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Integrating AI with Green Internet of Things in Healthcare for Achieving UN's SDGs

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Abstract- The integration of the Green Internet of Things (Green-IoT) and Artificial Intelligence (AI) in healthcare has the potential to revolutionize a wide range of industries, including healthcare wherein Green-IoT-connected medical devices and wearables can collect health data, which can be analyzed by AI algorithms to improve patient outcomes and support better decision-making by healthcare professionals. The convergence of AI and IoT in the field of smart health coupled with machine learning algorithms are enabling new and innovative solutions for healthcare delivery and management. AI algorithms and machine learning techniques can be used to analyze vast amounts of data generated by IoT devices, such as wearable devices, sensors, and smart home health devices, to provide insights into patient health and well-being. This research presents a review of patients' healthcare services. Particularly, we first give an overview of essential parameters of patients' healthcare services through Green-IoT-enabled sensor technologies under the use case scenario. We then present a basic architecture for IoT-based healthcare systems considering key requirements in the light of the UN's Sustainable Development Goals discussing their strengths and weaknesses in the context of the framework for patients' healthcare services. Finally, we explored various security threats for AI-based architecture and their solutions with a comprehensive methodology to design robust and resilient patients healthcare services system needed in the context of the UN's sustainable development goals.

Keywords- *Artificial Intelligence, Green IoT, Healthcare, UN's SDGs*

1. Introduction

The merger of AI and IoT in the field of smart health has the potential to transform healthcare management and delivery, improving patient outcomes and improving system efficiency. The world requires to achieve universal health coverage and a high standard of healthcare to foster both mental and physical wellness and well-being and to improve longevity for all. The Sustainable Development Goals (SDGs) of the United Nations attempt to ensure by 2030 that all individuals have equitable access to strong health care, including family planning, knowledge and instruction, and the inclusion of reproductive health in state plans and legislations {1,2,3]. The UN SDGs seeks to ensure that everyone can live a healthy life by putting an emphasis on prevention, treatment, and widespread availability of vital medical services and medications. The Sustainable Development Goals of the UN. The United Nations' Sustainable Development Goals (SDGs) include several targets related to quality healthcare, which are collectively referred to as SDG 3: Ensure healthy lives and promote well-being for all at all ages [3]. By allowing quicker and more precise diagnoses, enhancing treatment results, and lowering healthcare costs, AI algorithms have the potential to revolutionize healthcare. Medical imaging, clinical decision-making, drug development, and personalized medicine are some of the common AI algorithms used in healthcare. In addition, Machine Learning (ML) is being used in many areas of healthcare to improve diagnoses, treatment, and patient outcomes. Popular examples of how machine learning is being used in healthcare are Disease diagnosis, Drug discovery, Clinical decision-making, Patient monitoring and Resource optimization. Machine learning (ML)

is a type of artificial intelligence (AI) that involves training computer algorithms to learn from data and improve their performance over time.

