**AI for Industrial IOT**

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**Abstract**

The convergence of the Internet of Things, Artificial Intelligence and industrial automation systems is driving force for the fourth industrial revolution also referred to as Industry 4.0. This integration enables the advanced applications into various sectors like manufacturing, transportation, energy, healthcare and many other. However, the complexity and difficult interconnectedness of these systems also introduce various different security challenges that needed to be addressed to ensure to have safe and reliable operations.

In this paper review we try to provide an overview of the present state AI-driven IoT applications in the industrial area and their future settings with focus on Network, Mixed reality and cybersecurity aspects of the different industries. We explore the fundamental integration of IoT and AI technologies and examine the concepts such as the Industrial Internet of Things (IIoT), Industrial Automation Internet of Things (IAIoT) and the Internet of Robotic Things (IoRT).

It also critical to understand the role of AI in enhancing IIoT and it’s security which acts as both a guardian by increasing the defenses against threats and other novel attacks. We try to understand the dual nature of AI by acknowledging its ability to increase the cybersecurity measures and knowing the risks it can pose due to its complex structure.

We also explore the convergence of AI, IoT, and Mixed Reality (MR) technologies which presents a collaborative application platform and use cases in various different domains like disaster response, military surveillance, industrial digital twins and others.

Additionally, we address the role of AI in 5G network security which tells us about introduction of an AI-based network threat detection system for 5G usage in industrial IoT. Overall, we try to provide a comprehensive overview of the integration of AI and IoT into the industrial applications which emphasizes the important aspects like cybersecurity, reusable components and overlapping with other technologies and their practical implementations. Which aims to increase our understanding and development of secure, intelligent and efficient industrial systems with AI and IoT technologies together.

**Introduction**

* **Overview of Emerging Technologies**

Artificial Intelligence also known as AI. It has become part of our daily life and represents an important role in the landscaping the technology now-a-days due to it’s characteristics like it’s ability to mimic human intelligence and it’s computational processing power. This innovative domain of AI uses machine learning in which the algorithms learn from data without the need of any explicit programming and other is the deep learning which is a subset of machine learning which is based on neural networks with enough layers we can make it identify the patterns to make decisions. The AI's capability can extend beyond doing the simple tasks to performing complex decision-making processes by understanding a very huge chunk amounts of data very quickly and providing the results accurately which is not possible for regular human perform in the same amount of time the AI takes. With the ability the AI is trying to revolutionize the industries by automating most of the manual operations which used to require huge man power by providing new insights for improving both the efficiency and quality of services without any loss of.

The practical applications of AI are various which range from everyday smartphone assistants like Siri in Apple to more complex systems like autonomous vehicles and smart healthcare diagnostics. In business the AI is used to streamline operations, to predict consumer behavior, to optimize logistics and to manage supply chains by making it a cornerstone of the modern strategies of the all the enterprises. By integrating AI the companies are trying to take advantage of the predictive analytics to anticipate market trends which can help them understand the customer needs to one step ahead of their competitor which in turn enhances competitiveness to develop their product and service more. The AI's role in data security and network management is also very important along with safeguarding digital infrastructures which helps in ensuring AI's integral place in the advancement of technology.

The Internet of Things in short IoT. It refers to the vast pool of devices like from ordinary household objects to sophisticated industrial tools that can be connected to the internet to collect or exchange data to enable the ubiquity of internet access and the proliferation of smart sensors. The IoT extends internet connectivity beyond standard devices like computers and smartphones to a diverse variety range of environments. This connectivity allows the integration and automation of the different devices used in daily operations to enhance the efficiency by reducing human intervention to minimal or to zero if possible. The IoT can have much more impact as it offers new opportunities for technology to integrate from various different sectors like healthcare, agriculture, and manufacturing, for altering how cities and homes are managed and the processes in energy management to logistics and many more.

The next big thing is the Mixed Reality, it is a technology that mixes the real world with digital elements to create an interactive environments where the physical and virtual objects will coexist and we can interact in real time. This integration is done using the devices like headsets that can overlay digital content onto the physical world which can enhance the user's perception of reality. Mixed reality combines elements of both augmented reality which superimposes information on the user's view of the real world and that of virtual reality which immerses the user in the fully digital environment. The applications of mixed reality are so many that can range from enhancing gaming experiences to the educational tools to practical uses in medical training and the industrial design which can allow for detailed visualizations and manipulations of complex data in the spatial context which is the blend of realities which aim to create more immersive, productive and interactive experiences for transforming the way we can interact with the digital content in the physical world

**Technological Foundations**

Below we are trying to describe each paper dividing them into 3 different fields depending which has been major part of it in that particular paper. This can help us understand more in detail what technology involved what they are trying to achieve using it.

