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Big Data and Internet of Things (IoT) in Autonomous Navigation

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Abstract: Information and communication technology (ICT) has emerged a complex discipline, technology ecosystem, toolset, and practice with far-reaching ubiquitous applications. Needless to regard it as a disruptive technology anymore as it is more or less a culture of the 21st century humanity. Spanning through the Sciences, Engineering, Business, Arts, Industry, Manufacturing, Agriculture, Production, etc. ICT has become the most reliable tool for sustainability across global economies. In the auto manufacturing industry, the 21st century has witnessed a lot of successes and advancement in automotive technology. The driving power underlying these advancements is ICT. In recent times, modern vehicles are becoming equipped with smart features such as geomapping, navigation, traffic signaling, vehicular tracking, and security. These features are dependent on ICT. This study is aimed at providing a systematic and chronological expository content on the interface that exist among Big Data, Internet of Things (IoT), and autonomous navigation. It discusses the evolution and generations of autonomous systems, the architecture and functions of autonomous systems, the integral information and communication components in modern autonomous systems, as well as the future prospects of Big Data and IoT in sustaining the trend in the development of sophisticated autonomous systems. This study provides useful insights on the interplay between vital Artificial Intelligence, sensing, and transmission technologies which enable the receiving sending, processing of, and utilization, vital data from the autonomous systems immediate environment, routing information, managing obstacles, and automatic responses. It further highlights useful and material use cases and makes case on the ICT best practices for the design of better autonomous navigation systems.

Keywords: *Autonomous systems, information technology, artificial intelligence, internet of things, navigation*

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I. INTRODUCTION

The growth of computers and information technology and the emergence of mobile communication has opened up more opportunities for individual, groups and business organizations not only to thrive in their business operations with high level of productivity and efficiency but also has improved social interaction and communication beyond geographical boundaries. From healthcare, e-commerce, e-governance, education, research and development the ICT sector in the past three years contributed to the gross domestic product (GDP) of Nigerian economy with 17.43 percent in fourth quarter of 2020, 15.21 percent in fourth quarter of 2021 and 18.44 percent in second quarter or 2022 respectively [1]; [2]. One

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aspect of ICT that has influenced businesses and individuals recently is the internet of things (IoT) as it has been successfully deployed across different domains, The concept of IoT has also evolved in the last few years and the rise of in the number of people and devices on the internet has multiplied. IoT applications have emerged an everyday interaction and experience even though a lot of persons are still standing in awe of this technological advancement[3].

Kevin Ashton, a British technology pioneer, coined the term "Internet of Things" (IoT) in 1999 to describe a system in which sensors connect physical objects to the Internet. To illustrate the power of connecting RFID tags used in corporate supply chains to the Internet in order to count and track goods without the need for human intervention, Ashton coined the term. As a result, the term "Internet of Things" is now widely used to describe a wide range of objects, devices, sensors, and everyday items that are connected to the Internet [4]. Research has shown that the Internet of Things will have nearly 30 billion devices by the end of the decade. However, some management challenges are associated with IoT implementation and deployment, such as seamless integration, heterogeneity, scalability, mobility, security, and a variety of other issues [5].

A. *Statement of the Problem*

The challenges of road congestion and accidents occassioned by human error and fatigue on the road has remained a major concern to governemnt and other stakeholders in the road transport sector. With an estimated over 11.7 millioin registered vehicles on the Nigerian roads [6], road manned by both experienced and inexperienced drivers, the danger for both the driving public and pedestrians is high. There is therefore the need for the implementation and deployment of IoT driven autonomous vehicles to mitigate the foreseen danger and improve safety of lives and property on the road.

II. LITERATURE REVIEW

A. *IoT and Big Data*

Big data is a term that refers to large amounts of structured and unstructured data that organizations collect on a daily basis. The analysis of this data can result in operational insights that allow for better business decisions. The internet of things (IoT) is one of the key trends driving the adoption of big data analytics tools. Big Data and IoT are complementary dimensions of a view. Managing data and mining information from it is a critical task associated with IoT. To derive knowledge from IoT data, a suitable analytical platform is required. IoT devices generate consistent data streams in a scalable manner. It is critical to manage and exploit the large volume of stream data. In a typical Big Data scenario, the data is not stream data, but the actions are. The flow of IoT data is continuous. Real-time analytics are required in the IoT environment [7],

IoT applications could connect intentionally or unintentionally to one or more big data systems outside the ecosystem, resulting in a big data system aggregate orders of magnitude larger than any of the constituents. Every IoT system, even a small, local IoT ecosystem, is a potential big data system in this sense [8]. Big data on IoT data would aid in the analysis of data collected over a long period of time, providing a better understanding of systems and their behavior. To develop models for forecasting future outcomes and optimizing them [9]. Data can be Collected to estimate factors that would not be directly measured by sensors by determining the connection between various system parameters and their impact on one another.

