THE COLLOQUIUM -A Multi disciplinary Thematc Policy Journal
www.ccsonlinejournals.com
Volume 10 , Number 1 , 2022 Pages 194 - 208
CC-BY-NC-SA 4.0 International Print ISSN : 2971-6624 eISSN: 2971-6632

Sensor Technologies Perception for Intelligent Vehicle Movement Systems on Nigeria Road Network

ORIE, Chukwulenwenwa John
Department of Automobile Technology Education,
School of Secondary Education Technical,
Federal College of Education Technical Omoku,
Rivers State , Nigeria
Corresponding Email : oriechukwulenwenwa@gmail.com

Abstract

The transportation networks of modern society are plagued with major issues, including but not limited to traffic congestion, safety, and pollution. In contemporary transportation networks, information and communication technologies have garnered increasing attention and significance. Automotive manufacturers are developing in-vehicle sensors and their uses in several fields, such as safety, traffic management, and information technology. Currently, government agencies are constructing roadside infrastructures, such as cameras and sensors, to collect data on environmental and traffic conditions. This paper focuses on the sensing and communication capacities of cars and sensing devices can be used seamlessly to produce intelligent and smart transportation networks. How sensor technology may be linked with the transportation infrastructure to produce a sustainable Intelligent Transportation System (ITS) and how safety, traffic control, and entertainment applications can benefit from many sensors deployed in various ITS components were also discussed. In order to enable a fully functional and collaborative ITS environment, the researcher outlined some of the challenges that must be overcome in the conclusion.

Keywords*: Applications, Intelligent Transportation Systems, Sensors, Vehicle*

Introduction

Transportation networks have been a crucial foundation for all nations' economic success. Despite this, many urban cities around the world are experiencing an uncontrollable increase in human and vehicular traffic, resulting in environmental issues such as delays, traffic jams, higher fuel prices, an increase in CO_2 emissions, accidents, emergencies, and a decline in society's quality of life. Based on a Texas Transportation Institute assessment, commuters spend about 57 hours a year stuck in traffic. Drivers squander more than 6 billion gallons of various fuels per year, which has a national cost of $170 billion, or $998 for every commuter in the US. The data was analyzed in the Technical Report 2016 Urban Mobility Scorecard. The Population Reference Bureau (2012) and the United Nations Population Fund (2012) predict that these issues will get worse in the future as a result of the global population boom and the rising migration to major economic centres in many nations. Therefore, improving the security and efficiency of transportation systems is crucial. Advancements in hardware, software, and communications in information and communication technology (ICT) have opened up new possibilities for the creation of intelligent, sustainable infrastructure and transportation systems. The transition to Intelligent Transportation Systems (ITS), which prioritizes several fundamental principles: sustainability, integration, safety, and responsiveness, will be made possible by the integration of modern ICT with the transportation

Cite this article as
Orie, C. J. (2022). Sensor Technologies perception for Intelligent vehicle movement systems on Nigerian road network. *THE COLLOQUIUM*, 10(1), 194 – 208

infrastructure. This will make travelling safer and more enjoyable. The main objectives of intelligent transportation systems include access and mobility, environmental sustainability, economic development, and human development in states with poor transportation systems.

The approach to be taken in accessing, gathering, creating, and processing certain data from the area under evaluation will have a significant impact on how well ITS works. Sensing platforms can be divided generally into two groups: The intra-vehicular sensing platform, which gathers information about a vehicle's conditions and operations, is the first category. Urban city sensing platforms, the second category, are employed to gather data on traffic conditions. When using vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications technology, sensor technology is a crucial component for data gathering and protection. The transportation management systems are then given this data to process it further, analyse it, and take any necessary judgments or actions. High fuel sales, high CO_2 emissions, high levels of traffic congestion, and better road conditions are projected to be addressed by smart and intelligent ITS systems (Contreras et al., 2017).
This research's primary contributions are examined in a number of different orders. In order to create a sustainable intelligent transportation system that will address issues like high levels of CO_2 emissions exposure in urban areas, high levels of traffic congestion within the states, and how to improve road safety in every location, the researcher will first describe and discuss how sensor technology can be integrated with the transportation infrastructure. The researcher will also discuss possible locations for sensors in the road infrastructure, the kinds of data they gather, and how that data is used to make transportation better and more intelligent than ever. Second, the researcher will talk about how ITS applications (traffic control, road conditions, among others) and user applications (driving assistance, passenger entertainment, collision alarm, among others) might profit from sensor technologies built into ITS components. The researchers will also outline a strategy for developing applications that will directly benefit from all the sensor data gathered and enhance transportation systems by making them more affordable, dependable, and effective for end users and the state's management organisations for transportation systems. In order to create an entirely functional, non-intrusive, cooperative ITS environment in Rivers state, the researcher will conclude by highlighting some of the issues that sensor technologies will need to overcome in the future.