* **Internet of Things (IoT)**
  + It tries to describe how these technologies can revolutionize the industries by facilitating more efficient machine-to-machine communication and automating complex processes. The paper emphasizes the concept of "Industry 4.0," where industrial devices are interconnected and make intelligent decisions through AI. It also covers various implementations of IoT and AI across different sectors, providing a comprehensive overview of current technologies and potential future developments. The integration of AI and IoT is the main catalyst for making more dynamic and intelligent systems in the industries that can significantly improve the operational efficiency which can pave the way for the innovation into industrial automation solutions
  + It tries to describe the innovative approach which focus on the reuse of AI components for the streamlining the deployment of IIoT applications across different sectors. This method can addresses the high costs and time needed for the demand which is associated with building a custom IoT solutions by offering a flexible and configurable AI-centric components like Smart Contracts, AI Planners and the condition monitors. These components are designed to be very versatile and adaptable by making them usable across various different industries which can increase the application development process by reducing the costs which is needed for building new and individual one every time.
  + It tries to describe the relationship between AI technologies and industrial IoT security. In this study we get to the AI’s dual role in increasing the security which can also give rise to new vulnerabilities within IoT frameworks. By analyzing patterns and understand them from the data breaches. We can develop a predictive algorithms for the AI which can be used to proactively handle threats and increase the system defenses. However, the paper also delves into the potential of the AI to cause sophisticated cyber-attacks such as adaptive malware and automated hacking techniques. These dynamics help us understand the ongoing challenges in cybersecurity where AI's capabilities are used for both the protection of the system and exploitation in same amount. This analysis serves as a very important resource for understanding and knowing where the balance required so that we can maximize AI's benefits, while also mitigating its risks at the same time.
* **Artificial Intelligence (AI)**
  + It tries to explain on enhancing industrial automation techniques or methods through the process of combining both AI and IoT. It introduces the Artificial Intelligence Assisted Network Paradigm (AIANP) which can leverage the use of AI to improve control and monitoring processes within industrial settings. This system aims to decrease the security vulnerabilities while trying to manage the operations more efficiently by using AI to analyze the data and automate the responses without the need of human intervention to it. Which tries to addresses the limitations of traditional IoT-based automation technologies by providing a robust and automated framework that can ensure security effectively which is very important for any modern industrial applications.
  + As the 5G technology has become the new height in communication which can facilitate much faster data transmission with increased capacity for connectivity that which also increases the security vulnerabilities associated with it mainly within the industrial applications where security breaches can have very severe repercussions. In this paper it tries to introduce us to the sophisticated AI-based network threat detection system which is designed specifically to mitigate the risks by enhancing the detection capabilities using AI against the evolving network threats in 5G environments due to new architecture. The AI system tries to use the following deep learning models FCNNs, CNNs and LSTMs for analyzing the network traffic and identify any potential threats effectively to ensue robust security measures are in place to safeguard the sensitive and important industrial operations​ from threats.
* **Mixed Reality**
  + It tries to explain us the integration of Mixed Reality with IoT and AI technologies to facilitate the enhanced collaborative environments. This convergence can be utilized to create a multilateral for the collaboration platform which is particularly useful in complex operational settings like disaster response and military operations. By using the mixed reality, the platform allows the user to have a hands-free operation where they can see the real-time data from IoT devices which are seamlessly integrated and then processed by AI for providing it’s users with intuitive and interactive visualizations to view and the control over them. This can enhance the situational awareness and the decision-making processes in very crucial conditions. The platform's versatility can further be highlighted by its applications across various fields by demonstrating its capability to adapt any different operational needs while ensuring to have effective communication and operational coordination.

**Industrial Applications**

We can divide AI in IIoT security into 4 types namely:

* Device Security
* Connectivity and Network Security
* Configuration Security
* Alignment Challenges

The reason for dividing into four different categories is to make the providing the security more easily then when treating everything as one entity. Where device security tries to analyze the software on the device to identify vulnerabilities that can result in security threats. So, each area covers fields different fields like network, configuration and other’s respectively.

The security issue’s we see in 5G network are as following as authentication, availability, data confidentiality and privacy. To overcome these issue’s by using the high false alert rate using anomaly-based network intrusion detection. So, for doing the security analysis using neural networks like FCNN, CNN, LSTM. This can be done in multiple steps the first step is the labelling the data to use it for the supervised learning model and next is the preprocessing stage by embedding the events to the even vector’s and the resulting collection consists of pattern profiles to use it to train deep learning which is done using gpu for faster and parallel analysis. So, for the NSL-KDD dataset we can the FCNN as more accuracy compared to other two but the difference is quite negligible. By employing multiple model we can increase the detection rate and have faster results.

The MR-IoT/AI Convergence Platform MIAcP delve into a transformative approach where Mixed Reality (MR), Artificial Intelligence (AI), and the Internet of Things (IoT) merge to create a multifunctional platform poised to revolutionize multilateral collaboration and decision-making across various sectors.

