Review

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4IR Applications in the Transport Industry: Systematic Review of the State of the Art with Respect to Data Collection and Processing Mechanisms

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Review

4IR Applications in the Transport Industry: Systematic Review of the State of the Art with Respect to Data Collection and Processing Mechanisms

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Abstract: Transportation systems through the ages have seen drastic evolutions in terms of transportation methods, speed of transport, infrastructure, technology, connectivity, influence on the environment, and accessibility. The massive transformation seen in the transportation sector has been fueled by the industrial revolutions which have continued expansion and progress into the fourth industrial revolution. However, the methodologies of data collection and processing used by the many drivers of this progress differ. The significance of standardized data and its mode of collection cannot be overstated as it has a major impact on the process outcomes. In order to achieve a better understanding of the impact of this, this study methodically reviewed the literature on the subject of the data collection and processing mechanism of 4IR technologies in the context of the transport industry with an emphasis on the areas of accomplishment of several studies and drawing attention to their limitations. Although the industry has advanced significantly as a result of the adoption and application of various research studies in this field, considerable focus needs to be placed in the areas of standardized data collection and computational approaches, which will ultimately assist in achieving various benefits in the transportation industry.

Keywords: transportation systems; systematic review; industrial revolution; data collection; data processing

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1. Introduction

The word 'Transport' can be considered to be a partition-able word (trans - port), where trans is a prefix that emanates from Latin referring to the movement or carrying from one place to another. The suffix 'port' on the other hand implies a place (city, town or land) having access to water through which loads can be conveyed from one end to the other. Transportation systems could therefore be described as a means of moving items, goods, people, and objects from one point to the other. It can also be described as a passage of conveying things from one location to the other in a safe mode. The authors in [1] highlighted that a sustainable transport system must provide mobility and accessibility to all urban residents in a safe and environment friendly mode of transport.

Transportation systems are intricately interwoven with nearly every facet of human activities, from work and production, to leisure and consumption, supporting a worldwide flow of goods, and linking societies. It is little wonder that the authors in [2] described it as the backbone of any economic, culture, social and industrial development. As these large technical systems become a pervasive and integral constituent of modern society, the manner in which human forces perceive,

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analyze and attempt to shape the development of these systems becomes increasingly complex, and increasingly important [3].

Mobility in the olden age can be considered undoubtedly different from modern day transportation in which transportation was achieved through the use of animals (horse-riding, donkey-riding, oxen-riding) and wheeled vehicles (wagons and carts). Today, transportation systems have witnessed significant evolution that have been driven largely due to changes and development in digital technologies which include Artificial Intelligence, Bigdata, Machine Learning, Blockchain, Cloud Computing, IoT, Fog Computing, etc. The level of impact of these technologies in easing mobility cannot be over-emphasized. The revolution that started in the 18th century undoubtedly has had huge impacts in the growth recorded in the transport sector and gave birth to a modern transportation structure that is today described as intelligent transportation system (ITS).

Figure 1 provides an overview of the various industrial revolutions. The first industrial revolution (1IR) contributed immensely to economic and industrial changes. The transportation industry was not left out in the impacts of the revolution which occurred between the mid-18th century to early 19th century. The traditional mobility approaches were transformed through the innovation of the steam-locomotive which contributed to transportation across the rails as well as steamboats that paved the way for movement of goods and persons across waterways, seas, and oceans. The second industrial revolution (2IR) surfaced in the year 1870 and its impact lasted till around 1914. While 1IR witnessed large mechanical production, the 2IR saw an extensive and expansive revolution of the first revolution as mass production was witnessed. There was expanded railroads, innovation of steamships, automobiles which lead to faster movement, and the development of bicycles and electric tramps/trolleys eliminating horse-based transportation mode. The end of the 1980's witnessed a boom in automated production as the 3IR was birthed; it brought a significant shift with the introduction of digital transformation. The revolution was a hybridization of 1IR and 2IR, and the innovations recorded here include but not limited to renewable energies, internet, communication systems, digital computing as against analog, distributed system, biotechnologies, and micro-electronics. The integration and deployment of these innovations lead to a sustainable global economy. Cyber-physical systems (CPS) was key in the birth of the 4th revolution in 2016 that was first defined after the World Economic Forum (WEF) [4] The revolution saw the adoption of Artificial Intelligence, Internet of Things (IoT), Big Data, Machine Learning, Virtual and Augmented Reality, and Blockchain, and emerging digital transformation approaches are contributing to the current great transformative experience being experienced in the evolution of the industrial space.

