. Unquestionably, the nature of work is changing, but in this partnership, humans and machines will each execute jobs that play to their strengths. Routine tasks will be automated by the machines, and exceptions will be handled by humans with the help of contextual recommendations and helpful alerts from the machines. Because of this, completely new job categories will be created, and when augmented intelligence penetrates more industries, strong regulatory frameworks will be required. Retraining people who are replaced by intelligent systems to take on these new responsibilities will be a major social challenge. With the increasing availability of data and the shift in emphasis from big data to little data for knowledge discovery, new augmented intelligence tools that encourage critical thinking from several angles will help with knowledge acquisition. The development of augmented intelligence thus suggests a revolution in work environments, legal frameworks, and cognitive instruments, highlighting the need to adjust to these significant shifts.

4.2. Explainable AI

Explainable AI is another new area of study (XAI). When an expert has to make a decision using augmented intelligence tools, or when these tools are integrated into our networks and services, they need to know how the outcomes were obtained and how confident the model is.

According to the statement, "ensuring that algorithmic decisions as well as any data driving those decisions can be explained to end-users and other stakeholders in non-technical terms" is the aim of allowing explain ability in machine learning. H. Wallach, S. Barocas, S. Friedler, M. Hardt, J. Kroll,

and S. Venka-Tasubramanian. The Fairness, Accountability, and Transparency in Machine Learning Workshop Series, FAT-ML. Reached on July 20, 2020. [Online]. http://www.fatml.org is accessible. Explain ability lies at the intersection of the following: bias (the absence of bias should be guaranteed), fairness (it should be confirmed that decisions made by AI are fair), safety (reliability of AI systems), transparency (consumers have the right to have decisions affecting them explained in understandable terms), and causality (it is expected of the algorithms to provide not only inferences but explanations as well). Hagras (2018).

We know that several machine learning algorithms have been dubbed "black box" models due to their mysterious inner workings, according to (BSI), 2016) and (Gasser & Almeida, 2017).

These models' accuracy stems from their extreme complexity, which makes it challenging to evaluate and comprehend the results. So, the models are not always auditable, even in cases when there is some abstraction or transformation that makes the models explicable.There is still room for discussion on audit AI (Forum, 2019).

5. Applications:

5.1. Augmented intelligence in Educational Data M (EDM):

Educational data mining (EDM) is the transformation of educational data into meaningful insights for stakeholders such as students and teachers. Common data mining techniques in EDM include classification, cluster analysis, outlier detection, and relational rule mining. Augmented Intelligence (AUI) combines human and artificial intelligence to improve decision-making and learning. In this study, we explore AUI in EDM, focusing on the iterative process in which humans and artificial intelligence work together to improve predictive models. Research studies have shown that AUI improves model accuracy and information retrieval. To meet the challenges of EDM, a new algorithm, the N-tree neural network, is developed and the advantages of the AUI method are demonstrated.

Conceptual Images Augmented Reality (AUI) methods in EDM combine human knowledge and AI to improve academic performance. This approach is based on open knowledge data mining where human knowledge is involved in the data mining process. A popular example is the Open Monitoring Environment (OME) by Jormanainen and Sutinen (2012), which demonstrates the benefits in small teaching environments by involving teachers in real-time data labelling and classification creation. Open educational data mining

Jormanainen and Sutinen (2012) describe an open data mining process in which teachers label data, build J48 decision tree classifiers, and visualize the results in practice during the formation show its benefits. - hours This interactive approach allowed teachers to customize strategies to learn about student progress and help design better intervention strategies. The open process has been particularly effective for the small data sets found in early childhood education, where key policy makers often struggle with sound data requirements.

Neural N-Tree AlgorithmThe Neural N-Tree algorithm was developed to address the limitations of existing classifiers and the need for different tools in EDM. This new clustering algorithm can interpret and manipulate predictive models, supporting the principles of the AUI method. It enhances an open and intuitive approach to EDM by enabling transformative changes where human learning and AI influence outcomes.

