Convergence of Artificial Intelligence and IoT: A Boom

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Abstract:

The merging of Artificial Intelligence (AI) and Internet of Things (IoT) forms a revolutionary partnership that is reshaping industries and influencing our global landscape. To begin with, it delves into the intricate dynamics between these two innovations, unveiling their mutually beneficial connection. With capabilities ranging from data collection and real-time decision making to predictive analysis and energy conservation, AI processes the extensive data generated by IOT devices, transforming it into valuable insights. This collaboration extends to healthcare, security, and other domains, as AI-empowered IoT devices facilitate remote patient monitoring and proactive threat identification. Nevertheless, ethical and privacy considerations arise as these technologies remodel our existence.

Moving onto the essential domains where AI and IoT intersect, fostering ingenuity throughout industries. Customized AI-generated insights enhance smart home automation, industrial IoT, and healthcare, whereas transportation, agriculture, and energy administration profit from refined resolutions. This collaboration further reaches into realms like entrainment and education, crafting immersive encounters and tailored learning trajectories. Nonetheless, assuming data privacy and upholding ethical concerns proves to be a hurdle. The fusion of Ai and IoT presents the potential to mold a more intelligent and effective world, necessitating a meticulous equilibrium between pioneering advancement and ethical duty.

Keywords: Back Propagation Neural Network (BPNN), multi-objective CSA, internet of medical things (IoMT), high dimensional LDA, hybrid ResNet 18, GoogLeNet classifier.

1. Introduction

The synergy between the Internet of Things (IoT) and Artificial Intelligence (AI) presents an opportunity to reshape industries and enhance our everyday experiences. This article deals the way in which IoT and AI converge and mutually benefit one another. The following points will give insights about converge of both.

1.1 Data Collection and Connectivity

The essence of IoT lies in the interconnection of ordinary devices with the internet, facilitating their communication and interaction. These interconnected devices generate extensive data, which holds significant value in deciphering user patterns, environmental cues, and other relevant aspects. The utilization of AI involves processing and comprehending this data, subsequently transforming it into meaningful and practical insights.

Ensuring the security of IoT networks has gained significant importance with the emergence of Internet of Things (IoT) technology. The integrity of these networks is susceptible to various threats and anomalies, motivating the exploration of intrusion detection systems (IDS) for predicting and identifying potential breaches. Timely identification of malicious activities holds the potential to avert data compromise within the IoT framework. The focal point of this study is the development of energy-efficient machine learning models driven by artificial intelligence. These models aim to discern and flag potential attacks targeting IoT networks. Constructing such models necessitates the accumulation of both normal and attack data from the IoT environment. Among the prospective approaches, the Bayesian Network, Artificial Neural Network, and Support Vector Machine are recognized for their promise. The application of a conventional three-layer Artificial Neural Network is examined using actual data encompassing roundtrip time and power consumption metrics [1].

1.2 Real-time Decision Making

Through the amalgamation of AI algorithms into IoT devices or at the network's edge, intelligent systems gain the ability to process real-time data and autonomously arrive at decisions. A prime illustration is the utilization of AI-driven sensors within a smart urban environment. These sensors can monitor traffic movement and, in response, dynamically adapt traffic signals to optimize the overall flow of vehicular movement.

An innovative framework that harnesses the capabilities of smartphone sensors is introduced to detect COVID-19 which offers an economical solution, leveraging the fact that many radiologists already possess smartphones for their daily activities. Furthermore, this framework is accessible for general users on their personal smartphones, capitalizing on the powerful computational processors, ample memory space, and diverse array of sensors, including cameras, microphones, temperature, inertial sensors, proximity sensors, color sensors, humidity sensors, and wireless chipsets. Central to this initiative is an Artificial Intelligence (AI)-enhanced framework that interprets signal measurements from smartphone sensors to predict the severity of pneumonia and forecast disease outcomes. This novel approach has the potential to revolutionize COVID-19 detection, making it more affordable and accessible to a broader spectrum of users. [2]

1.3 Predictive Analytics

AI and ML facilitate IoT devices in acquiring insights from past data and projecting future occurrences or patterns. This anticipatory aptitude holds significant importance in diverse sectors, including but not limited to foreseeing machinery malfunctions within industrial environments, preempting maintenance requirements, and predicting consumer actions.

