International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 1, January-February 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Cognitive Computing in Cyber-Physical Systems: Transformative Integration for Enhanced Capabilities

Manish Verma

Scientist D, DMSRDE, DRDO, Kanpur, Uttar Pradesh, India; DTT, Lucknow, Uttar Pradesh, India

ABSTRACT

Cyber-physical systems (CPS) represent a convergence of the digital and physical worlds, playing a crucial role in various industries, from manufacturing to healthcare and smart environments. The integration of cognitive computing into CPS marks a transformative leap, offering numerous merits that enhance adaptability, efficiency, and overall performance. This abstract explores the key contributions and advantages of incorporating cognitive computing in CPS.

Cognitive computing, with its adaptive learning capabilities, empowers CPS to dynamically adjust and improve performance over time. Its efficient data processing abilities enable the handling of large datasets, extracting valuable insights for real-time decision-making. Context awareness, heightened by cognitive computing, ensures precise responses to diverse situations, considering user behavior, environmental conditions, and system states.

Predictive analytics, facilitated by cognitive computing models, allows CPS to anticipate future events and trends, optimizing resource allocation and bolstering system reliability. The achievement of autonomous operation, driven by cognitive decision-making, reduces dependence on continuous human intervention, enabling swift responses to dynamic changes.

Natural Language Processing (NLP) enhances human-machine interaction, making CPS more accessible and user-friendly. Cognitive computing also contributes to anomaly detection and security, ensuring early identification and mitigation of potential threats, thereby enhancing overall system resilience.

Resource optimization, continuous learning, and human-centric design underscore the adaptability, sustainability, and user-centric focus of CPS enhanced by cognitive computing. In various applications, from healthcare and manufacturing to smart environments and robotics, cognitive computing plays a pivotal role in efficient decision support and improved user experiences.

This abstract concludes that the integration of cognitive computing in CPS signifies a paradigm shift towards more intelligent, responsive, and user-centric technologies. As research and development continue to advance, the potential for transformative impacts on industries, economies, and societies remains substantial. The synergy of cognitive computing and CPS holds promise for innovation, optimization, and sustainable development in the era of interconnected systems.

How to cite this paper: Manish Verma "Cognitive Computing in Cyber-Physical Systems: Transformative Integration for Enhanced Capabilities" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-1, February 2024, pp.77-84, URL: www.ijtsrd.com/papers/ijtsrd61329.pdf

IJTSRD61329

KEYWORDS: *Cognitive computing, CPS, BCI, NLP, User-Centric technologies*

I. INTRODUCTION

Cognitive Learning Evolution in the Realm of Cyber-Physical Systems: A Journey Towards Intelligent Interactions.

In the dynamic landscape of technology and interconnected systems, the evolution of cognitive learning has become intricately intertwined with the advancement of Cyber-Physical Systems (CPS). As we witness the convergence of the digital and physical realms, the amalgamation of cognitive learning principles with CPS marks a transformative chapter in the evolution of intelligent interactions.

Cognitive learning, a field rooted in understanding how the human mind processes and applies knowledge, has undergone a remarkable evolution. From the early behaviorist theories that emphasized observable behaviors to the more recent cognitive, constructivist, and connectionist approaches, cognitive learning has continuously adapted to capture the intricacies of human cognition. This journey has not only shaped our understanding of learning processes but has also paved the way for innovative applications in the realm of technology.

The evolution of cognitive learning finds a natural synergy with CPS, where computational intelligence meets the physical world. CPS, characterized by the seamless integration of computing, communication, and control in physical processes, represents a new paradigm in technological innovation. These systems span diverse domains, from manufacturing and healthcare to smart cities and transportation, embedding intelligence into the fabric of our everyday lives.

This convergence of cognitive learning and CPS brings forth a myriad of possibilities and challenges. Cognitive learning principles, such as adaptability, context awareness, and autonomous decision-making, align seamlessly with the requirements of CPS. The integration of cognitive learning in CPS not only enhances system capabilities but also opens doors to more intuitive, efficient, and user-centric interactions between humans and machines.

This exploration aims to delve into the evolution of cognitive learning and its intersection with CPS, examining the synergies that drive advancements in intelligent systems. From the early conceptualizations of cognitive theories to the practical applications in the design and optimization of CPS, this journey reflects the quest for a harmonious integration of human-like learning capabilities with the functionality of cyber-physical environments.