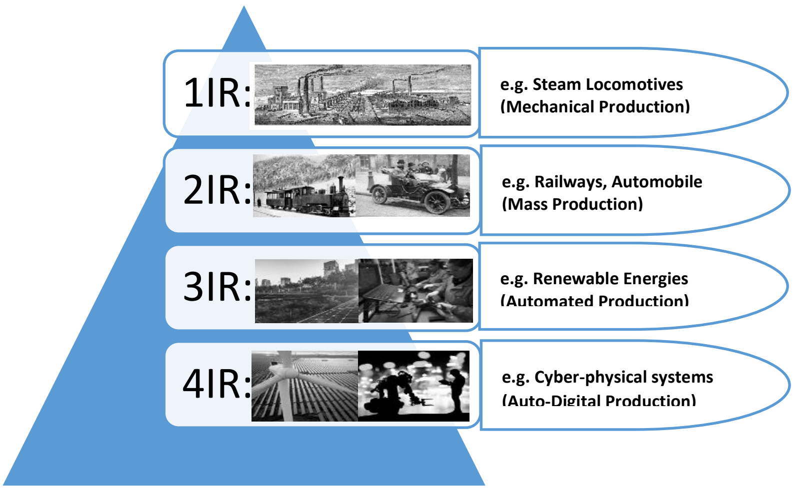

Figure 1. The Industrial Revolution (Authors).

Based on a prompting research question considered in this study: 'What technologies played a significant role in the various revolutions', Table 1 provides a summary of the impact on the

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Transport System while Figures 1 and 2 provides an overview of the trends of the evolutionary impact, and the relationship between the technological revolutions, respectively.

Table 1. Technologies that made a Revolutionary Impact on Transportation Systems (Authors).

S/N	Major technology	1st Revolution (1IR)	2nd Revolution (2IR)	3rd Revolution (3IR)	4th Revolution (4IR)
1.	Artificial Intelligence				✓
2.	Big data				✓
3.	Machine Learning				✓
4.	IoT				✓
5.	Blockchain				✓
6.	Smart Grid			✓	✓
7.	Cloud Computing			✓	✓
8.	Robotics			✓	✓
9.	Virtual and Augmented Realities				✓
10.	3D Printing			✓	✓
11.	Drones				✓
12.	Fog Computing				✓
13.	Internet Technology			✓	✓
14.	Communication Technology		✓	✓	✓
15.	Autonomous System				✓
16.	Quantum Computing				✓
17.	Electrical Technology		✓	✓	✓
18.	Energy/Power Technology	✓	✓	✓	✓

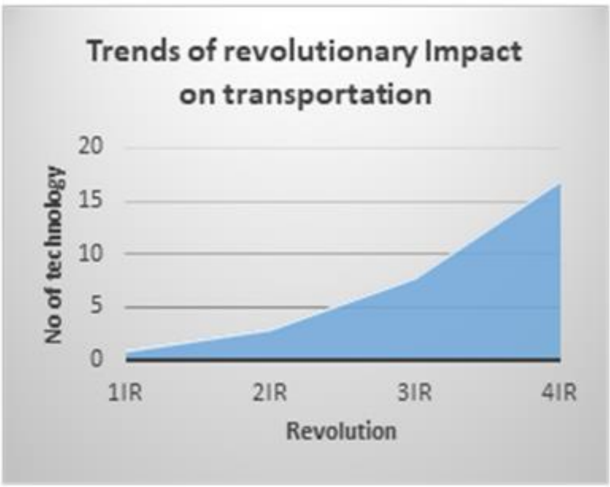

Figure 2. Trends of revolutionary impact on transportation.