A fog/cloud-based framework has been developed for the efficient administration of ocean data and the continuous surveillance of marine conditions. This innovative approach involves the incorporation of a fog layer, which employs a numerical gradient-centered technique to enhance data refinement, along with an enhanced algorithm rooted in evidence theory. This algorithm facilitates the fusion of data from multiple sensors, leading to decreased data volume and heightened data precision. Meanwhile, in the cloud layer, a predictive model utilizing BPNN has been integrated. The creators contend that this framework holds the potential to enhance data utilization efficiency, accelerate ocean data processing, and minimize time delays [3].

1.4 Energy Efficiency and Resource Optimization

Artificial Intelligence has the capability to enhance energy efficiency within IoT systems by analyzing data patterns and adapting device operations correspondingly. This results in optimized resource utilization and a decreased ecological footprint. Incorporating emerging technologies like IoT and artificial intelligence into the power grid system facilitates several advancements:

a. The creation of an intelligent decision support system for enhancing electricity distribution networks. This enables remote real-time monitoring of energy consumption status, empowering the management of energy usage and aligning it with consumer requirements.

b. Detection of irregular patterns in electricity consumption or generation, promoting proactive management of such anomalies.

c. Intelligent prediction of future electricity demand and energy consumption, leveraging data from smart meters to make informed forecasts.

The utilization of AI within edge-based smart grids can be segmented into three primary classifications: load/demand forecasting, demand-side management, and load-anomaly detection.

A structure earns the "smart" designation when its automated control systems utilize data to enhance design efficiency and occupants' comfort. Integrating AI into IoT-connected devices and structures can yield notable improvements in resident satisfaction, operational efficiency, and asset utilization. This integration facilitates the seamless amalgamation of excess data from IoT sensors and occupant behavior into building systems, generating insights, refining operations, and enhancing environmental efficiency. This endeavor aims to enhance environmental performance, uncover novel insights and streamline processes [4].

A strategy is established to ensure the least possible delay between hops and to prevent interference, all aimed at optimizing network efficiency. The central node assigns licensed channels to energy-harvesting-enabled IoT devices, considering factors such as network utility, energy harvesting capabilities, and energy sustainability. The study delves into the optimization of utility and minimal delay, a challenge decomposed into four distinct deterministic sub-problems: device battery management, data discard control, sampling rate control, and interference-free channel allocation. To tackle these, Lyapunov Optimization techniques are employed. Ultimately, an effective online algorithm is introduced, prioritizing network utility through minimal power allocation to central nodes, all while maintaining optimal data transmission speeds on optical channels [5].

1.5 Healthcare and Remote Monitoring

IoT devices equipped with AI capabilities have the potential to transform the healthcare sector by enabling remote patient monitoring, early detection of health issues, and supporting medical professionals in making well-informed decisions. In figure-1, the cloud system serves as a bridge between the medical facility and patients. Utilizing wireless sensor networks, smartphones, and various digital devices, real-time health updates and risk assessments can be transmitted through the cloud network. When a patient's health metrics fall below the benchmark values stored in a lookup table, an automated alert message is generated and sent to the designated physician, all facilitated by the cloud system. Using the E-healthcare patient monitoring system initially, patient data was obtained from sensors attached to the patient's body. This data was then transmitted via gateway or Wi-Fi and stored in the IoMT cloud repository. The stored data was preprocessed to remove noise, and relevant features were extracted using high-dimensional Linear Discriminant Analysis (LDA).

The most optimal features were chosen using a reconfigured Multi-objective Cuckoo Search Algorithm (CSA). Subsequently, a Hybrid ResNet 18 and GoogleNet classifier were employed to predict whether the data was normal or abnormal. Based on this prediction, a decision-making system determined whether an alert needed to be sent. If an anomaly was detected in the predicted data, an alert would be dispatched to hospital or healthcare personnel for further action [6].

