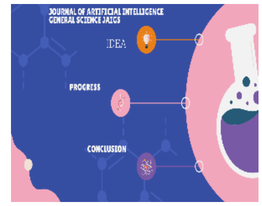
Vol. 2, Issue 1, January 2024
Journal of Artificial Intelligence General Science JAIGS

Home page http://jaigs.org



Exploring the Impact of Artificial Intelligence in Healthcare

Md. Mafiqul Islam

Department of Information Science and Library Management, University of Rajshahi, Bangladesh
*Corresponding Author: Md. Mafiqul Islam. Email: techbook1994@gmail.com

ARTICLE INFO
Article History:
Received: 05.03.2024
Accepted: 10.03.2024
Online: 22.03.2024
Keyword: *artificial intelligence; ethics; governance; healthcare*

ABSTRACT

The integration of artificial intelligence (AI) applications has revolutionized healthcare. This study conducts a comprehensive literature review to elucidate the multifaceted role of AI in healthcare, focusing on key aspects including medical imaging and diagnostics, virtual patient care, medical research and drug discovery, patient engagement and compliance, rehabilitation, and administrative applications. AI's impact is observed across various domains, including detecting clinical conditions in medical imaging, early diagnosis of coronavirus disease 2019 (COVID-19), virtual patient care utilizing AI-powered tools, electronic health record management, enhancing patient engagement and treatment compliance, reducing administrative burdens for healthcare professionals (HCPs), drug and vaccine discovery, identification of medical prescription errors, extensive data storage and analysis, and technology-assisted rehabilitation. However, the integration of AI in healthcare encounters several technical, ethical, and social challenges, such as privacy concerns, safety issues, autonomy and consent, cost considerations, information transparency, access disparities, and efficacy uncertainties. Effective governance of AI applications is imperative to ensure patient safety, accountability, and to bolster HCPs' confidence, thus fostering acceptance and yielding significant health benefits. Precise governance is essential to address regulatory, ethical, and trust concerns while advancing the adoption and implementation of AI in healthcare. With the onset of the COVID-19 pandemic, AI has sparked a healthcare revolution, signaling a promising leap forward to meet future healthcare demands.

Introduction:

Healthcare systems globally are currently facing a critical juncture, grappling with healthcare cost escalations that have far surpassed GDP growth rates, challenging the sustainability of these systems [1]. This issue became particularly evident with the onset of the 2019 coronavirus disease (COVID-19) pandemic and the Ukraine conflict. A combination of fiscal constraints, aging populations, escalating chronic illnesses, and the strain on healthcare infrastructures has exacerbated the challenge of meeting the escalating demand for accessible and available healthcare services. Moreover, the COVID-19 pandemic has exacerbated health system vulnerabilities in certain countries, such as India, Brazil, and Indonesia [2].

Health systems rely on robust disease management protocols and evidence-based care strategies to address needs and standardize practices in line with industrial healthcare delivery services. The concept of a "Highly Reliable Organization (HRO)" underscores the importance of managing services through entities such as "accountable care organizations (ACOs)" or "health maintenance organizations (HMOs)" [3]. However, chronic disease prevalence in the United States (USA) has been steadily rising, with 60% of adults affected by at least one chronic illness and 40% grappling with two or more chronic conditions, resulting in an annual healthcare expenditure of USD 3.3 trillion [4]. The landscape shifted dramatically with the emergence of an infectious disease first identified in Wuhan, China, in 2019, later designated as COVID-19 by the World Health Organization in February 2020 [5]. Subsequently, healthcare has undergone a digital metamorphosis, fundamentally altering many aspects of medical care [6]. This transformation has been driven by the immense pressure exerted by COVID-19 on global healthcare systems, infrastructure, supply chains, and personnel. The pandemic has compelled healthcare stakeholders to embrace digital technologies [7,8], precipitating significant foundational shifts in the healthcare sector post-pandemic. Notably, current-generation consumers (patients) have become actively engaged in healthcare decision-making processes, spurred by the increased adoption of virtual healthcare systems and associated digital innovations [9]. However, prominent challenges persist, necessitating strategies to navigate toward the future healthcare landscape.

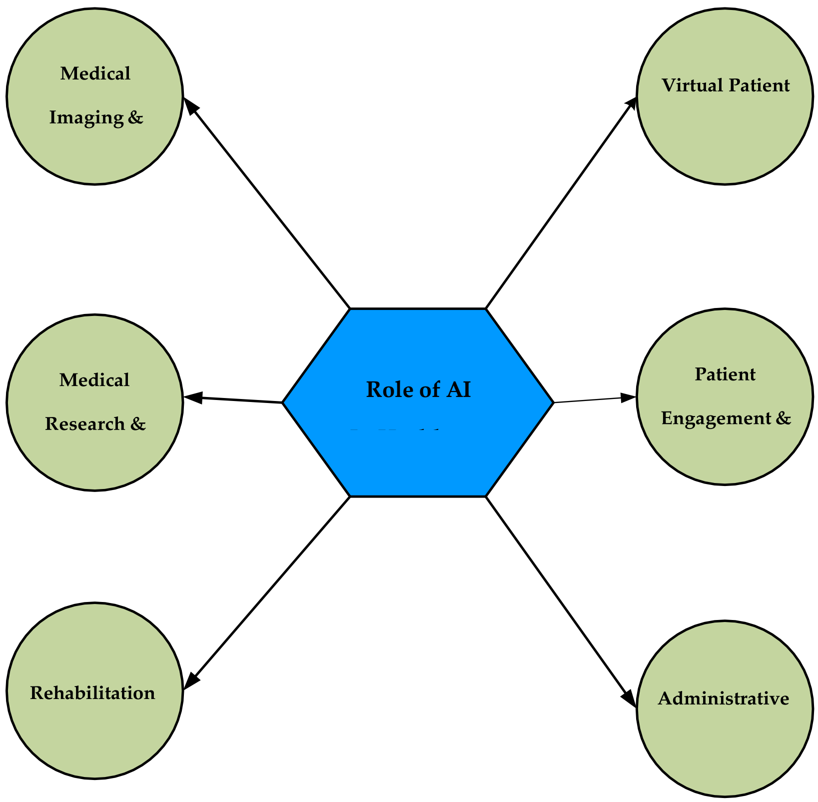
Patient experiences and needs serve as catalysts for innovations in the healthcare sector, with a growing emphasis on fostering digitally empowered physician-patient interactions and ensuring the provision of patient-centric services worldwide [10]. The demand for advanced digital tools has become imperative to enhance customer satisfaction, facilitate health monitoring, and promote better medication adherence [11]. Such advancements hold particular promise during the post-hospitalization period through digital health platforms. Concurrently, healthcare consumers remain vigilant about safeguarding their confidential data, prompting healthcare organizations (HCOs) to prioritize preserving customer trust through transparency, empathy, and reliability in service delivery [11].