Sensor Technology communication

Sensors have been used in numerous applications over the past ten years, including sports, healthcare, agriculture, forestry vehicles, marine monitoring systems, and human directional movement (Alaiad et al., 20017; Utin, 2018). The creation and development of a wide range of applications for human and vehicular traffic control, safety, and entertainment are made possible by sensor technology in the field of transportation (Orie, 2018). In recent years, sensors and actuators like tyre pressure sensors and rear-view visibility systems have become required (due to federal regulation agencies in contemporary states of developed countries) in the production of vehicles and the implementation of intelligent transportation systems, with the goal of providing services to increase human drivers' and passengers' satisfaction, improve road safety, and lessen traffic congestion in cities (Utin, 2018). Manufacturers may also place more sensors on the road infrastructure to track the efficiency and condition of the moving cars, helping human drivers and providing a higher level of safety. The average number of sensors in a vehicle today is between 60 and 200, but as cars get "smarter," that number might increase to 400 (Utin, 2018). Based on where the sensors are deployed in the vehicle, Orie (2020) proposes a classification of three types of sensors: power train, chassis, and body. In another study, sensors are categorised into four groups based on the applications they are meant to support: sensors for vehicle safety; sensors for diagnostics; sensors for convenience; and sensors for monitoring the human environment (Fleming,2008). The researcher adds two

THE COLLOQUIUM -A Multi disciplinary Thematc Policy Journal
www.ccsonlinejournals.com
Volume 10 , Number 1 , 2022 Pages 194 - 208
CC-BY-NC-SA 4.0 International Print ISSN : 2971-6624 eISSN: 2971-6632
more categories of sensors to the classification (four categories) proposed in (Fleming, 2008), namely sensors for human driving monitoring and human traffic monitoring.

Table 1: Classification of sensors used in a vehicle (based on (Fleming 2008)

Category of Sensors	Description	Example
Safety information within the state	Form the foundation of safety systems, with a focus on identifying accident threats and incidents almost in real time.	Various sensors such as micro-mechanical oscillators, speed detectors, cameras, radars, lasers, inertial sensors, ultrasonic detectors, proximity detectors, detectors for night vision, haptic feedback devices.
Diagnostic information within the vehicles	Emphasis should be placed on data collection to provide real-time information about the vehicle's status and performance in order to detect any fault.	Pressure, airbag, chemical, temperature, gas, and position sensors.
Traffic conditions within the environments	Observe the traffic conditions in specified zones and collect data to enhance traffic management.	Infrared, microwave, ultrasonic, and radio waves, as well as optical and mechanical
Assistance :human and vehicular within the state	In charge of information gathering that will help facilitate ease-of-use software.	The sensors include ones for measuring gas composition, humidity, temperature, position, torque, images, rain, fog prevention, and distance..
Environment information	Monitor environmental factors to inform and warn drivers and passengers to improve travels.	Temperature, pressure, distance, cameras, weather
User guideline	Collect data to detect aberrant health conditions and driver behaviour that can impair performance.	Cameras, thermistors, Electrocardiogram (ECG) sensors, Electroencephalogram (EEG). sensors, heart rate sensor.

The development of applications for Intelligent Transportation Systems that help address issues like: (1) vehicular traffic jams and parking challenges, (2) longer commute times in vehicle controls, (3) higher levels of CO_2 emissions in cities, and (4) an increase in the number of traffic accidents and fatalities, among others, is critically important for enhancing the performance of a vehicle. Some of the most common sensors found in contemporary vehicles are shown in Figure 1.

Different types of built in-vehicle sensors.

Applications for built In-Vehicle Sensors

The National Highway Traffic Administration has identified tire-pressure monitoring sensors as one application that is necessary in modern cities to warn drivers via acoustic, light, or vibration warning if the tyre air pressure is below normal level or gauge (Abdelhamid et al.,2014). Applications for reverse warning and vehicle parking assistance use proximity, ultrasonic, and electromagnetic sensors. When a vehicle approaches an object or a metallic environment that is hazardous to the vehicle's systems, proximity sensors can detect it. When a vehicle approaches a dangerous object closer than a predetermined threshold, ultrasonic sensors use a type of sonar to determine the distance between the vehicle and the object. They then alert the human driver. When an object enters the electromagnetic field that has been created around the front and rear bumpers, electromagnetic sensors warn the driver. In order to comply with various Insurance Institute for Highway Safety (IIHS) recommendations, proximity sensors have been used to develop a system based on a rectangular capacitive proximity-sensing array for occupant head position quantification (Guerrero-I et al., 2015).

However, temperature and humidity frequently have an impact on these types of sensors, lowering their operational accuracy. RAdio Detection and Ranging (RADAR) and laser sensors allow safety applications to adjust throttle and activate brakes to avoid potential collisions or risk situations by using radio waves to measure the distance between obstacles and the sensor when necessary. These sensors continuously scan the road for frontal, side, and rear collisions. When something close to the vehicle is detected, the application alerts the driver and automatically applies the brakes to prevent a collision. Inertial Navigation Systems (INS) use the gyroscope and accelerometer sensors to determine the parameters of the vehicle, such as its position, orientation, and velocity. To increase location accuracy, INS is used in conjunction with Global Positioning Systems (GPS). Radar and speed sensors are utilised in applications that warn drivers of potential hazards if they change lanes or drift out of their lane while driving. The typical method of warning a human driver is to vibrate the seat or steering wheel or to sound an alarm. Cameras are used to: (1) monitor the driver's body posture, head position, and eye activity to detect unusual circumstances like signs of fatigue or the vehicle acting erratically (driving in a crooked line on the road or pedestrians crossing in front of the vehicle suddenly); and (2) run night vision assistance applications to help drivers see further down the road and detect objects like animals, people, or trees in the path that can cause a potential risk of injury. The development of autonomous vehicles has become significantly influenced by LIDAR (LIght Detection and Ranging). With a few unique features, like continuous 360-degree visibility and extremely precise depth information, self-driving cars (or any robot) can observe the world. Laser light is continuously fired from LIDAR sensors, which then time how long it takes for the light to return. Each vehicle contains more sensors, but their integration with other parts and the absence of generally accepted standards among different brands is a major barrier to their adoption. In contrast, the capabilities of current automated systems are constrained. For instance, Volvo's city safety speed limit is 50 km/h or less to prevent hitting motorcycles or bicyclists or colliding with other vehicles. In some contemporary cities, a city safety system based on a laser unit can only detect a vehicle if its headlights and taillights are on and clearly visible to other road users (Guerrero-Ibáez et al., 2015).