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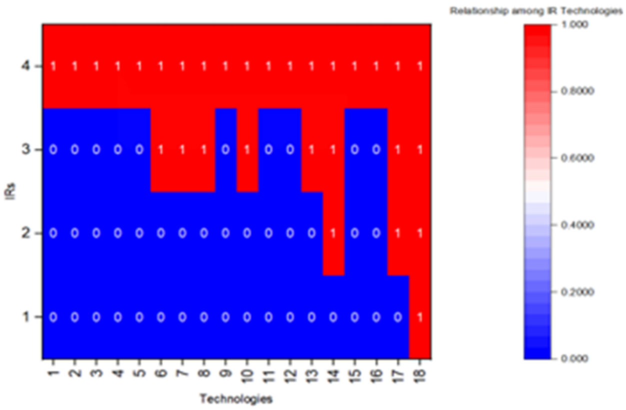

Figure 3. Relationship among the technologies. (Authors).

A critical look at the transportation ecosystem shows that these technologies are enhancing safety and efficiency, streamlining operations, and enabling data-driven decision-making. Several systematic literature review research works have been carried out on the general influence and impact of the 4IR technologies on the transportation sector ([5–32]), while others discussed the different contributive areas of specific technologies, such as Internet of Things(IoT)/Sensors ([33–40]) to achieve the interconnection of vehicles, infrastructure and users through a network of sensors and smart devices; Autonomous Systems ([41,42]) which ensures safety, efficiency and accessibility; Big data ([36,43–56]) to ease the burden of large data analytics; Artificial Intelligence ([57–77]) which enhances analytical capabilities and achieving streamlined transportation operations; Machine Learning/Deep Learning ([39,78–105]) which are deployed to achieve predictive data analysis, optimization and decision support; Computing Paradigms ([35,40,106–112]) for storage and processing of vast amount of generated and real-time data; GIS ([46,113–118]) for spatial analysis, mapping, and infrastructure management.

The use of 4IR technologies in the transportation sector is transforming the way transportation systems function improving efficiency, safety, and sustainability. This is especially true when it comes to data collection and processing. Though the 4IR technologies demonstrated great prowess in transforming the transportation industry and are aiding the fulfilment of a smart transportation network, these technologies rely heavily on data. Thus, the goal of this study is to systematically unravel the data collection and processing mechanisms of these technologies.

2. Methodology

A S4-Cardinal approach was adopted in this study as a procedure for the execution of the systematic review considered in the study. The first is the Source Selection; the second is a Search Key Approach; the next is the Selection of Closely Related Papers; while the last is a Systemic Analysis of Highly Related Articles.

Source Selection

Essential literature that addressed the subject under investigation were accessed (relevant articles published between 2014 and 2023 (10years)) from recognized publishing outlets and repositories. The selected database sources (IEEE Xplore, Elsevier Science Direct, ACM, Taylor and Francis, Springer, MDPI, and Google Scholar) were based on the premise of their vast collection of peer reviewed journals with high density/repository of engineering, computing science and technology related articles. The source selection as seen in Table 2 shows the number of papers retrieved from the various chosen publishing outfits, while Figure 4 provides a graphical representation.

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Table 2. Publishing Outfits/Search Engines and the number of papers retrieved.

S/N	Publishing Outfit/Search Engine	Number of Papers Retrieved
1.	IEEE Xplore	79
2.	Elsevier Science Direct	5
3.	ACM	1
4.	Taylor and Francis	1
5.	Springer	4
5.	MDPI	7
6.	Google Scholar	35
Total		**132**

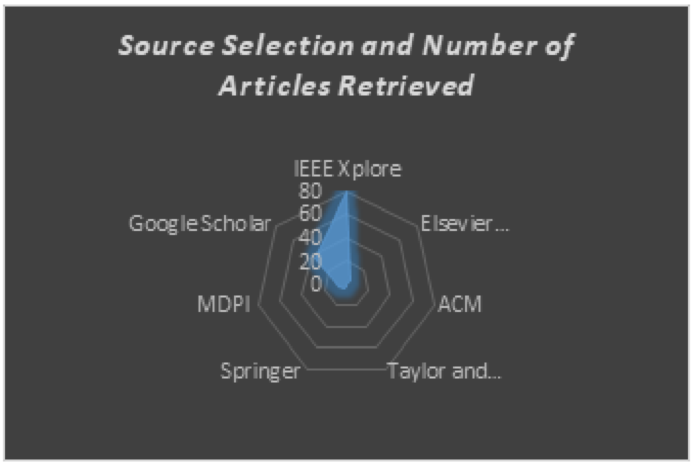

Figure 4. Source Selection.