The burgeoning field of biomedical science, encompassing genomics, digital medicine, artificial intelligence (AI), and its subset machine learning (ML), sets the stage for healthcare transformation, heralding the emergence of novel technologies and necessitating a new breed of workforce and practice standards. Genomics, along with other technologies such as biometrics, tissue engineering, and the vaccine industry, has the potential to revolutionize diagnostics, therapeutics, care delivery, regenerative treatments, and precision medicine models [12]. See Table 1 for definitions of terms related to AI.

Term	Definition
Machine learning (ML)	ML is a subtype of AI technology that aims to improve the speed and accuracy of physicians' work. It also denotes several statistical techniques that allow computers to learn from experience without being explicitly programmed. This learning usually takes the form of variations in how an algorithm works [17]. It is also a tool applied in healthcare to assist healthcare professionals in caring for patients and managing clinical data. It is an application of AI that involves programming computers to mimic how humans think and learn [18].
Distributed Ledger Technology (DLT)	DLT is an innovative and rapidly growing method for recording and sharing data across different data stores (ledgers) [19]. It is secure, immutable, and readily available. It can allow patients to take control of their own data, eventually generating trust in an industry that matters to all of us [20]. DLT integrated with AI describes a novel and advanced method to achieve the intelligent, resilient, and safe handling of electronic health record data [21].
Natural language processing (NLP)	Natural language processing (NLP) denotes the field of study that emphasizes the interactions between human language and computers [22]. NLP techniques can capture unstructured healthcare information, analyze its grammatical structure, determine the meaning of information, and translate information; therefore, it can be easily understood by electronic healthcare systems. These techniques also reduce costs and improve the quality of healthcare [23].
Metaverse	The metaverse represents a 3D space based on virtual and augmented reality, where individuals can utilize their own avatars to play, work, and synchronously interconnect with each other [24]. It delivers an entrancing, communicative, and pleasurable healthcare service experience tailored to achieve patients' desires. It includes modern technologies such as AI, telepresence, blockchain, virtual reality (VR), augmented reality (AR), and digital twinning. These technologies highly influence healthcare [25]. The metaverse application is exclusively associated with healthcare, establishing a "niche theme" for academics, such as education, research, training, and disease prevention and management. It has become a vibrant technology for strengthening medical students' competence. Furthermore, patients' health illnesses can be directly monitored at their homes, and real life can also be connected with the virtual one using digital twins, a diverse technology [26,27].
Chat Generative Pretrained Transformer (ChatGPT)	ChatGPT is an AI-based conversational agent that utilizes natural language processing (NLP) and machine learning algorithms to simulate human-like conversations [28]. Its critical applications in healthcare, including practice, education, and research, could be auspicious if the accompanying valid concerns are proactively inspected and tackled. It functions as a chatbot, a program that can comprehend and create responses using a text-grounded interface [29]. Xu et al. [30] described the application of chatbots in healthcare, comprising patient support; monitoring and administration; and tumor diagnostics, screening, and management.
Transformer	Transformer is a critical deep learning model and is broadly used in various areas, namely, computer vision (CV), natural language processing (NLP), and speech processing [31]. The applications of transformers are observed in electronic health records, medical imaging, and COVID-19 detection [32–36].

Furthermore, digital health technologies (DHTs) encompass a wide array of innovations, including mobile health (mHealth), health information technology (HIT), wearable devices, telehealth, telemedicine, mobile Internet devices (MIDs), and personalized medicine [37]. Recently, emerging technological advancements such as AI, the metaverse, and data sciences have been influencing smart health [38]. These technologies facilitate improved prevention, early detection of fatal diseases, and remote management of chronic conditions outside of traditional care settings, such as wirelessly observed therapy (WOT), which presents a novel method for monitoring therapy adherence [39]. A significant advancement is the ability to provide and access healthcare services anywhere and anytime, ushering in an era of disruptive and minimally invasive medicine. MIDs enable users to access essential resources, including relevant applications and social media (SM). The applications available on MIDs are vast, granting access to scientific databases like Medscape, Web of Science, and Scopus for professionals, while SM networks such as YouTube, Facebook, WhatsApp, Wikipedia, and other instant messaging applications (IMAs) cater to both professionals and non-professionals. The utilization of such digital health modalities, employing AI in healthcare, has accelerated in the post-COVID-19 era [40].

AI, ML, and DHTs have triggered a revolution in healthcare, particularly in response to the challenges posed by COVID-19 to the global healthcare system. Notably, AI is currently integrating new technologies like the Internet of Things (IoT) into consumer-oriented DHTs. As AI and ML become increasingly pervasive in healthcare systems, the IoT is poised to evolve into the "intelligence of things" [1]. The utilization of collected data to transform processes is expected to influence behavior and values [41]. Moreover, intelligent medical technology, powered by AI, has garnered enthusiasm among the general population as it enables the realization of the 4P model of medicine—predictive, preventive, personalized, and participatory—thus promoting patient autonomy [42]. Integration of AI into healthcare has demonstrated notable improvements in healthcare outcomes, offering enhanced efficiency, speed, and cost-effectiveness [12].



Digital health tools offer healthcare providers a comprehensive view of patient health by granting access to patient data, thereby enabling physicians to provide patients with more detailed insights into their health status. These tools present tangible opportunities to enhance therapeutic outcomes and effectiveness. However, concerns have been raised regarding the potential psychological impact, particularly with the widespread utilization of social media (SM) and instant messaging applications (IMAs) by patients, the general public, and healthcare professionals [43].