B. *IoT and Artificial Intelligence*

Although machines are not designed to completely replace humans, they can assist humans in reducing their workload. Obviously, humans must maintain their dominance over machines. AI works best when combined with human intelligence rather than replacing it. It emphasizes the idea that computers and humans have different strengths in the vast field of excellence: computers are far more efficient at doing arithmetic and counting, whereas humans excel at logic and reasoning. These various types of intelligence are complementary rather than diametrically opposed. As a result, AI is the technology that can enable us to have 'things' that can 'think' [10]. AI enabled-IoT can create intelligent machines that simulate intelligent behavior and assist in decision making with little or no human intervention. The combination of these two streams benefits both the general public and specialists. While IoT involves devices communicating via the internet, AI enables devices to learn from their data and experience.

Smart cities, healthcare and traffic surviellence are some of the areas where artificial intelligence has been incorporated and used in IoT scenarios. IoT is a broad concept that includes far too many sensors, actuators, data storage, and data processing capabilities that are linked by the Internet. As a result, any IoT-enabled device can sense its surroundings, transmit, store, and process data, and act accordingly. The final step of acting appropriately is completely dependent on the processing step. The level of processing or acting that an IoT service can perform determines its true smartness. A non-smart IoT system will be limited in its capabilities and will be unable to evolve in tandem with the data. A smarter IoT system, on the other hand, will have artificial intelligence and may serve the actual goal of automation and adaptation [11].

According to [12], machine learning, a subset of artificial intelligence, has recently been deployed to improve safety and efficiencies throughout the transportation sector, with automobiles connected to devices that generate massive amounts of data on a daily basis. Data is the fuel that will power tremendous insights to improve autonomous transportation systems, from tracking traffic and optimizing delivery routes to payment processing and insurance premiums based on real-time data. AI is one of the key drivers of IoT and the future is clear with the applkicatioin of AI and IoT in thetransport sector to learn from data in the environment for guiding the IoT devices to deliver on the required task.

C. IoT Applications

The main benefit of IoT is in its ability to enable communication between an infinite number of machines embedded in a large-scale wireless network. These automated devices and sensors generate and transmit information in real time, which supports a broad based application domain [13]. IoT holds the promise of improving people's lives through both automation and augmentation. The capabilities provided by the Internet of Things can save people and organizations time and money while also improving decision making and outcomes in a variety of application domain [14]. The applications and use of IoT in various domains are what drive and explain the evolution of this new trend, ultimately leading to its current state of global acceptance [15]. According to Redhu et al (2018) IoT daily generates information from one object and transmits it to another as a result of enabling object communication making the range of IoT applications broad and limitless. Some of the principal areas of the application of internet of things include healthcare, the environment, smart cities, commercial, industrial, and infrastructure and smart automation. This paper therefore shall concentrate on the application of IoT in the navigation of autonomous and the implication for future development.

The Internet of Things has the potential to play a significant role in the integration of communications, control, and information processing across various modes of transportation. The implementation of IoT cuts across all aspects of transportation system ranging from the vehicle of all types and drivers assisted devices. The dynamic interaction of these transport system components enables inter and intra vehicular communication, smart traffic control, smart parking, electronic, logistic, vehicle control, safety and road assistance [16]. Modern automobiles are fitted with sensors that are linked to the internet through the control systems to ascertain their positions, track them and detect faults. The Internet of Things (IoT) also helps in road safety systems which include collision detection, lane change warning, traffic signal control, and intelligent traffic scheduling respectively [17].

D. IoT in Autonomous Navigation

The concept of autonomous navigation refers to vehicles with the ability to make decisions about its course and carry them out on its own without human assistance or intervention. In some instance, planning involves the use of remote navigation aids, whilst in other situations, the only data utilized to compute a path is based on input from sensors mounted on the vehicle. An autonomous robot is one that can both plan its movements and keep its own stability while moving. In addition to using navigational assistance when appropriate, autonomous robots can also rely on olfactory, aural, and visual clues.

