Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 12, No. 4, December : 2023

A COMPREHENSIVE STUDY ON THE CONVERGENCE OF IOT IN VEHICLES AND AI IN ROBOTICS

[1]Sasidhar Gurugubelli, [2]Ajay kumar Lopinti, [3]Archana Nuka, [4]Sivaraj Mavuri
[1,2,3,4] Mechanical Department, GMR Institute of Technology, Rajam, Andhra Pradesh, India
Corresponding author: sasidhar.g@gmrit.edu.in

Abstract
Automation and the transportation industries are undergoing a change in direction as a result of the combination of IoT-enabled cars and AI-driven robotics. This study studies the mutually beneficial interaction between IoT in automobiles and AI in robots, examining how they might work together to improve automation and mobility. This combination delivers revolutionary breakthroughs by using AI's thinking powers in robots and IoT's networking and data-sharing capabilities within cars. It is the combination of robots driven by artificial intelligence (AI) for accurate actions, adaptive decision-making, and smooth interaction with the surroundings, and intelligent automotive systems that can communicate data in real-time, perform predictive maintenance, and improve driver assistance. Examining connectivity, security, and ethical considerations, the article highlights the potential for transforming sectors such as smart manufacturing, driverless transportation, and urban development.

Keywords: Smart manufacturing, Driverless transportation, Connectivity, Security, AI-driven robotics, IoT-enabled cars

Introduction

IOT: Internet of things, commonly known as IoT, is network of physical devices embedded with sensors, actuators, software, electronics and connectivity. It enables data interchange and connection between various devices. In simple words, IoT is a technology used to send and receive sensor data via internet networks. Automobiles, cellphones, and smartwatches are a few examples of these physical gadgets. The best thing about IoT is it allows remote control of devices which results in increase efficiency. accuracy and less human intervention. In businesses, the capability to track and code objects have enabled companies to increase efficiency, speed up their processes, prevent theft, reduce errors and incorporate compiles and flexible organizational systems through IOT. Wi-Fi, Bluetooth, and Radio Frequency Identification (RFID) are examples of open wireless technologies that have made the Internet of Things (IoT) ready for mass adoption.

IOT Working: The things are connected to the internet through a variety of means, including Wi-Fi,

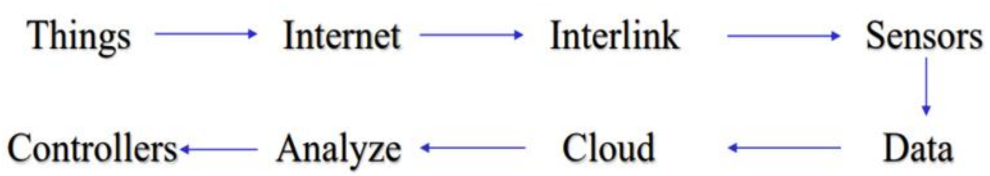

Figure 1. Flow chart of IoT working

Bluetooth, and cellular networks. Once connected, the things can collect data from their environment and send it to the cloud. The cloud is a central repository for storing and processing IoT data. Cloud-based IoT platforms provide a variety of services, such as data storage, analytics. IoT controllers are used to control the things connected to an IoT system. Controllers can be used to turn things on and off, adjust settings, and respond to events. IoT controllers can be located at the edge of the network, near the things they control, or in the cloud. Edge devices are used to process data locally before sending it to the cloud. This can reduce latency and improve performance for certain IoT applications as shown in figure 1.

AI: Recently, artificial intelligence (AI) has become a major technological breakthrough that could completely change the robotics industry. Growing interest has been seen in incorporating artificial intelligence (AI) methods into robotic systems so they can operate independently and adjust to changing surroundings. Robotics has made extensive use of machine learning techniques, such as reinforcement learning, supervised learning, and unsupervised learning, to allow robots to learn from data and make decisions based on patterns and experiences. Robotic perception has been greatly improved by advances in computer vision, an AI subfield, which have made it possible for robots to see and comprehend their environment. Additionally, human-robot communication has been facilitated by the use of natural language processing (NLP), which allows robots to comprehend and produce human language.