Road Sensors and its operations

Orie (2018) contends that strategic investment in transportation infrastructure is essential for a nation's development and forms the backbone of the contemporary economy. Governments from all over the world invest a sizable sum of money in the transportation industry each year. According to Ziraknejad et al., (2015), annual investment in the Rivers States is roughly 1.9 percent of GDP, and in 2014, Europe made investments totaling 102 billion euros, of which 55% went toward constructing road infrastructure. Although the automotive industry has made significant investments to improve vehicle performance, comfort, and safety using sensors inside the vehicle, one of the main challenges for intelligent transportation systems is the collection of traffic data using mechanisms located along the roadside. Drivers can benefit from new services like smart parking, which matches drivers with available parking spaces, and lower prices based on the amount of traffic on the roads thanks to the deployment of sensors within a transportation network. Real-time environmental data is gathered by sensors, which is then processed and analysed to strengthen and harden transportation networks. Based on their location, sensors can be divided into two categories: intrusive and non-intrusive (Orie, 2018). On the surface of the pavement, intrusive sensors are installed. Despite their high accuracy, they are expensive to install and maintain. Basically, there are three categories into which intrusive sensors can be placed: (1) Installed on roads, passive magnetic sensors that are wired or wirelessly connected to processing units (2) Placed across the road, pneumatic tube sensors send data to processing units via wired or wireless media. (3) Inductive loops, which are wire coils buried in roads and transmit data. The most common types of intrusive sensors in traffic control systems are embedded magnetometers, pneumatic tube sensors, and inductive loops (Mathew, 2014).

Advantage and disadvantage of road sensors

The main benefits of road sensors are their advanced technology and installation flexibility. They are frequently used and extremely accurate at spotting car problems. The main drawbacks of road sensors, however, are their high installation costs, the disturbance they cause to local traffic, human upkeep, and repairs. The advent of wireless battery-powered sensor nodes, which take the role of intrusive sensors and are installed over the pavement in big cities, is one solution that has been put into place to alleviate the aforementioned problem. The quality, quantity, precision, and dependability of data gathered from roads and avenues are predicted to improve thanks to this technology, which represents a change in the transportation sensor trend. It is also anticipated to be more affordable than existing options (Geetha & Cicilia, 2017). Non-intrusive sensors are installed in various locations on the pavement of the roadways to detect a vehicle's transit as well as other factors like lane coverage and road speed. They may be impacted by the local environmental conditions and are pricey. Applications that offer information about a chosen place, such as queue detection at a traffic light, traffic conditions, weather on the road, and pavement, are

Volume 10 , Number 1 , 2022 Pages 194 - 208
CC-BY-NC-SA 4.0 International Print ISSN : 2971-6624 eISSN: 2971-6632

typically developed using non-intrusive sensors. Some sensors are used to monitor a particular area and are positioned on a tower. Other sensors are positioned with a monitoring area right below on water and road crossings. Several sensors that use a beam that crosses the road are positioned along the side of the road at ground level. Because they are extremely vulnerable to interference from other objects, they are typically utilized for single lanes and with unidirectional flows. Many of the duties performed by invasive sensors can be easily accomplished by non-intrusive sensors. However, weather circumstances like snow, rain, and fog, among others, have a significant impact on them. Making informed judgments to enhance traffic conditions requires the use of precise traffic data. Human drivers are better able to notice non-intrusive sensors, which leads to different and quicker reactions like slowing down and using the proper driving lane, among others, after spotting those gadgets. Installing these sensors is difficult, but so is shortening drivers' reaction times based on the data gathered and giving them a more accurate understanding of the context and reality of the road or avenue. mast-mounted on the side of the road, bridge-mounted, and across the side of the road Several sensors are currently utilized on highways.

Table 2 shows the categories (intrusive and non-intrusive) of sensors that are currently used for keeping track of the number of vehicles, vehicle classification, or road conditions (Ahmad et al., 2013) as well as some other practical uses.

Table 2. Categories of sensors currently used for traffic control.