Furthermore, the accumulation of data from diverse sources, including health information systems (HISs), wearable devices, telemedicine, mobile health (mHealth), telehealth, mobile Internet devices (MIDs), and other AI-powered medical technologies, results in the generation of big data. These datasets accelerate the utilization of machine learning (ML) and artificial intelligence (AI) in healthcare systems through the learning process derived from the data obtained from research information, user experience, and the analysis of large datasets [44]. Additionally, electronic health records (EHRs) encompass a wide array of patient healthcare data. Leveraging novel AI technologies, these health datasets can be interconnected to extract precise insights into patient care. AI has emerged as a preferred choice for big data applications in healthcare [46].

Moreover, big data analytics empowers healthcare providers to enhance their clinical services by refining EHRs using analytical algorithms [47]. These analytics also leverage AI advancements to sift through big data based on various criteria for improved data analysis [48]. Given the widespread utilization of AI across various healthcare domains to enhance patient health outcomes and deliver cost-effective healthcare services, this review aims to elucidate its role in healthcare, with a focus on key aspects such as medical imaging and diagnostics, virtual patient care, medical research and drug discovery, patient engagement and compliance, rehabilitation, and other administrative applications. Additionally, the authors address several challenges associated with the use of AI in healthcare. These findings complement existing literature, paving the way to further harness the benefits of AI tools in healthcare.

Furthermore, AI plays a crucial role in medical imaging and diagnostic services, where it serves as a potent tool for image analysis. Radiology professionals increasingly rely on AI for the early detection of various diseases and for reducing diagnostic errors, thereby enhancing preventive measures. Additionally, AI aids cardiologists in decision-making by analyzing ECG and echocardiography charts. For instance, the Ultromics platform, utilized in an Oxford hospital, employs AI to analyze echocardiography scans, detecting heartbeat patterns and identifying ischemic heart disease [49]. AI has shown promising results in the early detection of diseases such as breast and skin cancer, eye diseases, and pneumonia through body imaging modalities [50–52]. Moreover, AI tools analyze speech patterns to predict psychotic occurrences and identify features of neurological diseases like Parkinson's disease [53,54]. Recent studies have even predicted the onset of diabetes using ML models, demonstrating the effectiveness of AI in disease prediction [55]. Additionally, AI techniques, including handcrafted feature learning (HCFL), deep neural networks (DNN), and hybrid methods, have significantly contributed to combatting COVID-19 by aiding in early diagnosis [56,57]. Deep learning models like transformers have been employed in medical imaging analysis, facilitating tasks such as registration, detection, classification, image-to-image translation, segmentation, and video-based applications [34]. Notably, AI has played a pivotal role in distinguishing COVID-19 from pneumonia using X-ray and CT images, thereby aiding in the efficient management of COVID-19 cases [58–60]. Furthermore, AI-based methods, such as wavelet Renyi entropy (WRE) and the three-segment biogeography-grounded optimization (3SBBO) algorithm, have shown promising results in automatically detecting COVID-19 based on chest CT scans [61]. Additionally, AI models like vision transformers (ViT) have demonstrated efficacy in classifying breast tissues based on ultrasound (US) images, surpassing traditional convolutional neural networks (CNNs) in accuracy [62].

Moreover, AI encompasses advanced techniques like Generative Adversarial Networks (GANs), which have significant implications in radiology. GANs, comprising a generator and a discriminator neural network, can synthesize images similar to real images and distinguish between synthetic and real images. In radiology, GANs can generate images consistent with training data, leading to advancements in abnormal detection, image synthesis, and cross-domain image synthesis [63]. Additionally, GANs have the potential to enhance medical education and research by swiftly developing training materials and simulations. These synthetic data can aid student learning by presenting edge-case scenarios and can even be used to model placebo groups in clinical trials, reducing costs and expanding treatment arms [64,65]. However, the use of AI models like ChatGPT for medical advice raises concerns, as it may encourage self-diagnosis and self-treatment without consulting healthcare professionals [66]. Moreover, the concept of "medical technology and AI" (MeTAI) enables AI-based medical practice, primarily guided by medical imaging, and facilitates virtual comparative scanning, raw data sharing, augmented regulatory science, and metaversed medical interventions. Although MeTAI holds promise, it faces challenges such as security, disparity, investment, and privacy [68].

Furthermore, medical scans, systematically gathered and saved, serve as valuable datasets for training AI systems, reducing the time and cost of analyzing medical scans and potentially allowing for more scans to be taken for targeted management [69,70]. AI also impacts clinical decision-making and disease diagnosis by processing and analyzing vast amounts of data across different modalities, supporting physicians in making better clinical decisions or even replacing human decisions in therapeutic areas [71]. However, outcome assessment in AI imaging studies often focuses solely on lesion detection, potentially overlooking the severity and nature of lesions and leading to overdiagnosis [72].

AI plays a pivotal role in revolutionizing medical imaging and diagnostic services, offering radiology professionals a powerful tool for early disease detection and diagnostic accuracy. Radiologists increasingly rely on AI to detect various diseases at an early stage and to minimize diagnostic errors. Additionally, AI serves as a smart tool for analyzing ECG and echocardiography charts, aiding cardiologists in decision-making processes. For example, the Ultromics platform, utilized in a hospital in Oxford, employs AI to analyze echocardiography scans, detecting heartbeat patterns and identifying ischemic heart disease [49].

AI has demonstrated promising outcomes in the early detection of diseases such as breast and skin cancer, eye diseases, and pneumonia using various body imaging modalities [50–52]. AI tools are also capable of analyzing speech patterns to predict psychotic occurrences and identifying features of neurological diseases like Parkinson's disease [53,54]. Recent studies have even utilized ML models to predict the onset of diabetes, with a two-class augmented decision tree showing superior performance in predicting different diabetes variables [55].

Furthermore, several medical imaging tools, including X-ray, CT, and ultrasound, utilize AI techniques to combat COVID-19 by aiding in early diagnosis [56]. Studies have reported that AI methods like handcrafted feature learning (HCFL), deep neural networks (DNN), and hybrid methods have successfully predicted COVID-19 cases [57]. AI-based models like transformers have been instrumental in differentiating COVID-19 from pneumonia using X-ray and CT images, facilitating efficient management of COVID-19 cases [58–60]. Additionally, innovative techniques like the ImageNet-pretrained vision transformer (ViT)-B/32 network have been applied to detect COVID-19 using inputs such as patches of chest X-ray images [60]. A novel hybrid chest CT-based method proposed by Wang et al. utilizes wavelet Renyi entropy (WRE) and a three-segment biogeography-grounded optimization (3SBBO) algorithm to automatically detect COVID-19, demonstrating superior performance compared to traditional methods [61]. Furthermore, ViT has shown efficacy in classifying breast tissues based on ultrasound (US) images, outperforming conventional convolutional neural networks (CNNs) [62].