Search Key Approach

Table 3 shows the search words used to retrieve the articles used for this study as well as the number of articled retrieved under each group. The search were partitioned into two clusters; the first centers on '4IR technologies' while the second targets at retrieving more relevant papers using the key 'Data Collection and Data Processing'. The search was limited to papers from 2014 to 2023 with the intent of covering research articles that did not date back more than 10 years.

Table 3. Search keywords and number of articles retrieved.

<table>
<tr><th>S/N</th><th>Search keywords</th><th>Number of Papers Retrieved</th></tr>
<tr><td rowspan="4">1.</td><td>4IR technologies and the transportation system</td><td rowspan="4">116</td></tr>
<tr><td>Impact of 4IR technologies on transportation system</td></tr>
<tr><td>Application of 4IR technologies on transportation system</td></tr>
<tr><td>4IR and the transportation system</td></tr>
<tr><td>2.</td><td>Data collection and processing approaches in the application of 4IR technologies</td><td>16</td></tr>
<tr><td colspan="2">Total</td><td>132</td></tr>
</table>

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Selection of closely related articles

First, articles that do not focus logically on the subject of this research but offers research tips on the domain and are in the form of newsletters, textbooks, whitepapers etc., were filtered and archived in folders while the research work progresses (Figure 5)(38 in number). Also, journal articles that were not directly parallel to this study but suggested future work in a relative way were separated and archived (Figure 5)(40 in number), while the entire used articles were systematically partitioned into two; survey/systematic literature review (SLR) papers, and experimental/analytical papers, totaling 132 (Figure 5). Table 4 and Figure 6 further present information on the number of articles used and unused in the study.

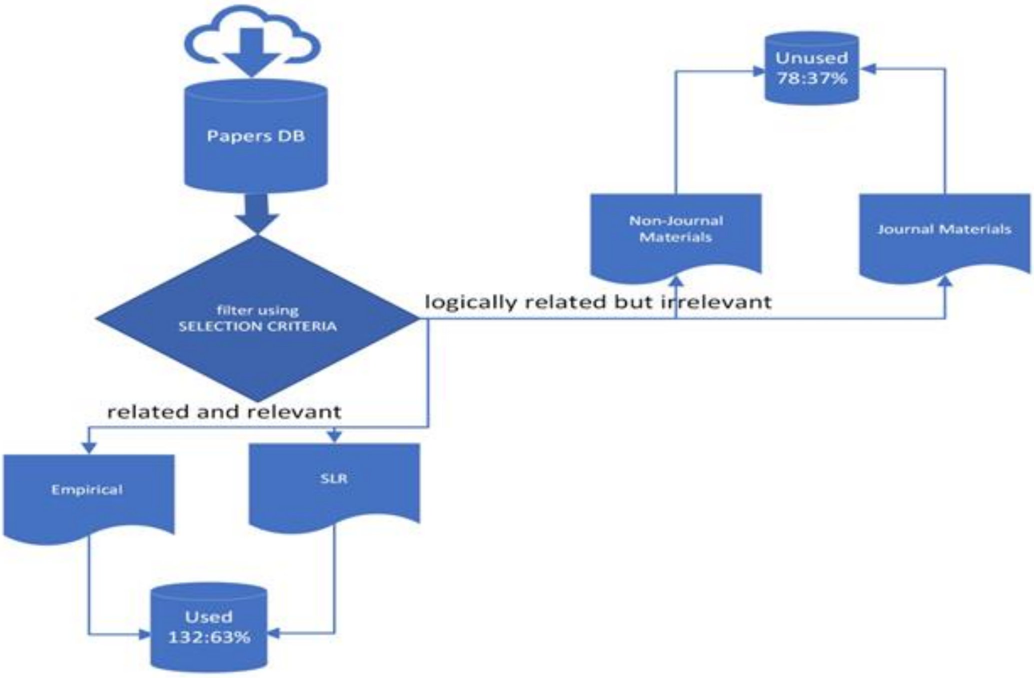

Figure 5. Article Types.