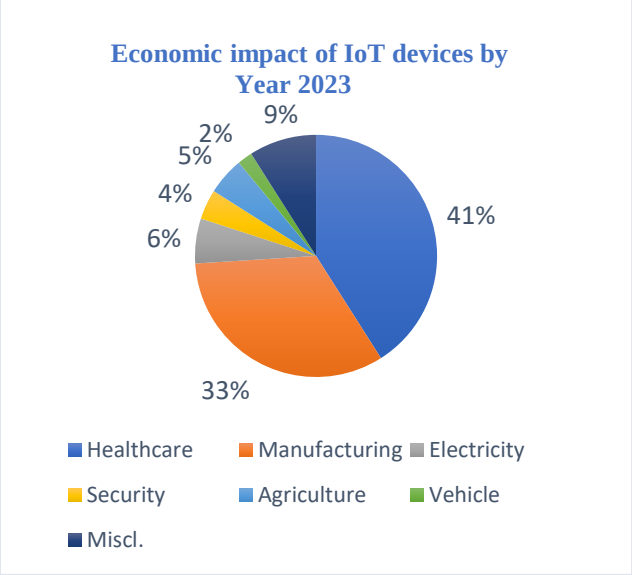

Figure 1: Economic impact of IoT devices by Year 2023

Green IoT (Internet of Things) in healthcare refers to the use of IoT technologies to improve sustainability and reduce energy consumption in healthcare facilities. Popular examples of how green IoT can be used in healthcare are Energy management, Lighting control, Water management, Waste management and Telemedicine. The share of economic impact of green-IoT on global economy until year 2023 is approximately 41% as shown in Figure 1. By using green IoT technologies in healthcare, healthcare facilities can reduce their environmental footprint, save energy, reduce costs, and improve the sustainability of healthcare delivery. However, it is important to ensure that the use of IoT technologies does not compromise patient safety or privacy. It is also important to ensure that IoT devices are properly maintained and disposed of at the end of their lifecycle to minimize their environmental impact.

2. Evolution of Healthcare Systems

In the evolution of modern and current healthcare system building, the previous four stages of healthcare development are [5, 6]:

- **Healthcare 1.0**: The era of traditional medicine, where healthcare providers provided healthcare on a one-to-one basis.
- **Healthcare 2.0**: The era of mass production and specialization, where healthcare was provided using standardized processes and procedures.
- **Healthcare 3.0**: The era of patient engagement and population health management, where healthcare providers began to focus on preventing illness and promoting health.
- **Healthcare 4.0**: The era of digital health, where healthcare providers began to use digital technologies, such as electronic health records (EHRs) and telemedicine, to improve healthcare delivery.
- **Healthcare 5.0** (aka healthcare 5.0) [7, 8] is seen as the next step in the evolution of healthcare. Healthcare 5.0 is a term used to describe the future of healthcare, which is expected to be characterized by the integration of advanced technologies, including artificial intelligence (AI), robotics, the Internet of Things (IoT), and 3D printing. This new era of healthcare is envisioned as being patient-centric, data-driven, and highly personalized.

- Healthcare 5.0 is expected to build on the foundations of these previous eras, using advanced technologies to further personalize healthcare and make it more accessible and affordable for patients. Some of the key features of Healthcare 5.0 include [7, 8]:
- **Personalized Medicine**: Healthcare 5.0 is expected to enable the use of patient-specific data and AI algorithms to tailor treatments to individual patients, improving treatment outcomes and reducing costs.
- **Remote Care**: Healthcare 5.0 is expected to enable the use of telemedicine and remote monitoring technologies to enable patients to receive care from anywhere, reducing the need for in-person visits and improving access to care.
- Smart hospitals: Healthcare 5.0 is expected to enable the use of IoT devices and sensors to monitor patient health and optimize hospital processes, improving patient outcomes and reducing costs.
- **Augmented Reality**: Healthcare 5.0 is expected to enable the use of augmented reality technologies to enhance medical education and training, as well as improve surgical outcomes.

Overall, Healthcare 5.0 [7] is expected to usher in a new era of healthcare that is more efficient, effective, and patient-centered, leveraging advanced technologies to transform the way healthcare is delivered and experienced.

3. Merger of AI with Green-IoT in Healthcare Systems to achieve SDGs

The Sustainable Development Goals (SDGs) of the United Nations are a collection of 17 worldwide objectives that were ratified by the UN General Assembly in 2015 as a component of the 2030 Agenda for Sustainable Development [3]. The SDGs seek to address some of the world's most pressing issues, such as poverty, inequality, climate change, and lack of access to health care and education. By doing so, they hope to end poverty, protect the environment, and guarantee prosperity for all. A framework for tracking progress towards each SDG's accomplishment is provided by the collection of targets and indicators that make up each one. The SDGs are intended to be universal, integrated, and indivisible, which means that the accomplishment of one objective depends on the accomplishment of others. All nations are urged to take action by the goals. Integrating Internet of Things (IoT) and Artificial Intelligence (AI) technologies [9,10,11] is a promising development that is transforming the way organizations operate and interact with the world around them. IoT provides a vast network of connected devices that can collect and transmit large amounts of data, while AI can analyze and make sense of that data, uncovering new insights and opportunities.