Category	Sensor Type	Application and Use
Intrusive format	Pneumatic road tube	Used to track vehicle count, categorization, and number
	Inductive Loop Detector (ILD)	Detects vehicle movement, presence, count, and occupancy. Roadside equipment records the signals.
	Magnetic sensors	Used for vehicle detection, recognising stationary and moving vehicles
	Piezoelectric.	Vehicle classification, counting, and weight and speed measurements.
Non-intrusive format	Video cameras.	Detects cars across multiple lanes, classifies them by length, and reports their presence, flow rate, occupancy, and speed.
	Radar sensors.	Measures vehicle volume and speed, detects vehicle direction, and manages traffic signals.
	infrared.	Speed, length, volume, and lane occupancy application.
	Ultrasonic	Tracking cars, presence, and occupancy.
	Acoustic array sensors	Used for measuring vehicle passage, presence, and speed.
	Road surface condition sensors	Used to measure surface temperature, dew point, water film height, road conditions, and grip.
	RFID (Radio-frequency identification	Toll management requires vehicle tracking..

Inductive Loop Detector (ILD) Sensor

The Inductive Loop Detector car sensor is one of the most widely used sensors in traffic control management, claims Orie (2018). The movement flow, vehicle capacity, length, and velocity are all collected using this method. When a vehicle passes over the sensor, an electrical current is generated and sent to the processing control, measuring the display in the electrical properties of the circuit. The sensor is made up of a long wire that has been wound into a loop and is installed into or beneath the surface of the road. When there is a shift in the magnetic field of the earth, magnetic sensors are employed to find moving objects. Magnetic sensors can be installed on bridges and are used to gather information about traffic flow, occupancy, vehicle length, and speed. Piezoelectric sensors can monitor up to seven lanes and can detect vehicles passing over them at high speeds of about 120 km/h by changing the voltage of the sensor. Piezoelectric sensors and ILD sensors are frequently used to create piezoelectric systems. Multiple video cameras, a computer for processing the images, and complex algorithm-software for analyzing the images and converting them into data for traffic analysis make up a video image processor (VIP) system. With the aid of traffic monitoring tools like flow volume and occupancy, video cameras positioned along the roadside gather and analyze human images and videos from a traffic scene to ascertain variations between subsequent frames. The fundamental drawback of VIP systems is their vulnerability to performance reductions brought on by favourable weather.

Radar Sensors and its operations.

Radar sensors emit low-energy microwave radiation that is reflected by any objects within the detection zone. Radar sensor systems come in a variety of forms: (2) A frequency-modulated continuous wave radar, like a simple continuous wave radar, emits continuous transmission power and is used to assess flow volume, speed, and presence. (1) Doppler systems for counting cars and calculating speed based on the frequency shift of their return. Radar sensors are frequently accurate and simple to install. These sensors' primary drawback is their great sensitivity to environmental factors. An acoustic array sensor is a group of microphones that are used to detect an increase in sound energy produced by an approaching vehicle travelling through the sensor's coverage area. Magnetic induction loops are being replaced by acoustic sensors in order to estimate traffic volume, occupancy, and average vehicle speed. In order to increase traffic safety and carry out road repair programmes, road surface condition sensors utilise laser and infrared technology to read road conditions (temperature and grip). This kind of sensor needs to be maintained on a regular basis to maintain its performance level. RFID sensors are used for smart parking and for recognising automobiles to distribute space for parking. RFID sensors are also used to automatically recognise operating vehicles on roadways and gather their data. The development and evolution of ITS as anticipated and forecasted by transportation authorities, auto manufacturers, road users, and all ITS is hampered by the lack of precise calibration and cluster integration despite the widespread installation of sensors on roads and streets. In order to improve transportation conditions, they are expected to use a variety of integrated sensors to provide scenario evaluation systems and quick decision-making based on the data gathered from integrated sensors. According to Zhou et al., (2017), Interconnection Methods for ITS and the Automotive Society have proposed a number of communication technologies to transmit data among automobiles, transportation infrastructure, and pedestrians. V2V Communication Access Technologies Many contemporary sensors, electronic systems, and in-vehicle communication networks are being installed in current automobiles. The various sensors and gadgets installed within the car communicate through a variety of protocols and networks. Table 3 shows taxonomy of protocols for sensors, communication networks, and infotainment applications based on different data rate ranges.

THE COLLOQUIUM -A Multi disciplinary Thematc Policy Journal
www.ccsonlinejournals.com
Volume 10 , Number 1 , 2022 Pages 194 - 208
CC-BY-NC-SA 4.0 International Print ISSN : 2971-6624 eISSN: 2971-6632

Table 3: Classification of communication protocols and communication networks for intra-vehicle communication

Data Rate	Application Domain	Protocols and Communication Network
Less than 10 Kb/s format	Control data used for driving and passenger monitoring Light Weight Protocol (TTP/A)	Local Interconnect Network (LIN), Time-Triggered
10–25 Kb/s	General data (temperature,	Controller Area Network-Bus. CAN-B), J1850
Format	Humidity sound level, among others) not related to diagnostic or critical information	
125 Kb/s–1 Mb/s	Transmission of information, related to powertrain and chassis	Controller Area Network-Bus (CAN-B).
Higher than 1 Mb/s	Multimedia and infotainment. Media Oriented System Transport (MOST Applications and chassis	
Higher than 1 Mb/s	Multimedia and infotainment, WiFi and Ultra-wideband (UWB)	Media Oriented System Transport (MOST Applications) Digital Data Bus, Bluetooth, FlexRay, ZigBee,