As we embark on this exploration, we will unravel the historical milestones in cognitive learning, contextualize them within the landscape of CPS, and envision the potential impact of this convergence on the future of technology. The evolution of cognitive learning within the context of CPS promises to redefine the possibilities of intelligent interactions, fostering a new era where machines not only respond to human needs but actively learn and adapt, shaping a symbiotic relationship between the cognitive mind and cyber-physical systems.

II. Cognitive Learning Evolution

Cognitive learning has evolved over time, with various theories and models shaping our understanding of how humans acquire, process, and apply knowledge. The timeline below provides a brief overview of key milestones in the evolution of cognitive learning theories:

1. Behaviorism (early to mid-20th century):

- Key Figures: John B. Watson, B.F. Skinner
- Focus: Behaviorism emphasized observable behaviors and external stimuli, ignoring internal mental processes.
- Impact: While not a cognitive theory, behaviorism laid the groundwork for future cognitive theories by emphasizing the study of behavior and learning through conditioning.

2. Cognitivism (1950s to 1970s):

- Key Figures: Jean Piaget, Lev Vygotsky, Jerome Bruner
- Focus: Cognitivism shifted the focus from observable behaviors to mental processes, emphasizing how people process information, solve problems, and make decisions.
- Impact: Piaget's stages of cognitive development and Vygotsky's socio-cultural theory influenced education and psychology, emphasizing the role of internal mental structures.

3. Information Processing Model (1950s to 1970s):

- Key Figures: George Miller, Ulric Neisser
- Focus: This model compared the human mind to a computer, emphasizing the processing of information through sensory input, storage, and retrieval.
- Impact: The information processing model contributed to the understanding of memory, attention, and problem-solving.

4. Social Cognitive Theory (1970s and onward):

- Key Figures: Albert Bandura
- Focus: Social cognitive theory emphasizes the role of observational learning, modeling, and the influence of social factors on cognitive processes.
- Impact: Bandura's work has had a significant impact on understanding how individuals learn through observing others and the role of self-efficacy in motivation.

5. Constructivism (1980s and onward):

- Key Figures: Jean Piaget, Lev Vygotsky, Seymour Papert
- Focus: Constructivism emphasizes the active construction of knowledge by individuals,

arguing that learning is a process of building meaning from experiences.
- Impact: Constructivist approaches have influenced education, promoting student-centered learning, problem-solving, and collaboration.

6. **Connectionism and Neural Networks (1980s and onward):**
- Key Figures: David Rumelhart, James McClelland
- Focus: Connectionism explores how neural networks and interconnected nodes simulate human cognitive processes, contributing to the development of artificial intelligence and machine learning.
- Impact: Connectionist models have influenced the study of learning, memory, and cognitive processes, especially in the context of neural network-based models.

7. **Cognitive Load Theory (1980s and onward):**
- Key Figures: John Sweller
- Focus: Cognitive load theory examines the limitations of working memory and how instructional design can optimize learning by managing cognitive load.
- Impact: This theory has practical implications for designing effective educational materials and instructional strategies.

8. **Embodied Cognition (1990s and onward):**
- Key Figures: George Lakoff, Mark Johnson
- Focus: Embodied cognition posits that cognitive processes are deeply connected to the body and its interactions with the environment.
- Impact: This perspective challenges traditional views of cognition, emphasizing the importance of sensory-motor experiences in shaping thought and learning.

9. **Neuroscience and Cognitive Learning (2000s and onward):**
- Key Figures: Advances in neuroscience research
- Focus: Ongoing research in neuroscience continues to uncover the neural mechanisms underlying cognitive processes, contributing to a deeper understanding of learning and memory.
- Impact: Integration of neuroscience findings with cognitive theories enhances our understanding of how the brain supports learning and informs educational practices.

10. **Technology-Enhanced Learning (2000s and onward):**
- Key Trends: Online learning, e-learning, educational technology
- Focus: The use of technology in education has transformed the learning landscape, providing new opportunities for personalized, interactive, and collaborative learning experiences.
- Impact: Technology has influenced instructional design, accessibility, and the delivery of educational content.

The evolution of cognitive learning is an ongoing process, with researchers and educators continually refining theories and incorporating new insights from various disciplines, including psychology, neuroscience, and technology. This timeline provides a broad overview, and ongoing developments will likely shape the future of cognitive learning theories.