Virtual Patient Care

The advancement of wearable technology, coupled with the integration of machine learning (ML) and artificial intelligence (AI) in healthcare, has opened avenues for virtual patient monitoring and management. Wearable technology solutions equipped with AI offer active and practical means for patient care, becoming integral parts of standard healthcare practices. These solutions play a significant role in managing chronic diseases like diabetes mellitus, hypertension, sleep apnea, and chronic bronchial asthma through the utilization of wearable, non-invasive sensors [74].

A proposed smart sensor system, incorporating a network of sensors, aims to monitor an individual's home and environment, gathering data on health status and behavior. These sensors, unobtrusive and wearable in nature, monitor physiological variables such as respiratory rate, pulse rate, breathing waveform, blood pressure, and ECG. Collected data are transmitted to the cloud for storage and analysis, particularly beneficial for elderly care [75].

In clinical scenarios, wearable digital devices have proven valuable in diagnosing conditions like atrial fibrillation, aiding in the accurate detection of underlying health issues [76]. Furthermore, ML models leveraging mobile sensor data offer promising avenues for predicting emotional states, providing physicians with valuable insights into patients' mood states [77].

The COVID-19 pandemic has accelerated progress in wearable devices for online patient monitoring, allowing for the early prediction of COVID-19 through physiological changes captured by these devices [78]. Real-time wearable research on COVID-19 cases continues to enhance understanding and detection of the virus, supplementing laboratory investigations [79].

AI, combined with ML and big data analytics, facilitates disease progression prediction and diagnosis, including conditions like diabetic nephropathy and SARS-CoV-2 infection in solid organ transplantation [80]. Integrating AI into bedside care during COVID-19 and future pandemics has been emphasized, highlighting the importance of AI-enabled applications for point-of-care use [81].

The necessity for remote healthcare services has surged during the pandemic, leading to the development of metaverse applications that offer enhanced experiences compared to traditional telemedicine. These applications leverage virtual reality (VR), augmented reality (AR), and digital twinning, providing innovative and cost-effective management solutions that improve patient outcomes [82]. The metaverse concept, simulating human emotions and interactions in a virtual world, holds promise for reinforcing healthcare experiences using AI [86].

Remote patient monitoring (RPM), a subset of telehealth, enables healthcare providers to monitor patient conditions remotely, facilitating timely medical interventions through sensors and communication technologies [88]. RPM platforms have been instrumental in maintaining patient care continuity during the pandemic, with AI-powered designs enhancing early patient deterioration detection and personalizing health monitoring [89].

ChatGPT, an AI language model developed by OpenAI, serves as an accurate AI-powered chatbot delivering medical information and reminders to patients. It aids in patient education, appointment scheduling, and medication adherence, offering personalized assistance in managing various health conditions [91]. However, challenges such as medical ethics, data privacy, and security remain pertinent concerns in deploying AI-driven virtual assistants in healthcare settings [91].

While wearable patient-monitoring systems offer promising solutions for remote healthcare, challenges related to data connectivity, end-user acceptance, and cost implications need to be addressed for widespread adoption and effectiveness [73].

Medical Research and Drug Discovery

Artificial intelligence (AI) is exceptionally well-suited for analyzing the vast and intricate datasets utilized in medical research [92]. Its applications extend to scouring scientific literature, integrating diverse data types, and facilitating drug innovation [93]. Pharmaceutical companies are increasingly turning to AI to streamline drug development processes. Predictive analytics enables scientists to identify suitable candidates for clinical trials and construct precise models of biological processes [92]. Machine learning (ML) contributes to various stages of clinical trials, from cohort selection and participant organization to data collection and analysis. It enhances the patient-centric approach, generalizability, efficacy, and success of clinical trials, although addressing functional and philosophical challenges remains imperative. Additionally, natural language processing (NLP) shows promise in enhancing participant management in clinical trials, but its impact on trial quality and participant experience warrants further investigation [94]. Generative AI can synthesize synthetic data to enrich datasets and enhance diversity in clinical research. Furthermore, researchers can conduct trials in immersive, controlled settings using metaverse applications, facilitating collaboration among geographically dispersed researchers [95].

ChatGPT, an AI-based tool, finds utility in clinical trials by supporting data collection and providing information about trial protocols. It aids in summarizing relevant publications, identifying significant findings, and assisting medical researchers in navigating vast amounts of online evidence [96]. However, ethical considerations regarding the use of chatbots in medical research need careful attention [91].

In the realm of drug discovery, AI technologies leverage ML, bioinformatics, and cheminformatics models to expedite the process and reduce costs [97]. AI-driven drug discovery efforts have shown promising results, with AI-based firms rapidly identifying potential drug candidates. For instance, Toronto-based Deep Genomics utilized an AI workbench platform to develop a novel genetic target and corresponding drug candidate for managing a rare form of Wilson's disease [97]. AI aids in identifying new drug targets, detecting hit and lead compounds, and optimizing drug structure design. It also facilitates drug repurposing efforts and prediction of drug-target interactions, accelerating the drug development pipeline [100,101]. ChatGPT's ability to assess vast amounts of scientific evidence makes it valuable in identifying new drug targets and generating innovative research ideas [102,103].

AI plays a crucial role in drug screening, employing various algorithms such as extreme learning machines, deep neural networks, random forest, support vector machines, and nearest-neighbor classifiers for virtual screening and predicting in vivo toxicity and activity [105,106]. Moreover, AI contributes to vaccine development by analyzing viral proteins to identify immunogenic components, aiding in the design of vaccines eliciting robust immune responses [107]. In the context of the COVID-19 pandemic, AI systems facilitate genomic sequencing of the virus and its variants, aiding in the development of vaccines, drugs, and drug repurposing strategies to combat the spread of the virus [108].