In addition to technological developments, ethical questions about AI's application in robotics have drawn a lot of attention. The responsible and ethical deployment of AI-powered robots in various domains requires addressing ethical issues like safety, transparency, accountability, and bias in decision-making. Even though artificial intelligence (AI) for robotics has advanced quickly, there are still difficulties. These include the incapacity of AI algorithms to handle dynamic and unpredictable environments, in addition to problems with safety, robustness, and interpretability. Furthermore, careful consideration must be given to the social and economic effects of the widespread use of AI in robotics, including any potential effects on employment and societal norms. However, there are a wide range of possible uses for AI in robotics, and it is anticipated that AI and robotics will be integrated.

Literature

2.1 Evolution of Wireless Technologies for the Internet of Things in Smart Vehicles**:** The evolution of the Internet of Things (IoT) in smart vehicles has been driven by key moments in wireless technology. RFID devices emerged in 1972-1975 for inventory tracking, while IEEE standard 802.11 laid the foundation for Wi-Fi. In 1997, Hayes' Wi-Fi enabled wireless internet access, while Zigbee established low-power wireless communication standards. Bluetooth's 1999 standardization propelled short-range wireless connectivity.

Innovations in IoT deployment techniques and smartphone adoption further propelled IoT applications [1]. IoT technology is transforming autonomous vehicles by enabling data sharing and infrastructure improvements. However, challenges like better software and maps remain. DSRC and 5G are promising wireless technologies. Major players include carmakers, software developers, self-driving feature vendors, and IoT providers [2].

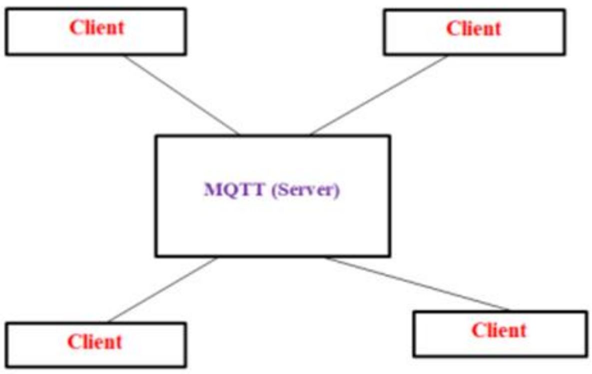

Figure 1.Communication model of MQTT [3]

2.2 A Lightweight Messaging Protocol for Efficient IoT Communication: Message Queuing Telemetry Transport (MQTT) is a lightweight, publish-subscribe machine-to-machine messaging protocol designed for resource-constrained devices and low-bandwidth, high-latency, or unreliable networks. It is used in various applications, including IoT devices, industrial control systems, and smart home appliances. MQTT consists of three main components: clients, a central server that manages message flow between clients, and topics, named channels used by clients to publish and subscribe to messages as shown in figure 2. MQTT messages are small and simple, designed for efficient transmission over low-bandwidth networks. They have a header including topic, message ID, and QoS level. MQTT uses a publish-subscribe pattern, meaning clients connect to the broker, which manages message routing. This makes it easy to scale MQTT applications, as new clients can be added without affecting existing ones [3]. The experiment developed a Vehicle Security System using Internet of Things (IoT) technology. The system enables user authentication for access control and monitors the vehicle for suspicious activity. It also notifies the user via SMS in case of unauthorized access, theft, intrusion, or towing. The system uses various technologies, including a keypad for password input, an IR sensor for intrusion detection, a limit switch for towing detection, GPS for tracking, GSM for SMS communication, and Bluetooth for mobile communication. The prototype successfully unlocked the car, started ignition, and detected intrusion and towing. The system is a promising solution for vehicle security [4].