III. Cognitive Memory and Cognitive Mind Role in Brain Computer Interaction

Cognitive memory refers to the processes and systems in the brain responsible for storing, retaining, and recalling information. It involves various aspects of memory, including sensory memory, short-term memory, and long-term memory. Cognitive memory plays a crucial role in brain-computer interaction (BCI), where the brain communicates with external devices, such as computers, through neural signals. Here's an overview of the cognitive memory and cognitive mind's role in BCI, along with examples:

1. **Working Memory and BCI:**
- Explanation: Working memory is a component of cognitive memory responsible for temporarily holding and manipulating information. In BCI, working memory is essential for tasks that require real-time interaction, such as controlling a cursor on a computer screen or navigating through virtual environments.
- Example: In a brain-controlled cursor system, users may use their working memory to focus on specific targets or objects on a screen, and their brain signals are translated into cursor movements.

2. **Long-Term Memory and BCI:**
- Explanation: Long-term memory stores information for an extended period, and it plays a role in BCI when users need to recall stored patterns or commands. This is particularly relevant in systems that involve training or adaptation over time.
- Example: In a BCI system for speech recognition, long-term memory may be used to store personalized speech patterns or commands, allowing the system to adapt and improve its accuracy based on the user's historical data.

3. **Episodic Memory and BCI:**
- Explanation: Episodic memory involves the recall of specific events and experiences. In BCI, episodic memory can be leveraged for tasks that

require context-aware interactions or remembering past user preferences.
- ➢ Example: A BCI system for smart home control could use episodic memory to recall specific routines or preferences, such as adjusting the lighting or temperature based on the user's past behavior.

4. Sensory Memory and BCI:
- ➢ Explanation: Sensory memory is the initial stage of memory where sensory information is briefly retained. In BCI, capturing and interpreting sensory information from the brain can be crucial for applications involving perception and feedback.
- ➢ Example: In a BCI-driven virtual reality system, sensory memory might be engaged to provide a seamless and immersive experience by quickly updating visual or auditory stimuli based on the user's changing focus or environment.

5. Neural Interfaces and BCI:
- ➢ Explanation: Neural interfaces bridge the gap between the cognitive mind and external devices in BCI. These interfaces translate neural signals into commands that can be understood and executed by computers or other devices.
- ➢ Example: Brain-machine interfaces (BMIs) can be used to control prosthetic limbs. The cognitive mind's intent to move a limb generates neural signals, which are captured by the interface and translated into corresponding movements of the prosthetic limb.

6. Feedback Loop and BCI:
- ➢ Explanation: BCI systems often involve a feedback loop, where the system provides information to the user based on their actions or the system's response. This loop can influence cognitive processes and memory during interaction.
- ➢ Example: In a neurofeedback-based BCI for meditation or stress reduction, users may receive real-time feedback on their brain activity, helping them learn to modulate their cognitive states over time.

In summary, cognitive memory, encompassing working memory, long-term memory, episodic memory, and sensory memory, plays a significant role in brain-computer interaction. The development of effective BCIs relies on understanding and leveraging these cognitive processes to create seamless and intuitive interfaces that enable users to interact with technology using their thoughts and intentions.

IV. Brain Computer Interaction to Control Various Cognitive Computing Cyber-Physical Systems

Brain-computer interaction (BCI) has the potential to revolutionize the control of cognitive computing cyber-physical systems by enabling direct communication between the human brain and machines. This intersection of BCI and cognitive computing allows individuals to influence and manage complex systems, such as robotics, smart environments, and other cyber-physical systems, through their cognitive processes. Here's an overview of how BCI can be applied to control various cognitive computing cyber-physical systems:

1. Neuro-robotics:
- ➢ Application: BCI can be used to control robotic systems directly through the user's thoughts and intentions.
- ➢ Example: A person wearing a BCI device could control the movements of a robotic arm in a manufacturing setting, enhancing precision and efficiency.

2. Smart Environments and Home Automation:
- ➢ Application: BCI can facilitate control over smart home devices and environments based on the user's cognitive commands.
- ➢ Example: Using BCI, individuals can adjust lighting, temperature, or entertainment systems in their homes by simply thinking about the desired changes.

3. Prosthetics and Assistive Devices:
- ➢ Application: BCI can be applied to control prosthetic limbs or other assistive devices, providing individuals with greater mobility and independence.
- ➢ Example: A person with a BCI-controlled prosthetic hand can execute complex grip patterns by thinking about the specific movements they want to perform.

4. Healthcare Systems:
- ➢ Application: BCI can contribute to healthcare systems by allowing individuals to control medical devices or interface with healthcare technologies using their thoughts.
- ➢ Example: BCI could enable paralyzed patients to control electric wheelchairs or communicate with external devices to manage their health conditions.