Patient Engagement and Compliance

Patient engagement and compliance represent critical challenges in healthcare, often acting as the final barrier between improved and poor health outcomes. Non-compliance occurs when patients fail to adhere to prescribed treatment regimens or take recommended medications. Studies indicate that highly engaged patients tend to achieve better health outcomes, leading to reduced healthcare utilization, costs, and enhanced patient experiences [109]. However, surveys conducted among healthcare leaders and executives reveal that less than half of patients are actively engaged in their treatment plans [110]. Despite healthcare providers' efforts to develop comprehensive treatment plans tailored to address patients' acute or chronic health issues, adherence to behavioral changes such as weight management, follow-up visits, and treatment adherence remains a significant challenge [109]. To address these challenges, the integration of artificial intelligence (AI) has emerged as a promising approach to enhance patient engagement. Machine learning (ML) algorithms and workflow engines are increasingly being utilized to design tailored interventions across the care continuum [111]. Research in this area focuses on deploying messaging alerts and personalized content to encourage behavior change at critical moments in patient care journeys [109].

Furthermore, studies have demonstrated that leveraging mobile applications and online portals to facilitate communication between patients and healthcare providers can significantly improve engagement rates by more than 60%. Healthcare apps enable patients to store, access, and share their health data securely on cloud platforms, empowering them to monitor their health status anytime, anywhere. These AI-driven apps also offer features such as medical consultations and medication reminders, contributing to improved health outcomes and patient adherence [112]. Additionally, ChatGPT is increasingly being integrated into various healthcare apps to automate tasks such as summarization, note-taking, and report generation, thereby enhancing efficiency and saving time. By assisting patients in symptom checking, appointment scheduling, medication management, and providing educational resources, ChatGPT contributes to patient compliance and the self-management of chronic diseases [91].

Rehabilitation

Artificial intelligence (AI) has revolutionized rehabilitation, encompassing both physical (robotics) and virtual (informatics) realms. Machine learning (ML), a subset of AI, involves sophisticated algorithms that improve with practice, offering precise methods for various applications in rehabilitation. ML techniques find utility in perioperative medicine, brain-computer interface technology, myoelectric control, and symbiotic neuroprosthetics, among others. In the musculoskeletal domain, ML aids in patient data evaluation, clinical decision support, and diagnostic imaging interpretation. Moreover, in therapy sessions, artificial cognitive applications evaluate rehabilitation exercises based on machine signals [113].

Technological advancements in AI and robotics are reshaping rehabilitation research and practice. Smart homes equipped with AI technologies assist residents in daily activities and alert caregivers when assistance is required.

Wearable devices and mobile apps collect data and provide users with personalized health information, enabling them to monitor progress toward rehabilitation goals. Inertial sensors in wearables track exercise adherence, ensuring proper performance and compliance with regimens [114]. Additionally, socially supportive robots aid individuals in recovering from injuries or illnesses, bridging gaps caused by cognitive, motor, or sensory impairments. These technologies enhance functional ability, independence, and overall well-being [114].

Patients with musculoskeletal issues benefit from treatments involving robotic hands for mobilization, although long-term efficacy remains to be demonstrated [119]. AI-enabled robotics monitor patient movements for accuracy and facilitate efficient movement execution [120]. Integrating AI-driven tools like ChatGPT into rehabilitation sessions complements conventional therapy by providing tailored, collaborative assistance. ChatGPT offers exercise recommendations, monitors progress, and engages patients during recovery, assisting stroke or head injury patients in speech and language practice [121]. Moreover, metaverse neurorehabilitation utilizes AI-based systems to enhance rehabilitation outcomes and reduce COVID-19 transmission risk [123,124].

In sports medicine, AI integrated into wearable technologies shows promise for monitoring physiological measurements and improving athlete performance. AI enhances injury prediction models, diagnostic precision, and patient experience quality. However, challenges such as missing data, data security, and patient acceptance hinder widespread adoption of AI in wearables. Patient education on AI's role in healthcare and its limitations is crucial for improving acceptability and adoption rates [129-133].

Administrative Applications

Artificial intelligence (AI) offers solutions to alleviate administrative burdens in healthcare settings by automating tasks such as populating structured data areas from therapeutic notes, retrieving key data from past medical records, and documenting patient encounters [134]. For instance, nurses in the United States spend a significant portion of their working hours on regulatory and administrative duties, which can be reduced through AI-driven solutions like voice text writing [135]. While rule-based systems integrated with electronic health record (EHR) systems are commonly used, ML-based algorithmic systems offer higher accuracy and efficiency [110].

Innovative ML solutions, such as those developed by Amazon, aim to extract valuable information from unstructured EHR data and scientific notes, enhancing data utilization and analysis [68]. Deep neural sequence transduction models like bidirectional encoder representations from a transformer for EHR (BEHRT) enable comprehensive characterization of a patient's clinical history and improve predictive accuracy for various medical conditions [32]. Hierarchical transformer-based models like hierarchical BEHRT (Hi-BEHRT) further enhance risk prediction tasks for patients with complex medical histories [35].

Robotic Process Automation (RPA) finds applications in healthcare functions ranging from clinical records management to revenue cycle administration and claims processing [136]. Chatbots utilizing natural language processing (NLP) serve as interfaces for telehealth services, mental health support, and patient inquiries, facilitating simple transactions like appointment booking and prescription refills [137]. ML technologies enhance payment administration and claims processing by matching data across different platforms, thereby reducing errors and improving efficiency [134].

In clinical settings, hybrid ML-based decision support systems demonstrate superior accuracy in detecting prescribing errors, emphasizing the potential of AI-driven solutions to enhance patient safety [138]. The development of AI tools for clinical pharmacy services, leveraging ML techniques and subsets like NLP and deep learning, shows promise but requires further validation and integration into real-world settings [139]. Pharmacists need to embrace these advancements to optimize patient care while maintaining interpersonal relationships with patients and healthcare teams.

Challenges Faced by AI Utilization in Healthcare

Ethical and Social Challenges

The increasing reliance on artificial intelligence (AI) in healthcare raises several ethical and social concerns, echoing broader issues associated with technology adoption. As AI becomes more effective, questions arise about accountability in decision-making, the potential for erroneous judgments, data authentication, and the protection of sensitive information. Additionally, intrinsic biases in AI training data can lead to unfair outcomes and impact public trust. Ensuring transparency, accountability, and explainability in AI systems is crucial to overcoming these challenges. Explainable artificial intelligence (XAI) techniques aim to make AI decision-making processes transparent and understandable to humans, fostering trust and acceptance. However, challenges remain in addressing data scarcity, biases, and privacy concerns, emphasizing the need for adherence to ethical principles such as beneficence, autonomy, equity, and non-maleficence in AI integration into healthcare systems.