Green IoT refers to the development and deployment of Internet of Things (IoT) technologies and solutions that prioritize environmental sustainability and minimize their environmental impact. This includes reducing the carbon footprint of IoT devices and networks, as well as using IoT technology to monitor and mitigate environmental issues such as pollution and resource consumption mapping SDG 3. The growth of IoT has been accompanied by a significant increase in energy consumption and electronic waste, which can have negative impacts on the environment. To address these challenges, Green IoT focuses on developing IoT devices and networks that are energy-efficient, use sustainable materials and resources, and are designed for recyclability and end-of-life management [9,10,11]. Examples of Green IoT include:

- **Energy-efficient IoT devices**: IoT devices that have been designed to be energy-efficient, reducing the amount of energy consumed and extending the life of the device.
- **Smart Grid and Renewable Energy**: IoT-enabled smart grids that optimize energy consumption and promote the use of renewable energy sources such as solar, wind, and hydro.
- **Sustainable Materials**: The use of sustainable materials in the production of IoT devices, such as biodegradable plastics, recycled metals, and low-carbon materials.
- **Environmental Monitoring**: IoT-enabled environmental monitoring systems that can detect and track environmental changes and help organizations take action to mitigate their impact.

By incorporating environmentally sustainable practices into IoT development and deployment, Green IoT has the potential to play a significant role in mitigating the impact of technology on the environment, while also helping organizations to achieve their sustainability goals.

- **Manufacturing**: IoT-enabled sensors and devices can be used to monitor and control industrial processes, while AI algorithms can analyze data from these devices to optimize operations, reduce waste, and improve efficiency.
- **Smart Cities**: IoT-connected devices and sensors can be used to monitor and manage a range of urban services, including traffic, energy, and waste management. AI algorithms can analyze the data generated by these devices to improve the sustainability and livability of cities.
- **Agriculture**: IoT-enabled sensors and devices can be used to monitor crop health, soil moisture, and other environmental factors. AI algorithms can analyze this data to optimize crop growth, reduce waste, and improve yields.

Some examples of AI and IoT convergence in smart health include:

- **Predictive maintenance of medical devices** - AI algorithms can be used to analyze data from IoT connected medical devices to predict when they may need maintenance or repair, reducing downtime and increasing patient safety.
- **Wearable devices** - Wearable devices, such as fitness trackers, smartwatches, and heart rate monitors, can collect and transmit data about a person's health, activity, and sleep patterns to healthcare providers, enabling them to monitor patients remotely and make informed treatment decisions.
- **Remote patient monitoring** - IoT connected devices can be used to monitor patients in their homes, providing healthcare providers with real-time data about their health, reducing the need for in-person visits and enabling early detection of health issues.
- **Clinical decision support** - AI algorithms can be used to analyze patient data from IoT connected devices and electronic health records to provide physicians with real-time insights and recommendations, improving the accuracy and speed of clinical decision-making.

By combining the vast data-gathering capabilities of IoT with the powerful analysis and decision-making capabilities of AI, organizations can gain new insights, improve efficiency, and create new business opportunities. However, it is important to note that the integration of IoT and AI also raises important ethical and privacy considerations, as well as the need for secure and reliable data networks. AI-based healthcare modeling involves the use of artificial intelligence (AI) algorithms and models to analyze medical data and make predictions about patient outcomes, disease diagnosis, and treatment options. AI-based healthcare modeling is becoming increasingly popular due to the growing availability of medical data and the development of advanced AI algorithms. The main benefit of AI-based healthcare modeling is that it can enable more accurate and personalized diagnosis and treatment options. AI algorithms can analyze large amounts of medical data and identify patterns and insights that may not be visible to human clinicians. This can lead to diagnoses that are more accurate and personalized treatment plans, which can improve patient outcomes and reduce healthcare costs.