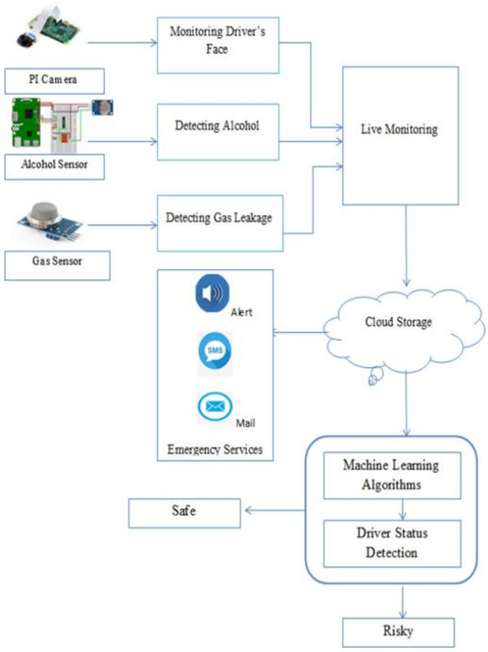

Figure 2. Architecture Harnessing Technology [5]

2.3 Harnessing Technology for Enhanced Road Safety: A comprehensive system for driver monitoring is designed to enhance road safety and minimize accidents. The system uses a camera to capture the driver's face, which is then scrutinized by a machine learning algorithm to identify signs of impairment. A sensor then scans the cabin environment for signs of alcohol or gas leaks. If detected, the system activates an alert mechanism, either by notifying the driver directly or transmitting a signal to a remote monitoring center. The captured video footage and sensor data are stored securely in cloud storage, allowing for continuous data analysis and algorithm refinement. This system has the potential to improve road safety, prevent accidents caused by drowsy driving, drunk driving, or gas leaks, assist fleet managers, insurance companies in developing more precise pricing models, and homeowners in protecting their homes from potential hazards as shown in figure 3 [5].

2.4 A Hybrid Access Control Model: It discusses the various technologies that the Internet of Things has employed over time. Bluetooth, Wi-Fi, RFID, and Zigbee are among the technologies. RFID technology is used to identify and track objects. The size of RFID devices was reduced in 1979.The following technological advancement was Wi-Fi, which was created in 1997. Wi-Fi is a technology for wireless networking that enables internet connectivity for devices. Based on this, we can conclude that Wi-Fi, with a bandwidth of about 11,000 kbps, is the fastest communication medium available. following the 1998 invention of Zigbee. Zigbee is a low-power device-oriented wireless networking technology. Bluetooth is a wireless networking technology utilised for communication within a short range [6].

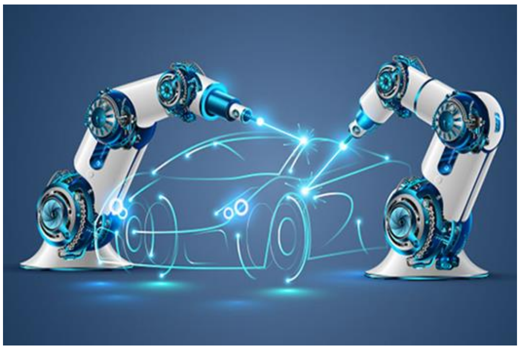

Figure 3. Robot welder in automobile industry [22]

2.5 Industrial Robots in Modern Manufacturing: Industrial robots are capable of movement on three or more axes which are used for manufacturing. Nearly more than 3 million robots were in operation world-wide according to Industrial Federation of Robotics [17] as shown in figure 4. Typical application of robots includes welding, Assembly, disassembly, pick and place, packing and labelling, product inspection and testing.

IoT sensors have the ability to record engine performance, making vehicle maintenance simpler. They send the real time data, so we can take necessary actions. Even the passenger's medical conditions, heartbeat etc can be sensed by the wearable sensors [19]. Thus, by getting the real time data of the operation of the vehicle and its driver's situations [22] one can predict the faults and predict the problems based on these real time data. New Machine Learning algorithms and Artificial Intelligence technologies, can forecast the problems that would arise, therefore help to overcome the problems before it arrives.
Four types of V2X applications:

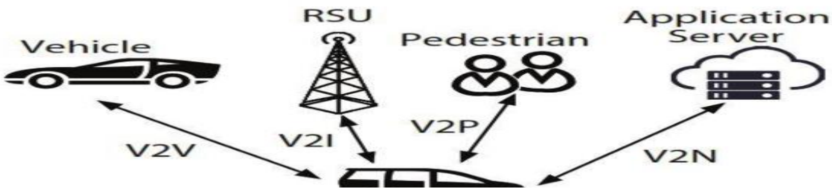

Figure 4. Type of vehicular communication [23]

i. **V2V (Vehicle-to-Vehicle):** This communication allows vehicles to directly exchange information with nearby vehicles. It enhances safety by enabling cars to communicate about their speed, position, direction, and other relevant data to avoid collisions and improve traffic flow.
ii. **V2I (Vehicle-to-Infrastructure):** V2I refers to communication between vehicles and infrastructure, like traffic lights, road signs, or centralized traffic management systems [20]. This exchange assists in traffic optimization, providing data on road conditions, traffic signals, and other information to improve overall transportation efficiency.
iii. **V2X (Vehicle-to-Everything):** V2X is an umbrella term encompassing various types of communication involving vehicles. It includes V2V, V2I, V2P (vehicle-to-pedestrian), V2D (vehicle-to-device) [23] and sometimes V2G (vehicle-to-grid) as shown in figure 5. It aims to create a comprehensive connectivity network to improve transportation safety, efficiency, and sustainability.

iv. **V2P (Vehicle-to-Pedestrian):** V2P facilitates communication between vehicles and pedestrians or other vulnerable road users [21]. It allows vehicles to detect pedestrians, bicyclists, or other individuals and warns drivers or takes action to prevent accidents.

v. **V2D (Vehicle-to-Device):** This refers to the communication between a vehicle and other devices, such as smartphones, wearables, or other gadgets. It enables functionalities like remote vehicle control, data sharing, and integration with personal devices for enhanced user experience and convenience.

2.6 Showing the Whole Integration of Artificial Intelligence Techniques: Artificial Intelligence (AI) in robotics encompasses a comprehensive methodology, intertwining sensor integration, machine learning, reinforcement learning, computer vision, natural language processing, and iterative refinement [8]. The process initiates with sensor data acquisition, where the robot captures real-time information from its environment. These sensors could include cameras, lidar, radar, and other detectors, enabling the robot to perceive and understand its surroundings. Subsequently, the collected data undergoes processing through machine learning algorithms [11]. This phase involves training the robot's AI model to recognize patterns, correlations, and anomalies within the input data. The machine learning component empowers the robot to make informed decisions based on its acquired knowledge, enhancing its adaptability to diverse situations. Reinforcement learning is a pivotal step in the methodology, refining the robot's actions through continuous feedback [9]. The robot learns from its experiences, receiving positive reinforcement for successful tasks and adjusting its behavior in response to negative outcomes.

This iterative learning process contributes to the robot's ability to optimize its actions over time, making it more efficient and adaptable users [10]. Computer vision plays a crucial role in enabling robots to interpret visual inputs. Through image recognition and analysis, robots can identify objects, navigate through environments, and interact with surroundings [12]. This capability is fundamental for tasks requiring visual understanding, such as object manipulation or navigation through complex terrains. Natural language processing (NLP) is integrated to facilitate communication between robots and humans [14]. This involves the robot understanding and generating human-like language, allowing seamless interaction in scenarios where verbal or written communication is essential.

NLP extends the scope of robotic applications by enabling intuitive interfaces for human-robot collaboration [13]. The methodology culminates in continuous iteration and adaptation. As the robot operates and encounters new scenarios, the AI model undergoes refinement. This process involves updating algorithms, adjusting parameters, and incorporating new data to enhance the robot's overall performance [15]. Continuous improvement ensures that the robot evolves and stays relevant in dynamic and unpredictable environments. In essence, the methodology harmonizes these elements, leading to a sophisticated integration of AI into robotics [16]. This holistic approach empowers robots to navigate, interact, and perform tasks autonomously, heralding a new era in the capabilities and applications of intelligent robotic systems.