5. Brain-Controlled Vehicles:
- ➢ Application: BCI can be integrated into vehicles, allowing drivers to control certain functions without manual input.

- Example: A driver with a BCI device could activate specific vehicle features, such as adjusting the air conditioning or turning on the windshield wipers, through cognitive commands.

6. Cognitive Prosthetics in Industry:

- Application: BCI can enhance the control of machinery and equipment in industrial settings, improving safety and efficiency.
- Example: Operators in a manufacturing plant could use BCI to remotely control robotic arms or machinery, reducing the need for manual intervention in hazardous environments.

7. Brain-Computer Interface for Gaming:

- Application: BCI can be integrated into gaming systems, allowing players to control characters or elements of the game using their thoughts.
- Example: Gamers with BCI devices can navigate virtual environments, interact with objects, or trigger in-game actions by thinking about the corresponding commands.

8. Telepresence and Virtual Reality (VR):

- Application: BCI can enhance the immersive experience in virtual reality environments or telepresence systems by allowing users to control avatars or interact with virtual objects through their thoughts.
- Example: Users in a virtual meeting could use BCI to express emotions or gestures, creating a more natural and intuitive communication experience.

9. Cognitive Computing for Decision Support:

- Application: BCI can provide input to cognitive computing systems, assisting in decision-making processes based on the user's cognitive state.
- Example: BCI could be used in critical decision-making environments, such as air traffic control, where the operator's mental workload influences the system's recommendations.

10. Education and Training:

- Application: BCI can be utilized in educational settings to enhance learning experiences by allowing students to interact with educational technologies through their cognitive processes.
- Example: Students could use BCI to navigate virtual learning environments, control simulations, or interact with educational materials in a more engaging and immersive manner.

While these examples highlight the potential applications of BCI in controlling various cognitive computing cyber-physical systems, it's important to note that the field is continually evolving. Technical challenges, ethical considerations, and the need for seamless integration with existing technologies remain areas of active research and development in the advancement of BCI applications.

V. Role of Cognitive Computing in Cyber Physical Systems

Cognitive computing plays a significant role in enhancing the capabilities and efficiency of cyber-physical systems (CPS). Cyber-physical systems integrate computing, communication, and control to monitor and manage physical processes. The role of cognitive computing in CPS involves leveraging advanced technologies to enable systems to learn, reason, and make decisions in complex and dynamic environments. Here are several key aspects of how cognitive computing contributes to the effectiveness of cyber-physical systems:

1. Data Processing and Analysis:

- Role: Cognitive computing helps process and analyze vast amounts of data generated by sensors and devices within a cyber-physical system.
- Significance: With the ability to understand patterns, correlations, and anomalies, cognitive computing enhances the system's decision-making capabilities based on real-time data.

2. Machine Learning for Adaptation:

- Role: Cognitive computing, especially machine learning algorithms, enables cyber-physical systems to adapt and optimize their behavior over time.
- Significance: The system can learn from historical data, user interactions, and changing conditions, allowing for more intelligent and context-aware responses.

3. Context Awareness:

- Role: Cognitive computing enhances the awareness of context within a cyber-physical system, considering factors such as user preferences, environmental conditions, and system states.
- Significance: Improved context awareness enables more precise decision-making and allows the system to respond appropriately to diverse and dynamic situations.

4. Decision Support Systems:

- Role: Cognitive computing provides decision support capabilities to cyber-physical systems, assisting in complex decision-making processes.
- Significance: By analyzing data, identifying patterns, and considering various factors, cognitive computing helps in generating insights that aid decision-makers in optimizing system performance and resource utilization.

5. **Autonomous Operation:**
- Role: Cognitive computing contributes to the autonomy of cyber-physical systems by enabling them to make decisions and take actions without direct human intervention.
- Significance: Autonomous systems can respond quickly to changing conditions, improving efficiency, and reducing the need for constant human oversight.

6. **Natural Language Processing (NLP) and Human-Machine Interaction:**
- Role: Cognitive computing incorporates NLP and facilitates human-machine interaction within cyber-physical systems.
- Significance: Users can interact with the system using natural language, making it more accessible and user-friendly. NLP also enables the system to understand and respond to human commands or queries.

7. **Predictive Analytics:**
- Role: Cognitive computing models can predict future events or system behavior based on historical data and real-time inputs.
- Significance: Predictive analytics in cyber-physical systems can anticipate potential issues, optimize resource allocation, and improve overall system performance.