One example of AI-based healthcare modeling is the use of deep learning algorithms for medical image analysis. Deep learning algorithms can analyze medical images, such as MRI scans or X-rays, and identify patterns and anomalies that may be indicative of disease. This can help clinicians make diagnoses that are more accurate and develop personalized treatment plans.

Another example of AI-based healthcare modeling is the use of predictive modeling for disease diagnosis and patient outcomes. Predictive modeling algorithms can analyze medical data, such as patient demographics, medical history, and lab results, and make predictions about disease progression and patient outcomes. This can help clinicians develop personalized treatment plans that are tailored to the individual patient's needs.

However, there are also some challenges and limitations associated with AI-based healthcare modeling. One challenge is the need for high-quality, standardized medical data to train the AI algorithms. Another challenge is the need for transparency and ability to explain in the AI models, so that clinicians can understand how decisions are made and can ensure that the models are making ethical and unbiased decisions.

3.1 Strengths and Weaknesses of Current AI and Green-IoT Healthcare Systems

Current Healthcare Systems such as 4G and 5G have the significant potential to revolutionize healthcare by enabling faster and more reliable data transfer, remote monitoring, and real-time communication between healthcare providers and patients. Here are some of the strengths and weaknesses of 5G healthcare systems:

Strengths:

- **Faster data transfer speeds**: 5G networks can provide data transfer speeds up to 100 times faster than 4G networks, which can enable real-time communication and high-resolution video streaming for telemedicine applications.
- **Low latency**: 5G networks have ultra-low latency, which can enable real-time monitoring and control of medical devices and enable remote surgeries and other procedures that require real-time feedback.
- **Improved connectivity**: 5G networks can support a massive number of connected devices, which can enable real-time health monitoring, and data collection from wearables and other sensors.
- **Remote patient monitoring**: 5G networks can enable real-time remote patient monitoring, which can improve patient outcomes and reduce healthcare costs by allowing healthcare providers to identify potential issues before they become critical.
- **Improved healthcare accessibility**: 5G networks can improve healthcare accessibility for patients in remote or underserved areas, as well as for patients with limited mobility or transportation options.

Weaknesses:

- **Limited coverage**: 5G networks are still in the early stages of deployment and are not yet widely available, which can limit their use in some areas.
- **High cost**: The development and deployment of 5G networks can be costly, which can limit their use in some healthcare applications.
- **Data security concerns**: As with any network-based technology, 5G networks can be vulnerable to cyberattacks and data breaches, which can compromise patient data and privacy.
- **Regulatory challenges**: The development and deployment of 5G networks can be subject to regulatory challenges, which can slow down their adoption in some areas.
- **Interference issues**: 5G networks operate at higher frequencies than previous generations of wireless networks, which can make them more susceptible to interference from other wireless devices and materials.

In summary, 5G healthcare systems have the potential to significantly improve healthcare accessibility, patient outcomes, and reduce healthcare costs, but there are also challenges including limited coverage, high costs, and data security concerns.

3.2 XAI in Healthcare 5.0

XAI stands for Explainable Artificial Intelligence. XAI in healthcare 5.0 refers to the use of explainable AI technologies in the next generation of healthcare to enable more personalized, precise, and efficient care [12,13]. XAI or sometimes EXAI and Healthcare 5.0 is a term used to describe the next generation of healthcare that leverages advanced technologies such as AI and machine learning. Figure 2 shows structure of Explainable Artificial Intelligence. In the context of healthcare, XAI refers to AI systems that can provide clear and understandable explanations for their decisions and actions. This is important for ensuring transparency, accountability, and trust in AI-powered healthcare applications [12,13].