Governance Challenges

Proper governance is essential to address regulatory, ethical, and trust issues associated with the implementation of AI in healthcare. Comprehensive governance structures at both hospital and healthcare system levels are needed to ensure patient safety, clinician confidence, and accountability. National and international regulations, such as the European Union's General Data Protection Regulation (GDPR) and proposed Artificial Intelligence Act (AIA), play a vital role in regulating AI applications in healthcare and mitigating associated risks.

Technical Challenges

Technical challenges in AI utilization in healthcare include the complexity of AI models, the lack of IT infrastructure, and high costs associated with data storage and validity. AI algorithms may suffer from shortcomings such as bias and brittleness, requiring careful consideration of dataset shifts, interpretability, and generalizability. Explainable AI solutions can enhance end-user trust and facilitate widespread adoption. However, healthcare providers must address factors influencing clinicians' perceptions of AI, such as risks, trustworthiness, workload, and training. Ensuring user-friendly AI interfaces and engaging stakeholders in the development process are crucial steps in overcoming technical challenges and promoting the responsible use of AI in healthcare.

Limitations of AI in Healthcare

The utilization of machine learning and deep learning models in healthcare necessitates vast datasets for accurate classification and prediction of various tasks. However, the healthcare sector faces challenges with data accessibility due to patient confidentiality and reluctance among healthcare organizations (HCOs) to share health data. Additionally, once an algorithm is initially trained with data, ongoing access to updated datasets is often hindered by corporate resistance. Moreover, AI-based applications raise concerns related to data security and privacy, as health records are prime targets for hackers during data breaches.

Furthermore, issues such as overfitting, data leakage, and the lack of explainability in deep learning algorithms pose significant challenges. Overfitting occurs when algorithms mistakenly identify spurious correlations between patient characteristics and outcomes, leading to inaccurate predictions. Data leakage describes the phenomenon where algorithms predict occurrences beyond the scope of their training dataset, potentially compromising prediction accuracy. Additionally, the lack of transparency in AI predictions presents legal challenges and may erode public trust in healthcare systems.

The integration of AI in healthcare also raises concerns among the healthcare workforce regarding job displacement and the need for retraining. Moreover, the investment of time and resources required to train healthcare professionals in AI usage adds to the overall cost. Insufficient empirical data validating the efficacy of AI-based interventions in clinical settings further impedes their widespread adoption. Additionally, the reluctance of institutions to implement AI solutions stems from the lack of robust empirical evidence and the perceived quality of research in this area.

Overall, the disadvantages of AI in healthcare include high development costs, potential job displacement, reliance on data quality, and the limitations of AI in reflecting human characteristics such as compassion and creativity.

Conclusions

While AI technologies offer promising solutions for various healthcare challenges, they also face technical, ethical, and governance hurdles. Data security and privacy concerns, coupled with limitations in data quality and AI's inability to replicate human connections, underscore the need for careful consideration of AI implementation in healthcare. Despite these challenges, AI has the potential to enhance healthcare delivery, provided that it aligns with people's interests and addresses technical, ethical, and social considerations. This study contributes to the existing literature by examining the applications of AI in healthcare and highlighting the challenges faced by healthcare professionals in adopting AI technologies.

References:

[1]. Guzman, N. (2023). Advancing NSFW Detection in AI: Training Models to Detect Drawings, Animations, and Assess Degrees of Sexiness. *Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (online)*, *2*(2), 275-294. DOI: https://doi.org/10.60087/jklst.vol2.n2.p294

[2]. Kumar, B. K., Majumdar, A., Ismail, S. A., Dixit, R. R., Wahab, H., & Ahsan, M. H. (2023, November). Predictive Classification of Covid-19: Assessing the Impact of Digital Technologies. In *2023 7th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 1083-1091). IEEE.
Doi: https://doi.org/10.1109/TNNLS.2011.2179810

[3]. Schumaker, R. P., Veronin, M. A., Rohm, T., Boyett, M., & Dixit, R. R. (2021). A data driven approach to profile potential SARS-CoV-2 drug interactions using TylerADE. *Journal of International Technology and Information Management*, *30*(3), 108-142.
DOI: https://doi.org/10.58729/1941-6679.1504

[4]. Schumaker, R., Veronin, M., Rohm, T., Dixit, R., Aljawarneh, S., & Lara, J. (2021). An Analysis of Covid-19 Vaccine Allergic Reactions. *Journal of International Technology and Information Management*, *30*(4), 24-40. DOI: https://doi.org/10.58729/1941-6679.1521

[5]. Dixit, R. R., Schumaker, R. P., & Veronin, M. A. (2018). A Decision Tree Analysis of Opioid and Prescription Drug Interactions Leading to Death Using the FAERS Database. In *IIMA/ICITED Joint Conference 2018* (pp. 67-67). INTERNATIONAL INFORMATION MANAGEMENT ASSOCIATION.
https://doi.org/10.17613/1q3s-cc46

[6]. Veronin, M. A., Schumaker, R. P., Dixit, R. R., & Elath, H. (2019). Opioids and frequency counts in the US Food and Drug Administration Adverse Event Reporting System (FAERS) database: A quantitative view of the epidemic. *Drug, Healthcare and Patient Safety*, 65-70.
https://www.tandfonline.com/doi/full/10.2147/DHPS.S214771

[7]. Veronin, M. A., Schumaker, R. P., & Dixit, R. (2020). The irony of MedWatch and the FAERS database: an assessment of data input errors and potential consequences. *Journal of Pharmacy Technology*, *36*(4), 164-167.
https://doi.org/10.1177/8755122520928

[8]. Veronin, M. A., Schumaker, R. P., Dixit, R. R., Dhake, P., & Ogwo, M. (2020). A systematic approach to'cleaning'of drug name records data in the FAERS database: a case report. *International Journal of Big Data Management*, *1*(2), 105-118.

https://doi.org/10.1504/IJBDM.2020.112404

[9]. Schumaker, R. P., Veronin, M. A., & Dixit, R. R. (2022). Determining Mortality Likelihood of Opioid Drug Combinations using Decision Tree Analysis. https://doi.org/10.21203/rs.3.rs-2340823/v1

[10]. Schumaker, R. P., Veronin, M. A., Dixit, R. R., Dhake, P., & Manson, D. (2017). Calculating a Severity Score of an Adverse Drug Event Using Machine Learning on the FAERS Database. In *IIMA/ICITED UWS Joint Conference* (pp. 20-30). INTERNATIONAL INFORMATION MANAGEMENT ASSOCIATION.