8. **Anomaly Detection and Security:**
- Role: Cognitive computing aids in the detection of anomalies or security threats within a cyber-physical system.
- Significance: By continuously monitoring data patterns, cognitive systems can identify deviations from normal behavior, helping to detect and mitigate potential security breaches or system failures.

9. **Resource Optimization:**
- Role: Cognitive computing contributes to the optimization of resources, such as energy, bandwidth, and processing power, within a cyber-physical system.
- Significance: By analyzing data and making intelligent decisions, cognitive computing helps ensure efficient resource utilization, reducing waste and enhancing sustainability.

10. **Continuous Learning and Improvement:**
- Role: Cognitive computing enables cyber-physical systems to engage in continuous learning, adapting to evolving conditions and improving their performance over time.
- Significance: The ability to learn from experience allows systems to stay relevant and effective in dynamic environments, ensuring long-term adaptability and resilience.

In summary, cognitive computing enhances the capabilities of cyber-physical systems by providing advanced data processing, decision-making, and adaptive learning. This synergy results in more intelligent, responsive, and efficient systems that can operate autonomously, understand context, and deliver enhanced user experiences.

VI. Merits of Cognitive Computing in Cyber Physical Systems

Cognitive computing offers several merits when integrated into cyber-physical systems (CPS), enhancing their capabilities and performance in various domains. Here are some of the key advantages or merits of employing cognitive computing in cyber-physical systems:

1. **Adaptive Learning:**
- Merit: Cognitive computing enables cyber-physical systems to adapt and learn from data over time.
- Significance: This adaptive learning allows systems to improve their performance, optimize processes, and make more informed decisions based on evolving conditions and changing requirements.

2. **Data Processing Efficiency:**
- Merit: Cognitive computing excels in processing and analyzing vast amounts of data quickly and efficiently.
- Significance: In CPS, where numerous sensors generate large datasets, cognitive computing helps extract valuable insights, identify patterns, and make real-time decisions, contributing to overall system efficiency.

3. **Context Awareness:**
- Merit: Cognitive computing enhances context awareness by considering various factors such as user behavior, environmental conditions, and system states.
- Significance: Improved context awareness allows cyber-physical systems to make more precise and relevant decisions, enhancing their ability to respond effectively to different situations.

4. **Predictive Analytics:**
- Merit: Cognitive computing models enable predictive analytics, forecasting future events or trends based on historical data.
- Significance: Predictive analytics in CPS helps anticipate issues, prevent potential problems, and optimize resource allocation, contributing to enhanced system reliability and performance.

5. **Autonomous Operation:**
- Merit: Cognitive computing supports autonomous decision-making within cyber-physical systems.
- Significance: Autonomy enables CPS to operate without constant human intervention, responding in real-time to dynamic changes and improving overall system efficiency.

6. **Natural Language Processing (NLP):**
- Merit: Integration of NLP enables human-machine interaction in a more intuitive and user-friendly manner.
- Significance: Users can communicate with cyber-physical systems using natural language, facilitating easier system control, monitoring, and troubleshooting.

7. **Anomaly Detection and Security:**
- Merit: Cognitive computing contributes to the identification of anomalies and security threats within CPS.
- Significance: Early detection of abnormal behavior helps prevent security breaches, system failures, and potential damages, enhancing the overall resilience and security of the cyber-physical system.

8. **Resource Optimization:**
- Merit: Cognitive computing aids in the optimization of resources such as energy, bandwidth, and processing power.
- Significance: Efficient resource allocation reduces waste, improves sustainability, and enhances the cost-effectiveness of cyber-physical systems.

9. **Continuous Learning:**
- Merit: Cognitive computing enables cyber-physical systems to engage in continuous learning.
- Significance: Systems can adapt to new information, evolving conditions, and changing requirements, ensuring long-term relevance and effectiveness in dynamic environments.

10. **Human-Centric Design:**
- Merit: Cognitive computing facilitates human-centric design in CPS.
- Significance: By understanding human intent, preferences, and natural language commands, cognitive computing makes cyber-physical systems more user-friendly and aligned with human needs and expectations.

11. **Efficient Decision Support:**
- Merit: Cognitive computing provides efficient decision support by analyzing complex data and generating insights.
- Significance: In applications such as healthcare or manufacturing, where quick and informed decisions are critical, cognitive computing enhances decision-making processes.

12. **Enhanced User Experience:**
- Merit: Cognitive computing improves the overall user experience in interacting with cyber-physical systems.
- Significance: Users benefit from systems that can understand and respond to their needs, making the interaction more intuitive and seamless.