Access Technologies for V2I Communications

Vehicle-to-Infrastructure (V2I) is based on the mobile wireless exchange of vital operational and safety data between vehicles and the roadside infrastructure to enhance the performance of movement systems, according to vehicle detector clearinghouse (2007) and Bargaglis et al., (2012). A variety of access technologies have been proposed for V2I communications. Passive magnetic sensors, pneumatic tube sensors, and inductive loops can use this technology to transmit data to vehicles, pedestrians, or traffic control offices(Road to Growth Business Roundtable, 2015) providing mobile users with broadband access for data exchange in order to enable the implementation of traffic analysis and road safety applications. In recent years, research has concentrated on the advantages of using current and emerging mobile communication standards (such as LTE—X2 interface and 5G Device-to-Device (D2D) Volvo Car2018]) as substitute technologies for delivering automotive applications. The main goal is to use existing communication networks and infrastructures to collect data that can be used to make new Advanced Driver Assistance System solutions for the state of Rivers.

A Low-power Wide Area (LPWA) network is now available globally that can be used in ITS for the transmission of data collected from various sensors (pollution level sensors, temperature and humidity sensors, among others) located on roads and avenues. Recently, the majority of sensors have proven to be a viable solution for exchanging data among IoT devices Volvo Car 2018. For safety applications, latency periods of less than 5 ms may be supported by wireless technology (Department of Transportation, 2007). The biggest drawbacks, however, are the expensive infrastructure costs and the necessity of a carrier subscription or service agreement in order to use the network.

THE COLLOQUIUM -A Multi disciplinary Thematc Policy Journal
www.ccsonlinejournals.com
Volume 10 , Number 1 , 2022 Pages 194 - 208
CC-BY-NC-SA 4.0 International Print ISSN : 2971-6624 eISSN: 2971-6632

Traffic Management Category ITS applications

The traffic flow on roadways and in urban areas is improved by this category. Fixed surveillance systems, which are made up of stationary stations with cameras and sensors put on the roadways to track traffic conditions, are one kind of surveillance application. The second classification is "surveillance-on-the-road," and it employs sensors and cameras built into cars to aid in surveillance (Guerrero Ibáez et al., 2017). Applications for managing lanes are mostly used when there are unusually heavy traffic loads due to incidents, emergency evacuations, or dangerous weather (Bolourchi &Uysal, 2013). This application detects vehicle direction, velocity, and occupancy using radar, cameras, and infrared sensors. A version of lane management systems, special event transportation management systems are used to manage and lessen traffic congestion issues in unique locations like stadiums or convention centres. Based on traffic demands, lanes can be changed in terms of flow direction using sensors (such as radar and infrared) and cameras. Applications for managing intersections in groups work in place of the more conventional traffic light-based approaches to controlling intersections. In order to more effectively coordinate traffic safety, road users, infrastructure, and traffic control centres collaborate in this application. They do this by utilising RFID technology, proximity, ultrasonic, radar sensors, cameras, trajectory planning (Bolourchi & Uysal, 2013), and virtual traffic light modeling (Khamukhin& Bertoldo, 2016). Parking Management Applications (PMA) use magnetometers, microwaves, inductive loops, infrared, or RFID technologies to gather data on parking occupancy and notify drivers about parking opportunities or available spaces close to their zone. By assisting in the management and distribution of parking spaces, PMA helps to lessen the frustration of drivers and traffic issues caused by parking searches. ITS traffic management applications include lane management, surveillance, parking management, automatic tolling, special event transportation, and intersection management. Applications for traffic control are getting more and more significant. To enable the implementation of ITS, it is necessary for all those apps to work together and form a cohesive system. States must improve traffic management by taking a comprehensive approach to the neighborhood and all of the stakeholders. For example, suppose a city is hosting a sizable event, and the traffic authorities decide to set up some regulations to ensure a smoother flow of traffic. In order to optimise arrival at the event, the lane management application changes the number of lanes in the same direction from three north-souths and three south-norths to five north-souths and one south-north. However, the core issue (smooth vehicle flow) is not resolved because most people will search for parking, and as the flow increases, the time to find a spot becomes more unmanageable. The latter is one of the reasons for which it necessitates the methodical integration of all the related applications. In this scenario, lane management and parking management software might collaborate to assign a predetermined automatic parking space without a decision being made in-person.

Diagnostic Category

This category focuses on offering diagnostic services that enable the detection of component failures that could result in a breakdown (Khamukhin & Bertoldo, 2016). These sensors include:

(1) powertrain sensors to check the status and functioning of the mechanical parts and engine of the vehicle in real-time;
(2) sensors to monitor fuel level;
(3) chemical sensors to check fluid quality; and
(4) temperature sensors to check the temperature of fluids.

By sending data directly to the cloud and the vehicle's service and maintenance area, communication technologies can help in this category. A personal vehicle register makes it possible to spot and avoid potential vehicle problems by keeping track of the condition of each vehicle component.

Environment Category of sensor application

In the environmental category, data is collected from sensors installed in or above the pavement to assess factors such as road temperature, road conditions, chemical constituent quantity, and surface friction or grip in order to assess human road conditions. Applications for ITS that monitor the environment include
(a) road weather conditions,
(b) surface conditions, and
(c) pollution management.