Conclusion

The integration of IoT and AI is a significant advancement in various sectors, offering potential for improved human wellbeing, social issues, and increased production, safety, and efficiency. However, this technology also requires a commitment to ethical considerations, requiring cooperation from engineers, ethicists, politicians, and the general public. Ethical frameworks must address security, transparency, responsibility, privacy protection, and justice. Transparency and responsible practices are crucial for building trust and understanding between users and stakeholders. Clear decision-making procedures and AI algorithms grounded in ethics and justice are essential for reducing disadvantage and promoting equitable results. Continuous effort is needed to update moral standards to keep up with technology advancements. Education and awareness-building among developers, users, and the broader community are essential for creating an ethical mentality and ensuring responsible use of IoT and AI technologies. In conclusion, while IoT technology offers significant advancements, it requires a shared commitment to moral values. By advancing cooperation and adopting responsible methods, we can harness the potential of IoT technology for a future that values ethical issues, human values, and social well-being.

References

[1] Keertikumar, Malagund, Mahalank Shubham, and R. M. Banakar. "Evolution of IoT in smart vehicles: An overview." 2015 International Conference on Green Computing and Internet of Things (ICGCIoT). IEEE, 2015.
[2] Krasniqi, Xhafer, and Edmond Hajrizi. "Use of IoT technology to drive the automotive industry from connected to full autonomous vehicles." IFAC-PapersOnLine 49.29 (2016): 269-274.
[3] Bhavya, Battula, et al. "Prediction of vehicle safety system using internet of things." Journal of Green Engineering 10 (2020): 1786-1798.
[4] Mukhopadhyay, Debajyoti, et al. "An attempt to develop an IOT based vehicle security system." 2018 IEEE International Symposium on Smart Electronic Systems (iSES) (Formerly iNiS). IEEE, 2018.
[5] Uma, S., and R. Eswari. "Accident prevention and safety assistance using IOT and machine learning." Journal of Reliable Intelligent Environments 8.2 (2022): 79-103.
[6] Aftab, Muhammad Umar, et al. "A hybrid access control model with dynamic COI for secure localization of satellite and IoT-based vehicles." IEEE Access 8 (2020): 24196-24208.
[7] Kuffner JJ (2010) Cloud-enabled robots. IEEE RAS International Conference on Humanoid Robots, Nashville, Tennessee, USA.
[8] https://link.springer.com/article/10.1186/s41469-019-0050-0
[9] https://www.frontiersin.org/articles/10.3389/frobt.2017.00075/full
[10] https://www.accenture.com/us-en/insights/future-workforce/transforming-learning
[11] https://ieeexplore.ieee.org/abstract/document/1423975.
[12] http://ai-elsi.org/wp-content/uploads/2017/05/JSAI-Ethical-Guidelines-1.pdf
[13] https://aichatgpt.co.za/artificial-intelligence-in-robotics-research paper/#Current_State_of_Robotics_and _AI
[14] https://arxiv.org/pdf/1707.07217.pdf
[15] https://www.sciencedirect.com/science/article/pii/S0004370217300310
[16] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3803010
[17] Manasseh E (2018) Combined artificial intelligence and IoT for smart sustainable cities, 1st Forum on Artificial Intelligence and the Internet of Things in Smart Sustainable Cities in Latin America, Buenos Aires, Argentina.
[18] Tzafestas SG (2018) Information, Communication, and Automation Technology Ethics in the Knowledge Society Age, Hauppauge. Nova Science Publishers, New York, USA
[19] Gawali S K and Deshmukh M K 2019 Energy autonomy in IoT technologies Energy Procedia. Elsevier B.V. 156 222–226
[20] Richardson, M.D., Sheeks, G., Waller, R.E. and Lemoine, P.A., 2021, “Pursuit of online services for online students”, In Research Antholog on Developing Effective Online Learning Courses (pp. 1850-1880).
[21] Rahim, M. A., Rahman, M. A., Rahman, M. M., Asyhari, A. T., Bhuiyan, M. Z. A., & Ramasamy, D. (2021). Evolution of IoT-enabled connectivity and applications in automotive industry: A review. Vehicular Communications, 27, 100285.
[22] https://images.app.goo.gl/mcPpW1gm7WXLXe6JA
[23] https://images.app.goo.gl/nxGVDRLKrHvKzdYy7