[11]. Dixit, R. R. (2018). Factors Influencing Healthtech Literacy: An Empirical Analysis of Socioeconomic, Demographic, Technological, and Health-Related Variables. *Applied Research in Artificial Intelligence and Cloud Computing*, *1*(1), 23-37.

[12]. Dixit, R. R. (2022). Predicting Fetal Health using Cardiotocograms: A Machine Learning Approach. *Journal of Advanced Analytics in Healthcare Management*, *6*(1), 43-57. Retrieved from https://research.tensorgate.org/index.php/JAAHM/article/view/38

[13]. Dixit, R. R. (2021). Risk Assessment for Hospital Readmissions: Insights from Machine Learning Algorithms. *Sage Science Review of Applied Machine Learning*, *4*(2), 1-15. Retrieved from https://journals.sagescience.org/index.php/ssraml/article/view/68

[14]. Ravi, K. C., Dixit, R. R., Singh, S., Gopatoti, A., & Yadav, A. S. (2023, November). AI-Powered Pancreas Navigator: Delving into the Depths of Early Pancreatic Cancer Diagnosis using Advanced Deep Learning Techniques. In *2023 9th International Conference on Smart Structures and Systems (ICSSS)* (pp. 1-6). IEEE. https://doi.org/10.1109/ICSSS58085.2023.10407836

[15]. Khan, M. S., Dixit, R. R., Majumdar, A., Koti, V. M., Bhushan, S., & Yadav, V. (2023, November). Improving Multi-Organ Cancer Diagnosis through a Machine Learning Ensemble Approach. In *2023 7th International Conference on Electronics, Communication and Aerospace Technology (ICECA)* (pp. 1075-1082). IEEE. https://doi.org/10.1109/ICECA58529.2023.10394923

[16]. Ramírez, J. G. C. (2023). Incorporating Information Architecture (ia), Enterprise Engineering (ee) and Artificial Intelligence (ai) to Improve Business Plans for Small Businesses in the United States. *Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (online)*, *2*(1), 115-127. **DOI:** https://doi.org/10.60087/jklst.vol2.n1.p127

[17]. Ramírez, J. G. C. (2024). AI in Healthcare: Revolutionizing Patient Care with Predictive Analytics and Decision Support Systems. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *1*(1), 31-37. **DOI:** https://doi.org/10.60087/jaigs.v1i1.p37

[18]. Ramírez, J. G. C. (2024). Natural Language Processing Advancements: Breaking Barriers in Human-Computer Interaction. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *3*(1), 31-39. **DOI:** https://doi.org/10.60087/jaigs.v3i1.63

[19]. Ramírez, J. G. C., & mafiqul Islam, M. (2024). Application of Artificial Intelligence in Practical Scenarios. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 14-19. **DOI:** https://doi.org/10.60087/jaigs.v2i1.41

[20]. Ramírez, J. G. C., & Islam, M. M. (2024). Utilizing Artificial Intelligence in Real-World Applications. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 14-19.

DOI: https://doi.org/10.60087/jaigs.v2i1.p19

[21]. Ramírez, J. G. C., Islam, M. M., & Even, A. I. H. (2024). Machine Learning Applications in Healthcare: Current Trends and Future Prospects. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *1*(1). **DOI:** https://doi.org/10.60087/jaigs.v1i1.33

[22]. RAMIREZ, J. G. C. (2023). How Mobile Applications can improve Small Business Development. *Eigenpub Review of Science and Technology*, *7*(1), 291-305. **https://studies.eigenpub.com/index.php/erst/article/view/55**

[23]. RAMIREZ, J. G. C. (2023). From Autonomy to Accountability: Envisioning AI's Legal Personhood. *Applied Research in Artificial Intelligence and Cloud Computing*, *6*(9), 1-16. https://researchberg.com/index.php/araic/article/view/183

[24]. Ramírez, J. G. C., Hassan, M., & Kamal, M. (2022). Applications of Artificial Intelligence Models for Computational Flow Dynamics and Droplet Microfluidics. *Journal of Sustainable Technologies and Infrastructure Planning*, *6*(12). https://publications.dlpress.org/index.php/JSTIP/article/view/70

[25]. Ramírez, J. G. C. (2022). Struggling Small Business in the US. The next challenge to economic recovery. *International Journal of Business Intelligence and Big Data Analytics*, *5*(1), 81-91. https://research.tensorgate.org/index.php/IJBIBDA/article/view/99

[26]. Ramírez, J. G. C. (2021). Vibration Analysis with AI: Physics-Informed Neural Network Approach for Vortex-Induced Vibration. *International Journal of Responsible Artificial Intelligence*, *11*(3). https://neuralslate.com/index.php/Journal-of-Responsible-AI/article/view/77

[27]. Shuford, J. (2024). Interdisciplinary Perspectives: Fusing Artificial Intelligence with Environmental Science for Sustainable Solutions. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *1*(1), 1-12. **DOI:** https://doi.org/10.60087/jaigs.v1i1.p12

[28]. Islam, M. M. (2024). Exploring Ethical Dimensions in AI: Navigating Bias and Fairness in the Field. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *1*(1), 13-17. **DOI:** https://doi.org/10.60087/jaigs.v1i1.p18

[29]. Khan, M. R. (2024). Advances in Architectures for Deep Learning: A Thorough Examination of Present Trends. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *1*(1), 24-30. **DOI:** https://doi.org/10.60087/jaigs.v1i1.p30

[30]. Shuford, J., & Islam, M. M. (2024). Exploring the Latest Trends in Artificial Intelligence Technology: A Comprehensive Review. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1). **DOI:** https://doi.org/10.60087/jaigs.v2i1.p13

[31]. Islam, M. M. (2024). Exploring the Applications of Artificial Intelligence across Various Industries. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 20-25. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p25

[32]. Akter, S. (2024). Investigating State-of-the-Art Frontiers in Artificial Intelligence: A Synopsis of Trends and Innovations. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 25-30. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p30

[33]. Rana, S. (2024). Exploring the Advancements and Ramifications of Artificial Intelligence. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 30-35. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p35

[34]. Sarker, M. (2024). Revolutionizing Healthcare: The Role of Machine Learning in the Health Sector. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 35-48.