Applications for weather forecasting are based on observation, monitoring, and forecasting of weather and road conditions in order to perform the necessary management activities that enhance driving safety and lessen the effects of any unfavourable conditions (Ojha et al., 2017). Applications for road weather are used to help with judgments about upkeep plans and driver advice. On roads, weather stations and infrared sensors are placed to measure air temperatures, precipitation, fog, smoke, and other variables that could make driving more dangerous or influence how roads are maintained. Applications for measuring road factors such as temperature, water content, ice, and snow using clever signal processing and infrared sensors to measure the infrared radiation emitted by the surface (Contreras et al., 2017). The road surface anomalies monitoring programme is one type that searches for abnormalities like potholes or speed bumps using sensors like GPS, lasers, infrared, and accelerometers within the vehicle. The data gathered is utilised to build a map of anomalies for drivers and assist road managers in carrying out infrastructure maintenance and management tasks to maintain driver comfort (Ojha et al., 2017). As was already noted, the work on individual applications did not result in the establishment of an ITS. For traffic management applications to make decisions taking into account not only vehicular flow but also environmental conditions and the surroundings in order to enable a balanced redistribution of traffic and reduce contaminants within a given zone without affecting others, full integration and data exchange supported by cloud computing and intelligent algorithms are crucial. User Category In the user category, sensors track the performance and behaviour of drivers, which is crucial for enhancing traffic safety and lowering accident rates (Figure 8), which incorporates factors including intoxication, weariness, and emotional disorders. According to the technical report of the American Automobile Association (AAA), drunk driving resulted in 30% and 79% of fatally injured drivers in high-income and low-income countries, respectively, while driving while fatigued was responsible for 25% of fatal traffic accidents and 10% of accidents that required hospitalisation (Contreras et al., 2017). The National Highway Traffic Safety Administration (NHTSA) estimates that distracted driving contributed to 15% of fatalities in 2021. Applications that alert drivers about drowsy driving employ cameras to track the motion of the eyes and head to look for indicators of tiredness. Radar sensors monitor the movement of the vehicle and detect abnormal driving. Steering angle sensors can be used in a variety of applications to identify driving anomalies. Vibrations or audible alerts are given to the driver within the car.

ITS User Monitoring Applications system ,

This application monitors (a) the driver's health and emotions, (b) drowsy driver warning, and (c) driver alert control. Driver alert control applications use front-facing video cameras to track the left and right lane markings to alert the driver if the vehicle drifts outside of those lanes, thus helping reduce the probability of an accident. When the lane is not clearly visible or erased, a camera can be used to monitor the driver by looking for signs of fatigue. The driver is alerted by a sound signal and a flashing message in the control panel of the vehicle (Ojbha et al., 2017). and evaluated drivers' stress (Guerrero-Ibáez et al.,2013) have been published. These applications can be classified into broad categories: first, car makers need to create non-intrusive sensors for the driver and car occupants' spots (sensors inside the seat, cameras in strategic spots) to help lessen the burden of the driving task. On the other hand, it is necessary to create intelligent algorithms based on AI, neural networks, machine learning, computer vision, cloud computing, fog, among others, to accurately identify different emotional statuses or abnormal physical conditions in the driver and the passengers in order to produce trustworthy notifications to the corresponding authorities or designated people.

Assistance category application system

Pre-trip information applications collect information about different road conditions, producing several trip options for various driving routes. Parking spot locator applications allow drivers to find available parking spaces at locations such as streets, garages, or parking lots. Magnetometers, RFID technologies, and GPS are used to collect data from different parking spots and can offer drivers a wide variety of opportunities to park their vehicles. Tourist and events applications are developed to cover the needs of travellers in unknown areas. Drivers are assisted in finding the most important places in a city, empty parking slots, and routes when they travel to major events (sporting games or concerts). Applications use the data collected from sensors (radar sensors, cameras, inductive loops, and weather sensors) deployed near the destination.

According to Zhang et al., (2014), the vehicle monitoring system detects a potentially dangerous situation using built-in and outside-vehicle sensors and wearable sensors on passengers; Hence, they are constantly deploying intelligent sensors within the physical infrastructure and within vehicles and mobile sensing units and systems based on computational vision. However, sensors by themselves cannot solve the mobility challenge. To improve transportation systems, we need the integration of other technologies and devices such as data analytics, automated operation tools, decision-making tools, and social and mobile networks to fulfil the requirements for a complete integration to capture, analyze, and share in real time, with the relevant parties, all the information generated by all the different sources. One of the main challenges faced by intelligent movement systems is the monitoring of sensing devices' ranges located on roads, vehicles, and transportation infrastructures. Currently, sensing systems are faced with a lack of or damaged infrastructure such as: blurry or erased transit lines, inadequate or, in some cases, inexistent traffic signals, fast object detection (pedestrians, cyclists, gravel, tyre residues, or animals) or risky road conditions (holes in the road, a sudden change in road surface from pavement to another material, and road floods or environmental conditions that could pose a threat to the vehicle's passengers).