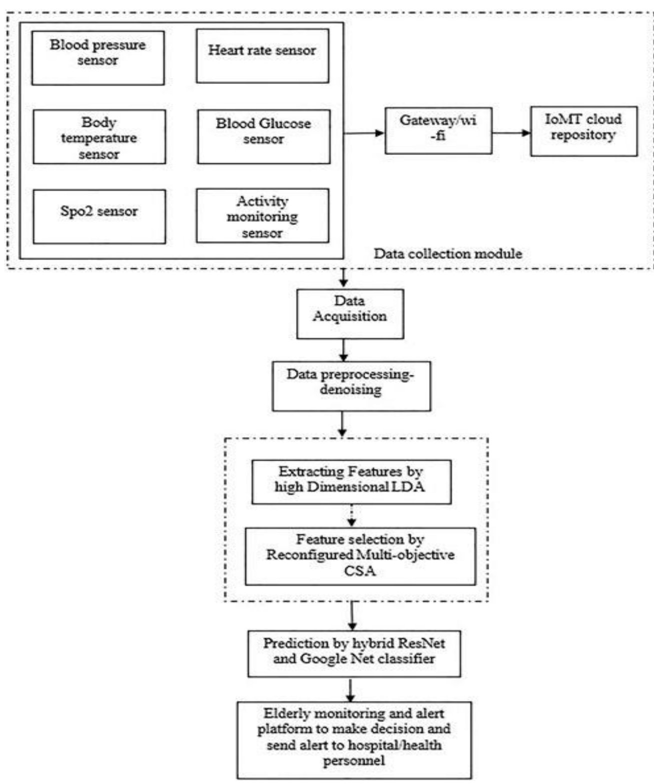

Figure.1: E-healthcare patient monitoring system [6]

1.6 Industrial Automation

The fusion of AI and IoT within industrial environments can result in the development of intelligent factories featuring automated operations, predictive maintenance, and streamlined production workflows.

Industry 4.0 encompasses digitized manufacturing facilities where numerous sensors gather extensive data. This data is harnessed to enhance production sustainability through activities like optimizing process variables, minimizing machine downtime, and reducing material wastage. However, the ability to make intelligent data-driven decisions promptly necessitates integrating time-sensitive networks with dependable data intake and processing systems that seamlessly support Machine Learning (ML) pipelines. Nonetheless, this integration is challenging due to the absence of flexible frameworks that amalgamate and program networking and computational infrastructures while enabling ML pipelines to assimilate collected data and make credible real-time decisions. In this paper, we introduce AIDA, an innovative comprehensive network and processing framework propelled by AI for dependable real-time industrial IoT applications. AIDA effectively manages and configures Time-Sensitive Networks (TSN) to enable real-time data acquisition within an observable AI-powered edge/cloud continuum. AIDA incorporates pluggable and reliable ML components that execute timely decisions for various industrial IoT applications while being an integral part of the infrastructure itself. Figure-2, illustrates the complete structure featuring the elements and linkages [7].