DOI: https://doi.org/10.60087/jaigs.v2i1.p47

[35]. Akter, S. (2024). Harnessing Technology for Environmental Sustainability: Utilizing AI to Tackle Global Ecological Challenges. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 49-57. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p57

[36]. Padmanaban, H. (2024). Revolutionizing Regulatory Reporting through AI/ML: Approaches for Enhanced Compliance and Efficiency. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 57-69. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p69

[37]. Padmanaban, H. (2024). Navigating the Role of Reference Data in Financial Data Analysis: Addressing Challenges and Seizing Opportunities. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 69-78. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p78

[38]. Camacho, N. G. (2024). Unlocking the Potential of AI/ML in DevSecOps: Effective Strategies and Optimal Practices. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 79-89. **DOI:** https://doi.org/10.60087/jaigs.v2i1.p89

[39]. PC, H. P., & Sharma, Y. K. (2024). Developing a Cognitive Learning and Intelligent Data Analysis-Based Framework for Early Disease Detection and Prevention in Younger Adults with Fatigue. *Optimized Predictive Models in Health Care Using Machine Learning*, 273. https://books.google.com.bd/books?hl=en&lr=&id=gtXzEAAAQBAJ&oi=fnd&pg=PA273&dq=Developing+a+Cognitive+Learning+and+Intelligent+Data+Analysis-Based+Framework+for+Early+Disease+Detection+and+Prevention+in+Younger+Adults+with+Fatigue&ots=wKUZk_Q0IG&sig=WDlXjvDmc77Q7lvXW9MxIh9Iz-Q&redir_esc=y#v=onepage&q=Developing%20a%20Cognitive%20Learning%20and%20Intelligent%20Data%20Analysis-Based%20Framework%20for%20Early%20Disease%20Detection%20and%20Prevention%20in%20Younger%20Adults%20with%20Fatigue&f=false

[40]. Padmanaban, H. (2024). Quantum Computing and AI in the Cloud. *Journal of Computational Intelligence and Robotics*, *4*(1), 14–32. Retrieved from https://thesciencebrigade.com/jcir/article/view/116

[41]. Sharma, Y. K., & Harish, P. (2018). Critical study of software models used cloud application development. *International Journal of Engineering & Technology, E-ISSN*, 514-518. https://www.researchgate.net/profile/Harish-Padmanaban-2/publication/377572317_Critical_study_of_software_models_used_cloud_application_development/links/65ad55d7ee1e1951fbd79df6/Critical-study-of-software-models-used-cloud-application-development.pdf

[42]. Padmanaban, P. H., & Sharma, Y. K. (2019). Implication of Artificial Intelligence in Software Development Life Cycle: A state of the art review. *vol*, *6*, 93-98. https://www.researchgate.net/profile/Harish-Padmanaban-2/publication/377572222_Implication_of_Artificial_Intelligence_in_Software_Development_Life_Cycle_A_state_of_the_art_review/links/65ad54e5bf5b00662e333553/Implication-of-Artificial-Intelligence-in-Software-Development-Life-Cycle-A-state-of-the-art-review.pdf

[43]. Harish Padmanaban, P. C., & Sharma, Y. K. (2024). Optimizing the Identification and Utilization of Open Parking Spaces Through Advanced Machine Learning. *Advances in Aerial Sensing and Imaging*, 267-294. **https://doi.org/10.1002/9781394175512.ch12**

[44]. PC, H. P., Mohammed, A., & RAHIM, N. A. (2023). *U.S. Patent No. 11,762,755*. Washington, DC: U.S. Patent and Trademark Office. https://patents.google.com/patent/US20230385176A1/en

[45]. Padmanaban, H. (2023). Navigating the intricacies of regulations: Leveraging AI/ML for Accurate Reporting. *Journal of Knowledge Learning and Science Technology ISSN: 2959-6386 (online)*, *2*(3), 401-412. DOI: https://doi.org/10.60087/jklst.vol2.n3.p412

[46]. PC, H. P. Compare and analysis of existing software development lifecycle models to develop a new model using computational intelligence. https://shodhganga.inflibnet.ac.in/handle/10603/487443

[47]. Camacho, N. G. (2024). Unlocking the Potential of AI/ML in DevSecOps: Effective Strategies and Optimal Practices. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *2*(1), 79-89. DOI: https://doi.org/10.60087/jaigs.v2i1.p89

[48]. Camacho, N. G. (2024). The Role of AI in Cybersecurity: Addressing Threats in the Digital Age. *Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023*, *3*(1), 143-154.

DOI: https://doi.org/10.60087/jaigs.v3i1.75

[49]. Islam, M. S., Ahsan, M. S., Rahman, M. K., & AminTanvir, F. (2023). Advancements in Battery Technology for Electric Vehicles: A Comprehensive Analysis of Recent Developments. *Global Mainstream Journal of Innovation, Engineering & Emerging Technology*, *2*(02), 01-28.

https://doi.org/10.62304/jieet.v2i02.63

[50]. Ahsan, M. S., Tanvir, F. A., Rahman, M. K., Ahmed, M., & Islam, M. S. (2023). Integration of Electric Vehicles (EVs) with Electrical Grid and Impact on Smart Charging. *International Journal of Multidisciplinary Sciences and Arts*, *2*(2), 225-234.

https://doi.org/10.47709/ijmdsa.v2i2.3322

[51]. Rahman, M. K., Tanvir, F. A., Islam, M. S., Ahsan, M. S., & Ahmed, M. (2024). Design and Implementation of Low-Cost Electric Vehicles (Evs) Supercharger: A Comprehensive Review. *arXiv preprint arXiv:2402.15728*.

https://doi.org/10.48550/arXiv.2402.15728