However, we must carefully determine where the real constraints and reach ability exist, as well as the algorithms that process sensor data. For example, if a vehicle is travelling at a high speed and the front sensors detect an obstacle (vehicle or object), and the algorithms' information processing time to select the alerting interface or the selected control system is too high, we may not receive the appropriate response in time before the impact. To reduce the likelihood of an accident, different types of sensors, infrared and photogrammetric systems along with efficient algorithms for multisource data fusion could interact and produce better vehicle response times in all driving conditions and improve maps produced in terms of better identifying traffic and road risky conditions (Bapat et al., 2017). Data fusion techniques have been extensively used in multisensory environments with the aim of fusing and aggregating data from different sensors according to the following criteria:

(a) Relationships between input data sources: supplementary data, redundant data, or cooperative data (Ojha et al., 2017),

(b) Data input/output type Architecture can be centralized, decentralized, or distributed,

(c) Data abstraction level: raw measurement, signals, characteristics, or decisions (Bapat et al., 2017).

The type of data and the different data sources are crucial in addressing many challenges related to transportation systems, such as seamless integration of data from a set of independent data sources that respond in real-time to the needs of actual traffic requirements. Data fusion techniques must be integrated with AI to allow the vehicle to understand the current state just as a human would and react accordingly, including anticipating different contexts and scenarios (Ojha et al., 2017).

Fusion between Sensors and Artificial intelligent

The future integration of thought inference into the car's control system could be made possible by this fusion of sensors and AI, which would help the car react more quickly to potential accident situations. The use of new tools, such as machine learning and data fusion, can provide more data to boost ITS performance by employing applications that learn transportation behaviour from real-time and historical data. Sensors can generate useful data of transportation systems. Fusion strategies are used to combine data from various sources in order to analyze and forecast a variety of conditions, such as traffic dynamics or driver behaviour. Based on association rules, machine learning is used to identify useful patterns and trends among various traffic data sources (Bapat et al., 2017). Creating effective learning-driven algorithms to identify and forecast traffic patterns and improve the performance of transportation systems is the challenge at hand. The challenge is the design and development of algorithms that analyse the data in order to: I perform data cleansing to remove anomalous data gathered by sources when data samples are collected from various sources (such as cameras and sensors) and are transmitted by various media (through wired/wireless links). In order to preserve the interpretability of the remaining features, some redundant features from the original feature space were removed (Ojha et al., 2017); and (iii) data from various sources were compared and fused (Bapat et al., 2017). Reducing intrusiveness on two levels is crucial for ensuring the privacy and security of automobiles. First, we should incorporate security and privacy protocols into the communication devices that are supported by the communication networks to safeguard drivers' or passengers' privacy within the vehicular network environment. Because the sharing of information in a connected environment can enable users to be identified, we should prevent the vehicle's occupants from disclosing any information that could lead to a potential privacy risk. Additionally, the incorporation of new devices into vehicles necessitates that they be positioned inside or outside the vehicle optimally in order to avoid distracting the driver while also enhancing his or her comfort by providing all necessary information about the various areas of the vehicle. Second, it's crucial to think carefully about the best interface for notifying the driver. Making systems to reduce distractions, such as alarms and information about the roadside infrastructure, is one potential answer. AI may also be used to automate some jobs based on human inference. The integration of many equipment within the vehicle is necessary to provide the driver with a 360-degree view, as this will expand the detecting range and the precision of the detection by utilising a variety of information sources. However, the associated hardware and software expenditures will be expensive in order to accomplish this goal. A significant amount of information will also be produced. The alert calculation could need a lot of processing resources. As a result, we must provide the best processing algorithms to decide which interface will alert the driver. The researcher must carefully balance the amount of sensing and alerting devices while keeping the cost of the vehicle competitive because high expenses would reduce sales of the vehicle. One strategy is to accelerate the rate of object detection and enhance the level and field of vision of the moving vehicle (Ojha et al., 2017). These advancements will allow for a quicker and more effective reaction to emergency circumstances.

Conclusion

Sensors will be a key part of ITS in the future. Their use enables the creation of a wide range of applications for driving assistance, entertainment, and traffic control. In order to address some of the issues that both the past and present transportation systems have encountered, sensors offer a mechanism for data collection pertaining to the vehicular context (such as road conditions, traffic conditions, and vehicle conditions). The application of analytical and statistical methods exemplifies the true potential of sensor integration with ITS. This integration is a potential study topic that will allow for the creation of numerous next-generation smart applications with the goal of enhancing traffic management and safety in both current and future transportation systems.

References

Abdelhamid, S., Hassanein, H.S., &Takahara, G. (2014). Vehicle as a Mobile Sensor. *Procedia Comput. Sci.*,34, 286–295.

Ahmad, F., Basit, A., Ahmad, H.,Mahmud, S.A., Khan, G.M. & Yousaf, F.Z. (2013).Feasibility of deploying wireless sensor based road side solutions for Intelligent Transportation Systems. In Proceedings of the 2013 International Conference on Connected Vehicles and Expo (ICCVE), Las Vegas, NV, USA, 2–6 December; pp. 320–326.

Alaiad, A., & Zhou, L., (2017). Patients' Adoption of WSN-Based Smart Home Healthcare Systems: An Integrated Model of Facilitators and Barriers. *IEEE Trans. Prof. Commun*., 60, 4–23.