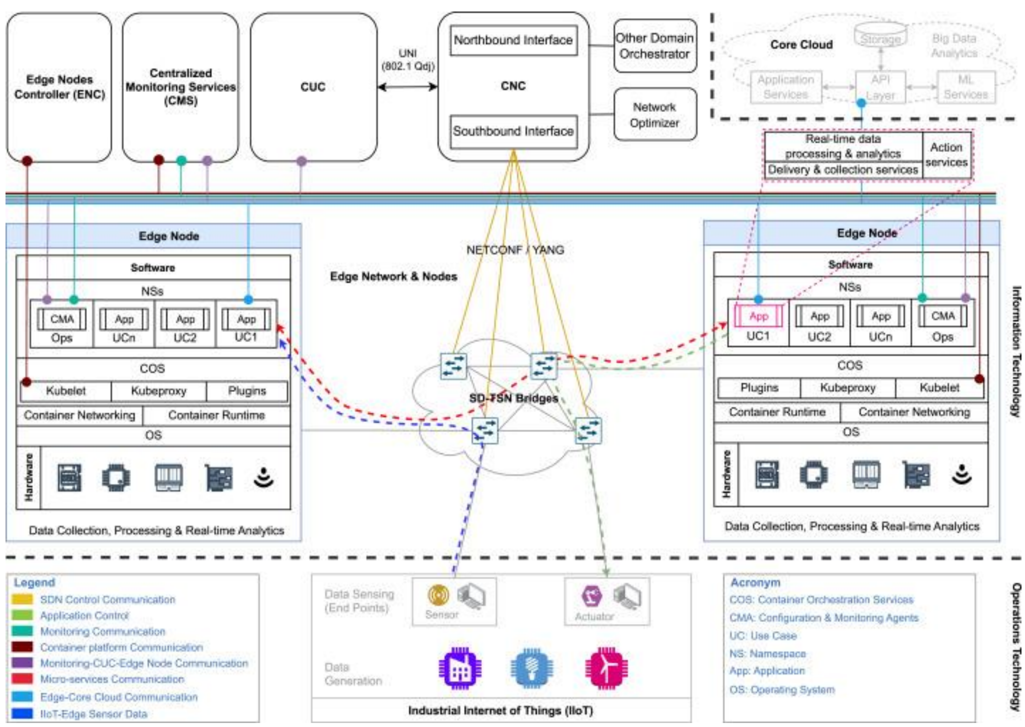

Figure.2: Overall AI-driven networking and processing (AIDA) architecture. [7]

2. Key application areas where AI and IoT converge

The combination of Artificial Intelligence (AI) and the Internet of Things (IoT) has a wide range of application areas that can significantly impact various industries and aspects of our daily lives. Here are some key application areas where AI and IoT converge:

Smart and Secure Home Automation: AI-powered IoT devices enable intelligent control of home appliances, lighting, heating, and security systems, making homes more energy-efficient, secure, and convenient. IoT-enabled devices with AI ensure the security of home.

Industrial Internet of Things (IIoT): AI and IoT are transforming industries by optimizing production processes, predictive maintenance, and improving overall efficiency in manufacturing and supply chain management. It helps to improve the business globally.

Healthcare and Remote Monitoring: IoT devices with AI capabilities enable remote patient monitoring, real-time health data analysis, and personalized treatment plans. It helps to diagnosis of any patient from anywhere remotely without doctor or medical practitioner.

Transportation and Autonomous Vehicles: AI-powered IoT systems are driving advancements in autonomous vehicles, intelligent traffic management, and smart transportation systems. It helps all citizens across the city to use vehicles with smart traffic information.

Agriculture: AI and IoT are used for precision farming, monitoring soil conditions, optimizing irrigation, and enhancing crop yield through real-time data analysis. It helps farmers to improve their farm production with less investment and loss due to nature.

Energy Management: AI in IoT devices helps optimize energy consumption by analyzing usage patterns and adjusting energy resources accordingly, leading to improved energy efficiency. This will save lot to money, infrastructure, loss of energy etc.

Environmental Monitoring: AI-enabled IoT sensors can monitor air quality, water levels, and other environmental parameters to aid in environmental conservation and pollution control efforts.

Retail and Customer Experience: AI and IoT enhance customer experience by providing personalized recommendations, optimizing inventory management, and enabling cashier-less checkout systems.

Wearable Devices and Healthcare: AI-powered wearables can track health metrics, monitor exercise, and provide real-time health advice and insights to users.

Smart Cities: AI and IoT are used in creating smart city solutions, including traffic management, waste management, energy distribution, and urban planning.

Security and Surveillance: AI and IoT systems enable intelligent video analytics, facial recognition, and real-time threat detection in security and surveillance applications.

Logistics and Supply Chain Management: AI and IoT technologies streamline logistics operations, monitor shipments, and enhance inventory management in the supply chain.

Financial Services: AI in IoT devices can provide personalized financial advice, detect fraudulent transactions, and improve risk assessment and fraud prevention.

Entertainment and Media: AI and IoT are used to create interactive and immersive experiences in virtual reality (VR), augmented reality (AR), and personalized content recommendations.

Education: AI-powered IoT devices can facilitate personalized learning experiences, adapt educational content, and provide individualized feedback to students.
These application areas demonstrate the diverse and transformative impact of AI and IoT when combined. As technology continues to advance, we can expect even more innovative use cases and improvements in various industries and aspects of our daily lives.

Conclusion

The intersection of IoT and AI offers a potent synergy that holds the capability to establish more intelligent, streamlined, and self-sufficient systems, fundamentally transforming diverse sectors and influencing the trajectory of technology. Nevertheless, this convergence also introduces complexities concerning data privacy, security, and ethical concerns that warrant meticulous attention and resolution.

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