According to Ramkumar (2022), completely autonomous mobile robot must complete a variety of duties in a hectic and demanding setting. An autonomous robot navigation system would be required to assist visitors in navigating the numerous exhibitions, including providing tourists with the right directions, engaging them in indoor and outdoor activities, etc. A mobile robot does not require the assistance of a human operator in order to move around in a certain environment, whether it be indoors or outdoors. Instead, the robot uses a thorough perspective method and efficient control architecture to independently plan and complete tasks based on the information at hand.

E. Evolution of Autonomous Vehicles

The growth of artificial intelligence and machine learning has brought about the emergence of many autonomous machines that has drastically reduced human involvement in risk prone domain and increased productivity and efficiency of the service delivery. The automobile industry has advanced technologically and grown significantly over the years. The incorporation of computer systems and the computerization of mechanical and manual functions have improved vehicle features. Driver-assist features such as adaptive cruise control, lane departure warning systems, and self-parking systems are becoming increasingly common in new cars [18].

According to [19], autonomous vehicles make roads much safer by significantly reducing human errors. Technology enables the deployment of automated/autonomous vehicles, and robust networks and powerful IoT solutions are critical components. In the mobility and transportation sectors, intelligent connectivity enables new transformational capabilities. Because many critical tasks are performed remotely, the networks used to connect IoT devices and vehicles must be ultra-reliable and rely on cost-effective edge infrastructure to enable low latency and scaling. As a result, connectivity is required for such services to function properly. Intelligence enables the enhancement of user experiences through multi-access edge computing with augmented reality (AR) and virtual reality (VR) technologies (GSMA, 2018).

Autonomous vehicles use connectivity to update their algorithms based on user data, interact with infrastructure to obtain environmental information, and communicate with other vehicles. They communicate with pedestrians through mobile and wearable devices, and they provide information about traffic attributes and data collected by vehicle sensors. The connected and automated vehicles require a significant amount of data collection and processing, and the autonomous vehicles share information about the road, the current path, traffic, and how to navigate around various obstacles via IoT applications and services. This data can be shared between IoT-connected vehicles and wirelessly uploaded to the cloud or/and edge system to be analyzed and operated to improve the levels of automation and autonomous driving function of each vehicle [19].

To perform and conduct their safety-critical operations, autonomous vehicles, IoT, and artificial intelligence (AI) connected systems are increasingly relying on information exchanged. Maintaining the trustworthiness, security, safety, and privacy of such systems and the data contained within for the required cases is a critical component for the acceptance and adoption of such autonomous systems. IoT devices and technologies can support and enhance autonomous driving functions in a variety of ways, depending on the use case.

F. *Internet of vehicles (IoV)*

As the number of vehicle ownership continues to increase with the growing urban population and city expansion, these vehicles due to their mobility, requires improved interconnectivity and communications. Vehicles play a crucial role in smart cities as they develop from simple modes of transportation to intelligent beings with sensing and communication capabilities [20]. Some key characteristics of smart cities include; electric automobiles, self-driving cars, safe driving, social driving, and mobile apps. When all of the connected smart items are automobiles, the Internet of Things becomes the Internet of Vehicles (IoV). Internet of vehicles (IoV) is therefore an expanded application of IoT for smart transportation. It is intended to function as a crucial platform for data sensing and processing for intelligent transportation systems [21]. A car will function as a sensor platform, absorbing data from the environment, other moving objects, and the driver and utilising it for traffic management, pollution reduction, and safe navigation. Furthermore, the data from connected vehicles, traffic surveillance cameras, social media feeds, and crowdsourcing can improve urban planning and administration (Pang et al., 2020).

[22] asserts that the infrastructure for the Internet of Vehicles (IoV) requires five primary forms of connections: vehicle-to-vehicle (V2V), vehicle-to-human (V2H), vehicle-to-infrastructure (V2I), vehicle-to-roadside unit (V2R), and vehicle-to-sensors (V2S) as indicated in figure 1.