The architecture of MIAcP is underpinned by a micro service architecture MSA which is critical for managing the diverse and dynamic inputs from IoT, AI, and MR technologies. This architecture divides the platform into three different layers namely infrastructure, user and the field. The infrastructure layer is located on cloud or edge servers that consists of the micro services which is used to provide the process and integrate data from IoT into the AI systems. This layer is the backbone for the whole platform which supports the complex data interactions which are necessary for real-time analytics and decision-making to support it.

At the user layer of the mixed reality users interface with the system through specially designed Application Programming Interfaces that facilitate the seamless communication between mr hardware and the micro services. This integration is very important for delivering immersive data visualizations directly to the user’s head-mounted display for him to view them immediately in the physical environment.

The field layer includes a different types of physical IoT devices like sensors and actuators that are used gather real-time environmental data. The data flow from all these devices up to the mr UI interfaces to ensure that users can interact with the data and their surroundings in the informed and enhanced way.

**Case Studies**

They are different use case’s for the application of mixed reality with AI and IoT. Some of them are as follows:

**Disaster Response:**

In disaster response the MIAcP can significantly improve the management and the operational effectiveness in case of emergencies like fires, floods and earthquakes. By equipping the field responders with mixed reality devices like head-mounted displays the platform can enable them to see the real-time overlay with the disaster area data collected which is collected from IoT sensors deployed in the field [8]. These sensors detects the structural damages, hazardous material leaks, and thermal readings and provide crucial important information to the UI that is displayed directly in the headset

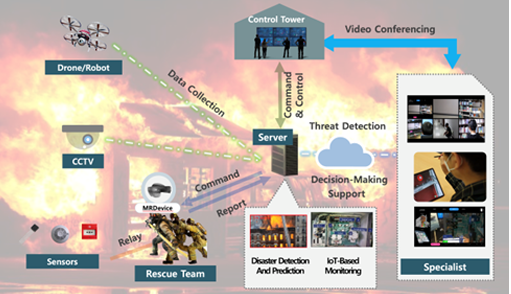


Fig 1: Conceptual usage diagram of MMCA platform for disaster response

AI component of is used to analyze the data to give recommendations or warnings for directing responders to a safe path or can highlight areas where survivors might be located. This not only speeds up the time taken for responding but also enhances the safety and efficiency of the operations by allowing teams to allocate their resources more effectively than before. This hands-free and data-rich approach ensures that responders have the immediate access to actionable insights which allows them to make informed decisions quickly which is often critical in life-threatening situations.

**Military Surveillance**

The application of MIAcP in military surveillance demonstrates its capability to reconnaissance the operational planning with advanced technological integration [7]. By utilizing MR devices the soldiers on the ground will be able to access the real-time data overlays that can provide enhanced situational awareness. This data might contain information from the live feeds from drones, satellite imagery and other reconnaissance data which is all integrated into their visual field through the MR UI interface.

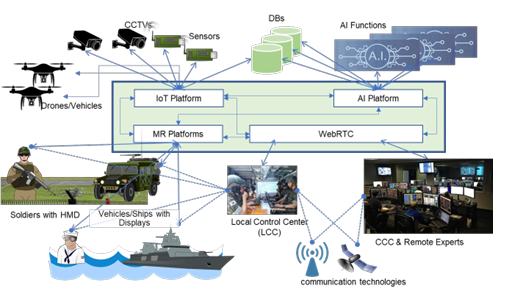


Fig 2: Example usage of MMCA platform for military surveillance

The AI algorithms process the incoming data to highlight important things like enemy movements, strategic points and can also provide suggestions for the optimal response strategies. This setup not only improves the informational depth but also the accuracy available to soldiers which allows for having more coordinated and strategic planning with remote command centers that situational awareness is important in high-stakes environments where the real-time data is need to be analyzed quick, accurate to make the decisions is very important.

**Industrial Digital Twins**

In the view of the industrial applications, the MIAcP gives the freedom for the creation and interaction with the digital twins which can be defined has a virtual replicas of the physical systems which are used in the process of manufacturing, for logistics and in other industrial sectors. These digital twins are used in visualizing the manufacturing processes of the machine, monitoring system performance virtually and for predicting maintenance needs before any actual problem can occur to the machinery [4][5].

The worker’s are equipped with MR headset devices so that they can interact with the digital twins of the machinery in real-time and overlaying the digital information onto the physical machinery and the processes they are managing/performing. This capability of mr headset is particularly beneficial as the worker for tasks like machine maintenance. Where the worker would be able to see all the operational metrics which get superimposed on the surface of the actual equipment or machinery or when performing the complex assembly processes, where we need to be very precise step-by-step instructions and getting them displayed via the MR device makes it easier for the worker doing the job. Furthermore, using AI to enhance this setup process by analyzing data from IoT sensors which are embedded into the industrial machinery for various purpose’s like to predict failures, monitor temperature’s, optimize performance and many more which can thereby help in providing the support for the proactive maintenance and management of the machinery [6].

**Conclusion**

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