XAI is especially relevant for applications such as clinical decision support systems, medical imaging analysis, and drug discovery. XAI in healthcare refers to the development of AI models and systems that are transparent, interpretable, and explainable in their decision-making processes.

In healthcare, it is important that AI systems are not only accurate and reliable, but also transparent and explainable, so that medical professionals and patients can understand how decisions are made. XAI in healthcare is becoming increasingly important as the use of AI in healthcare applications, such as clinical decision support systems, medical image analysis, and drug discovery, becomes more prevalent.

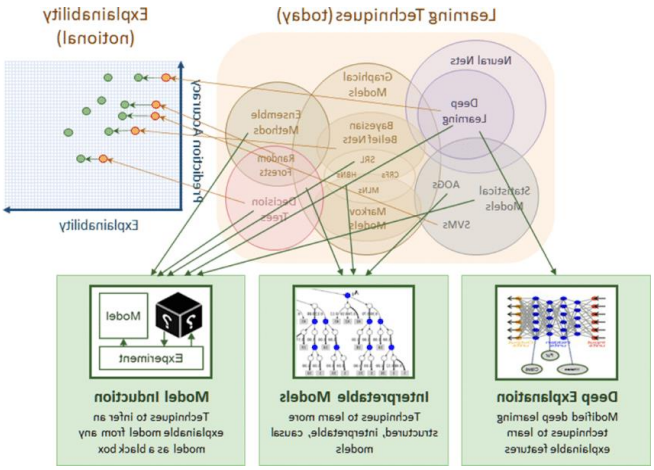

Figure 2: Explainable Artificial Intelligence (XAI) [12]

3.3 AI Models and Algorithms used in Healthcare Systems

The ability to explain the reasoning behind AI-based decisions can help build trust and acceptance among medical professionals, regulators, and patients. There are several techniques used to make AI models more explainable in healthcare, such as using decision trees, rule-based systems, and model visualization techniques. One common approach is to use "feature importance" methods, which help identify the key variables that are driving the AI model's predictions. XAI in healthcare has the potential to improve patient outcomes [12,13], reduce medical errors, and increase efficiency in the healthcare industry. It can help medical professionals make more informed decisions by providing insights into the AI models' decision-making processes and enable patients to better understand the reasoning behind their diagnosis and treatment plans.

There are many AI models and algorithms used in healthcare systems. Here are some examples:

- **Deep Learning**: This is a type of neural network that can learn to recognize patterns in large datasets. In healthcare, deep learning algorithms are used for medical image analysis, natural language processing, and predicting patient outcomes.
- **Convolutional Neural Networks (CNNs)**: These are a type of deep learning algorithm that are particularly useful for image analysis. CNNs are often used to analyze medical images, such as X-rays or CT scans.
- **Recurrent Neural Networks (RNNs)**: These are a type of deep learning algorithm that are useful for analyzing time series data, such as patient vital signs. RNNs are often used for predicting patient outcomes, such as hospital readmissions or mortality.
- **Support Vector Machines (SVMs)**: These are a type of machine learning algorithm that are useful for classification tasks. In healthcare, SVMs are often used for disease diagnosis or predicting patient outcomes.
- **Decision Trees**: These are a type of machine learning algorithm that can be used to make decisions based on a set of rules. In healthcare, decision trees are often used for clinical decision support, such as identifying the best treatment options for a particular patient.
- **Random Forests**: These are an extension of decision trees, where multiple trees are trained on different subsets of the data to improve accuracy. In healthcare, random forests are often used for disease diagnosis or predicting patient outcomes.