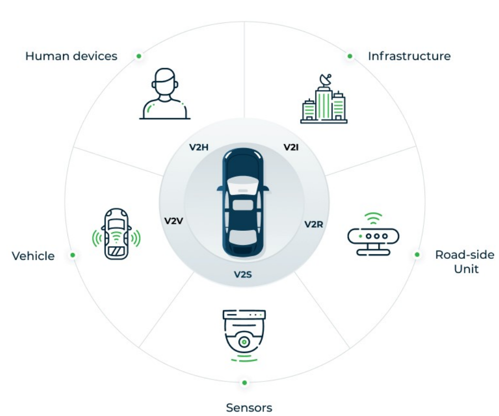

Fig. 1. Internet of vehicle (IoV) infrastructure

III. METHODOLOGY

The methodology deployed in this work is the exploratory research methodology which is typically regarded as qualitative, inductive research. Exploratory research uses an inductive method and contrasts with quantitative studies that use deductive confirmatory approaches. Explanatory study may generate new queries that prompt investigation. The questions here include both inductive and deductive processes operating concurrently or back and forth, especially as the literature is evaluated and the study strategy is developed (Casula et al., 2021).

A. Rationale for Choice of Methodology

The following are some of the benefit for the use of exploratory research:

- The researcher is extremely flexible and can modify as the study progresses.
- It typically has a low cost.
- It helps create the framework for a study that can motivate further research.
- It helps the researcher to assess right away whether the subject is worthwhile of the time and resources required to conduct further investigation.
- Other researchers may find it useful in identifying potential causes of the problem, which can then be thoroughly investigated to identify which one is most likely to be the culprit.

IV. DISCUSSIONS

A. Importance of IoT, Big Data and Autonomous Vehicles

Artificial intelligence and its subset of machine learning are the key enablers of IoT and autonomous vehicles as it drives and enhances the data processing and analysis capabilities of machines to effectively utilize data for effective decision making. From remote sensing to geographic information systems and positioning, artificial intelligence and machine learning play a pivotal role. Automotive IoT, which is the integration of components such as sensors, gadgets, clouds, and apps into vehicles and their use as a complex system for predictive maintenance, car connection, fleet management, and so on, has become a permanent fixture as embedded IoT solutions have transformed cars into "near-artificial intelligence." The Internet of Things enables manufacturers to implement numerous industry innovations, including self-driving cars, which are currently on everyone's lips. It is a vast platform for expanding IT capabilities [23].

Furthermore, nn autonomous vehicle will be useless on the road if it does not have access to a consistent and dependable stream of self driving cars big data. A connected car without data is like a baby who sticks its fingers into sockets, grabs a knife, or tries to catch a spark because it doesn't realize it's dangerous. IoT devices and connections generate vast streams of data in split seconds which enables the autonomous vehicle to effectively navigate, accelerate avoidc detours and possible stop or move. An autonomouos vehicle can develop strategies for a variety of road situations based on data collected. Data sharing among autonomous vehicles will aid in avoiding traffic jams, weather forecasting, and emergency response. Finally, big data from autonomouos vehicles can be used for the following purposes:

- See and sense - receive information; plan and act based on information gathered.
- Map out your surroundings in great detail.
- Using cameras, determine range, speed, and distance.
- Communicate and share information with other vehicles.

The advantages of autonomous technologies are massive as it cuts across different domain increasing efficiency and reliability of service delivery. In the case of autonomous vehicles, the following are some the advantages it bring to the manufacturers and users:

- Improved data collection and analysis;
- Acceleration of the entire manufacturing process;
- Avoidance of certain risks and financial losses;
- Higher industrial safety standards;
- Monitoring of equipment theft, and so on.

On the side of the users the benefits include:

- The ability to easily access all information about a car via a mobile app (on recent vehicle models, you can start the engine, check the fuel level, connect your event calendar, and even find your car in the parking lot with a single click on your smartphone app);
- Obtain predictive analytics about the condition of the vehicle, and thus the opportunity to reduce operational costs and make driving safer;
- Obtain a higher level of in-car infotainment experience, and so on.

V. CONCLUSION

The advent of information and technology has really impacted the world to a great extent on the positive and with the massive proliferation of mobile devices, internet of thing, big data and artificial intelligence has improved livelihood, wellbeing and information dissemination making it easy for autonomous vehicles which successfully navigate and understand its environment with the availability of big data generated through connected IoT devices relying on on-board sensors and technical equipment as the valid and accurate sensor data is critical for effective router planning, emergency manoeuvres, and route calculations.

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