Current EDM ToolsCurrent platforms such as Weka and RapidMiner also handle open data mining. With high visibility and the ability to adjust parameters, end users can gain insight into their data mining activities. For example, RapidMiner offers a user-friendly interface and cluster analysis views. However, correcting centroids with decision tree rules is still difficult.

Study and Evidence Clinical studies have shown that AUI techniques improve predictive model accuracy and knowledge discovery. In one study, teachers who used the Neural N-Tree algorithm and the AUI method showed benefits in understanding student progress and designing interventions. These findings demonstrate the potential of AUI to improve EDM by combining human expertise with AI insights.

By integrating human intelligence and artificial intelligence capabilities, EDM's AUI method promotes deeper and more effective decision-making and improved academic performance through collaborative data mining.

5.2. Business Sales:

Using Artificial Intelligence in Sales: A Wise Investing.

The integration of machine intelligence and human knowledge is essential to the advancement of contemporary business organizations. Vice presidents, team leads, and department heads are starting to realize how much augmented intelligence (AI) can help them find and seize business opportunities. Although augmented intelligence systems are useful in many organizational domains, sales departments are where they have the greatest impact.

Benefits and Strategic Location:

To empower sales teams, augmented intelligence is strategically positioned within sales departments. AI frees up salespeople's time to concentrate on comprehending and meeting customer needs by automating tedious sales tasks. By strategically investing in salespeople, you can increase their productivity and effectiveness, which in turn drives up revenue and improves customer satisfaction.

Analyzing Data and Producing Useful insights:

When it comes to evaluating sales data and turning it into useful insights, augmented intelligence shines. Businesses can obtain deeper insights into consumer preferences, market trends, and sales performance metrics by utilizing AI capabilities. With the help of these insights, targeted sales strategies and well-informed decision-making can produce better sales results and give businesses a competitive edge in the market.

Increasing Use in Business:

The use of intelligent augmentation in solving a wide range of business problems is still developing and growing. Augmented intelligence provides

scalable answers to a wide range of business issues, from lead prioritization and sales forecasting to CRM and customized marketing. Artificial Intelligence (AI) is becoming more and more essential in driving operational efficiency and innovation as businesses embrace digital transformation.

5.3. Implementation in Libraries:

In order to investigate the use of augmented intelligence (AI) in libraries, this study reviews the literature. What it finds is that there isn't much discussion of this topic in the field of librarianship. The review, which covers the LISTA abstract database, Google Scholar, Web of Science, and Scopus, emphasizes how important it is to take thorough ethical considerations into account before using AI in library settings. Even though AI has the potential to lead to creative service design, its introduction requires a careful consideration of the ethical implications.

The findings, which are mostly conceptual due to the scant material available, underscore the need of starting debates and raising awareness about AI's possible role in libraries. By addressing ethical considerations, this study hopes to create the framework for informed decision-making about AI integration. Despite the scarcity of actual evidence, the study presents a framework for practical implementation, as well as significant insights into the ethical aspects of AI integration in library services.

The study's social ramifications are noteworthy since it promotes discussion about the broader role of developing technology in libraries. The essay helps to foster talks about ethical issues and societal implications, resulting in a more responsible approach to technology adoption in library environments. It acts as a fundamental resource for guiding future research endeavours and informing decision-making processes regarding AI integration in libraries.

6. Conclusion:

In conclusion, Augmented Intelligence (AuI) represents a strategic fusion of human intelligence (HI) and artificial intelligence (AI), designed to enhance human capabilities and decision-making rather than replace them. While human intelligence excels in creativity, emotional understanding, and ethical reasoning, AI is unparalleled in processing large datasets and performing specific tasks with high efficiency. AuI leverages these strengths through systems that facilitate collaborative decision-making, such as HI-AI cascades and parallel decision-making processes. This synergy not only boosts productivity and innovation across various sectors, including healthcare, education, and business, but also addresses challenges related to technology integration, workforce adaptation, and ethical considerations. As AuI continues to evolve, it promises to redefine job roles, enhance human performance, and drive new advancements, making it a pivotal component in the future landscape of technology and human development.
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