In summary, the integration of cognitive computing in cyber-physical systems brings numerous merits, ranging from improved adaptability and decision-making to enhanced efficiency, security, and user experience. These advantages make cognitive computing a valuable component in advancing the capabilities and functionalities of cyber-physical systems across various applications and industries.

Conclusion

In conclusion, the integration of cognitive computing in cyber-physical systems (CPS) represents a transformative leap in enhancing the capabilities, efficiency, and adaptability of these interconnected systems. The merits of incorporating cognitive computing are vast and contribute to the evolution of CPS in diverse domains.

Cognitive computing's adaptive learning capabilities empower cyber-physical systems to dynamically adjust and improve performance over time. Its prowess in data processing efficiency enables CPS to handle large volumes of data, extracting valuable insights and making real-time decisions. The heightened context awareness facilitated by cognitive computing ensures that CPS respond precisely to varying situations, considering factors such as user behavior, environmental conditions, and system states.

Predictive analytics, made possible by cognitive computing models, empowers CPS to anticipate future events and trends, optimizing resource allocation and enhancing overall system reliability. The realization of autonomous operation, driven by cognitive decision-making, reduces reliance on constant human intervention, enabling CPS to respond swiftly to dynamic changes.

Natural Language Processing (NLP) fosters a more intuitive and user-friendly human-machine interaction, making cyber-physical systems accessible to a broader audience. Furthermore, cognitive computing contributes to anomaly detection and security, ensuring early identification and mitigation of potential threats, thereby enhancing the overall resilience of CPS.

Resource optimization, continuous learning, and human-centric design principles underscore the adaptability, sustainability, and user-centric focus of CPS enhanced by cognitive computing. In various applications, from healthcare and manufacturing to smart environments and robotics, cognitive computing plays a pivotal role in efficient decision support and improved user experiences.

In essence, the integration of cognitive computing in cyber-physical systems signifies a paradigm shift towards more intelligent, responsive, and user-centric technologies. This synergy not only addresses the complexities of modern interconnected systems but also opens avenues for innovation, optimization, and sustainable development. As research and development in cognitive computing and CPS continue to advance, the potential for further transformative impacts on industries, economies, and societies is substantial.

Acknowledgement

We are thankful to pupils of industry 4.0 and Director DMSRDE, DTT, Department of Physics, University of Lucknow, Lucknow.

References

[1] https://www.researchgate.net/publication/376832918_Theoretical_Aspects_of_Cyber-Physical_Cognitive_Systems_CP-CS; Manish Verma

[2] Manish Verma. "Cyber-Physical Systems: Bridging the Digital and Physical Realms for a Smarter Future." (2023).

[3] Manish Verma "Beyond AI: The Rise of Cognitive Computing as Future of Computing: ChatGPT Analysis" Published in International Journal of Trend in Scientific Research and Development(ijtsrd), ISSN:2456-6470, Volume-7 | Issue-6, December 2023, pp.676-684.

[4] (PDF) Beyond AI: The Rise of Cognitive Computing as Future of Computing: ChatGPT Analysis. Available from: https://www.researchgate.net/publication/376851249_Beyond_AI_The_Rise_of_Cognitive_Computing_as_Future_of_Computing_ChatGPT_Analysis [accessed Jan 05 2024].

[5] Noor, Ahmed K. "Potential of cognitive computing and cognitive systems." Open Engineering 5.1 (2014).

[6] Chen, Min, Francisco Herrera, and Kai Hwang. "Cognitive computing: architecture, technologies and intelligent applications." Ieee Access 6 (2018): 19774-19783.

[7] Chen, Min, et al. "Edge cognitive computing based smart healthcare system." Future Generation Computer Systems 86 (2018): 403-411.

[8] Lu, Huimin, et al. "The cognitive internet of vehicles for autonomous driving." *IEEE Network* 33.3 (2019): 65-73.

[9] Zhang, Pei, and Antonie Jetter. "A framework for building integrative scenarios of autonomous vehicle technology application and impacts, using fuzzy cognitive maps (FCM)." 2018 Portland International Conference on Management of Engineering and Technology (PICMET). IEEE, 2018.

[10] Finn, Anthony, and Steve Scheding. "Developments and challenges for autonomous unmanned vehicles." Intelligent Systems Reference Library 3 (2010): 128-154.

[11] Aeroplane Science In Ancient India By Harsh Dev Kumar. 2023