4. Key Network Requirements for a Robust, Secure and Resilient Healthcare System

Currently 5G Communication Networks are developing for a robust healthcare system. The development of 6G networks is still in the early stages, and it is difficult to predict exactly what the requirements of a 6G healthcare system would be. A 6G healthcare system would require ultra-fast data transfer speeds, low latency, high reliability, massive connectivity, edge computing capabilities, and advanced privacy and security mechanisms to enable real-time health monitoring, remote surgeries, and personalized medicine that are summarized as under:

- **Ultra-fast data transfer speeds**: 6G networks are expected to offer data transfer speeds that are 100 times faster than 5G networks, which could enable real-time, high-resolution video streaming for telemedicine applications and remote surgical procedures.
- **Low latency**: 6G networks are expected to have ultra-low latency, which could enable remote surgeries and other procedures that require real-time feedback and control.
- **High reliability**: Healthcare systems require high levels of reliability to ensure patient safety and data security. 6G networks will need to be designed with high levels of redundancy and failover mechanisms to ensure continuous operation.
- **Massive connectivity**: 6G networks will need to support a massive number of connected devices, sensors, and wearables to enable real-time health monitoring and data collection.
- **Edge computing capabilities**: 6G networks will need to support advanced edge computing capabilities, which could enable real-time analysis of medical data and support the development of personalized medicine.
- **Privacy and security**: Healthcare systems require high levels of privacy and security to protect patient data. 6G networks will need to have advanced encryption and authentication mechanisms to ensure secure data transmission and storage.

5. Results and Discussion

The seven privacy by design concepts were taken into account during the design phase while also taking into account the cyber threats for AI-based infrastructures, as shown in Figure 3. Privacy by Design (PbD) is a framework that aims to embed privacy considerations into the design and operation of technology, processes, and systems.

These seven key principles of Privacy by Design require anticipating and addressing privacy issues before they become problems, rather than trying to fix them after the fact and more importantly calls for privacy to be the default setting, meaning that individuals' personal information should not be collected, used, or shared unless they explicitly give their consent. It requires that privacy protections be implemented throughout the entire lifecycle of data, including storage, use, and disposal, to ensure that personal information is kept secure and confidential. In this context, we performed Green-IoT and AI market analysis till the year 2022 as shown in Figure 4.

Figure 3: Seven Privacy by Design Principles [13].

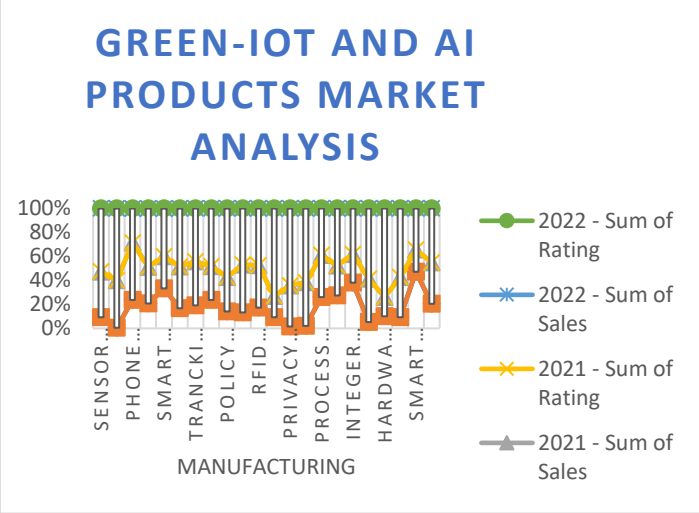

Figure 4: Market Analysis of Green-IoT and AI devices by 2022

6. Conclusion

The key components of healthcare have been examined in this review paper in the context of Green IoT and AI technologies with an eye towards achieving the UN's Sustainable Development Goals. A strong AI-based healthcare system using 5G and 6G technologies has been suggested using the XAI framework. The global consumer market is experiencing a significant shift in IT-based services, and a positive market analysis of green IoT and AI devices indicates that these technologies will likely experience significant growth and effect in the years to come. Along with 6G networking and communication technology enablers, deep learning, convolutional neural networks, and machine learning are key AI algorithms required to be merged with smart and wearable sensors to achieve targets set for achieving UN's Sustainable Development Goals for robust healthcare system.

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