Albaladejo Pérez, C., Soto Valles, F., Torres Sánchez, R., Jiménez Buendía, M., López-Castejón, F.,& GilabertCervera, J. (2017). Design and Deployment of a Wireless Sensor Network for the Mar Menor Coastal Observation System. *IEEE J. Ocean. Eng*, 1–11.

Bapat, V., Kale, P., Shinde, V., Deshpande, N.,& Shaligram, A. (2017). WSN application for crop protection to divert animal intrusions in the agricultural land. *Comput. Electron. Agric*, 133, 88–96.

Bargagli, B., Manes, G., Facchini, R., & Manes, A. (2012). Acoustic sensor network for vehicle traffic monitoring. In Proceedings of the First International Conference on Advances in Vehicular Systems, Technologies and Applications, Venice, Italy, 24–29 June

Bolourchi, P., &Uysal, S. (2013).Forest Fire Detection in Wireless Sensor Network Using Fuzzy Logic. In Proceedings of the 2013 Fifth International Conference on Computational Intelligence, Communication Systems and Networks, Madrid, Spain, 5–7 June ,pp. 83–87.

Business Roundtable (2015).Road to Growth, the Case for Investing in America's Transportation Infrastructure. http://businessroundtable.org/sites/default/files/2015.09.16%20Infrastructure%20Report%20-%20Final.pdf

Contreras, J., Zeadally, S., & Guerrero-Ibanez, J.A. (2017). Internet of Vehicles: Architecture, Protocols, and Security. *IEEE Internet Things*

Department of Transportation (2007) . *National Highway Traffic Safety Administration. Technical Report: Federal Motor Vehicle Safety Standards; Tire Pressure Monitoring Systems; Controls and Displays* . https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/fmvss/TPMSfinalrule.pdf

Fleming, W.J. (2008).New automotive sensors—A review. *IEEE Sens. J*, 8, 1900–1921.

Geetha, S., & Cicilia, D. (2017). IoT enabled intelligent bus transportation system. In Proceedings of the 2017 2nd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 19–20 October, pp. 7–11.

Guerrero Ibáñez, J.A., Cosío-Leon, M., Espinoza Ruiz, A., Ruiz Ibarra, E., Sanchez López, J., Contreras-Castillo, J., & Nieto-Hipolito, J. (2017). GeoSoc: A Geocast-based Communication Protocol for Monitoring of Marine Environments. *IEEE Latin Am. Trans*, 15, 324–332.

Khamukhin, A. A., & Bertoldo, S. (2016).Spectral Analysis of Forest Fire Noise for Early Detection using Wireless Sensor Networks. In Proceedings of the International Siberian Conference on Control and Communications (SIBCON), Moscow, Russia, 12–14 May, pp. 1–4.

Mathew, T.V. (2014). Transportation Systems Engineering. IIT Bombay.http://nptel.ac.in/ downloads/105101008/

Ojha, T., Misra, S., & Raghuwanshi, N.S. (2017). Sensing-cloud: Leveraging the benefits for agricultural applications. *Comput. Electron. Agric*., 135, 96–107.

Orie,C. J. (2018).New Automobile System :International Conference on Connected Vehicles and Expo (ICCVE), Las Vegas, NV, Germany , 2–6 December 2016 pp. 320–326.

Population Reference Bureau (2016). World Population Datasheet, Inform Empower Advance http://www.prb.org/pdf16/prb-wpds2016-web-2016.pdf

The Vehicle Detector Clearinghouse (2007). A Summary of Vehicle Detection and Surveillance Technologies Used in Intelligent Transportation Systems. https://www.fhwa.dot.gov/policyinformation/ pubs/vdstits2007/vdstits2007.pdf

Texas A & M Transportation Institute (2015). Technical Report 2015 Urban Mobility Scorecard, INRIX. https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-scorecard-2015.pdf

United Nations Population Fund (UNFPA) (2011). State of World Population 2011: People and Possibilities in a World of 7 Billion; Technical Report; United Nations Population Fund: New York, NY, USA

Utin , A. Y. (2018). Automotive Sensors and Electronics Expo. http://www.automotivesensors2017.com.

USA Today (2020). NHTSA to Require Backup Cameras on All Vehicles. https://www.usatoday. com/story/money/cars/2014/03/31/nhtsa-rear-view-cameras/7114531/

Volvo Car (2020). City Safety w/Collision Warning.http://volvo.custhelp.com/app/answers/ detail/a_id/9766/~/city-safety-w%2Fcollision-warning

Zhang, Y., Sun, L., Song, H.,&Cao, X. (2014). Ubiquitous WSN for Healthcare: Recent Advances and Future Prospects. *IEEE Internet Things J.*,1, 311–318.

Cite this article as

Orie, C. J. (2022). Sensor Technologies perception for Intelligent vehicle movement systems on Nigerian road network. *THE COLLOQUIUM*, 10(1), 194 – 208

Zhou, Y., Dey, K.C., Chowdhury, M., & Wang, K.C.(2017). Process for evaluating the data transfer performance of wireless traffic sensors for real-time intelligent transportation systems applications. *IET Intell. Transp. Syst.*, 11, 18–27.

Ziraknejad, N., Lawrence, P.D., & Romilly, D.P. (2015). Vehicle Occupant Head Position Quantification Using an Array of Capacitive Proximity Sensors. *IEEE Trans. Veh. Technol*., 64, 2274–2287.