Table 4. Articles Accessed.

S/N	Articles Accessed	Number of Papers
1.	Used	132
2.	Unused	78
Total Accessed		**210**

Figure 6. Articles Accessed.

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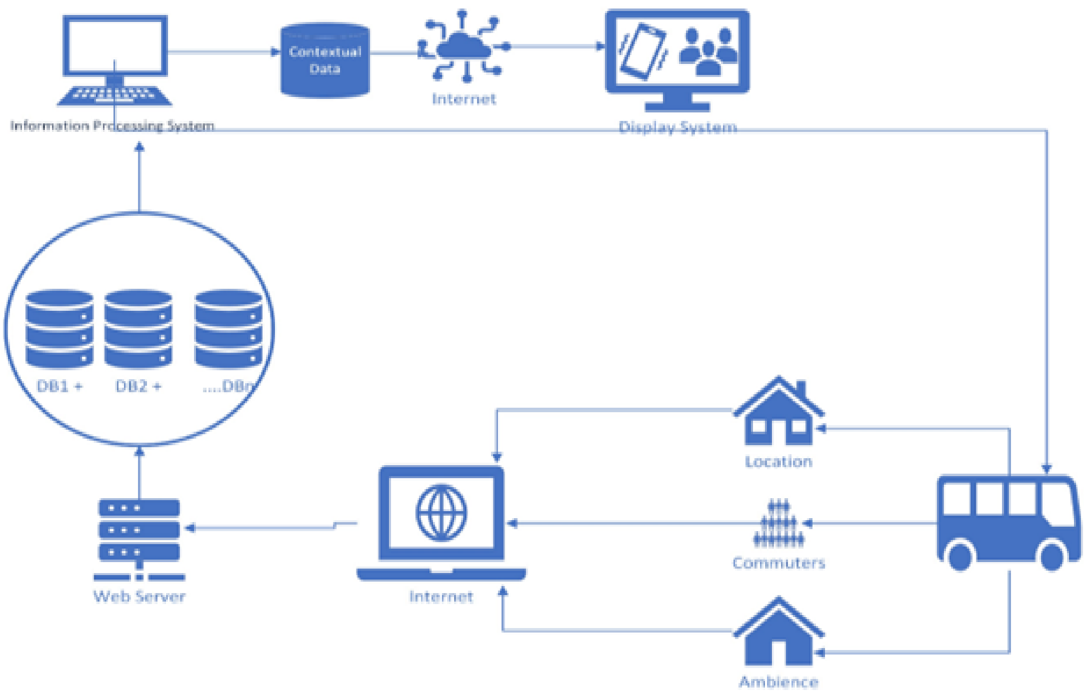
3. Systematic analysis of the application of 4IR technologies in the transport industry: a look into the data collection and processing approaches

Technologies of the Fourth Industrial Revolution (4IR) are changing many industries, and the transportation industry is no different. The confluence of technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), big data, and cloud computing is revolutionizing the transportation sector at a rate never seen before. The merger of digital, biological, and physical technology has given rise to previously unheard-of degrees of automation, connectedness, and intelligence, defining this new era. The transportation ecosystem as a whole is becoming safer and more efficient thanks to these technologies, which is also enabling data-driven decision-making and the optimization of operations. The transportation industry is undergoing a transformation in its operations with the deployment of 4IR technologies, especially in data collecting and processing, improving sustainability, safety, and efficiency. Because of their heavy reliance on data, these technologies cannot function properly without efficient data collection and processing.

The authors in [119] considered 'An Internet of Things-Based Intelligent Transport System'. The study which aimed at developing a prototype of an intelligent transport system that tracks vehicles, enables payment ticket, analyze crowd and ambience inside the bus, deployed a prototype model approach using sensor, monitoring and display systems. Figure 9a and 9b show the system architecture and the storage process model.



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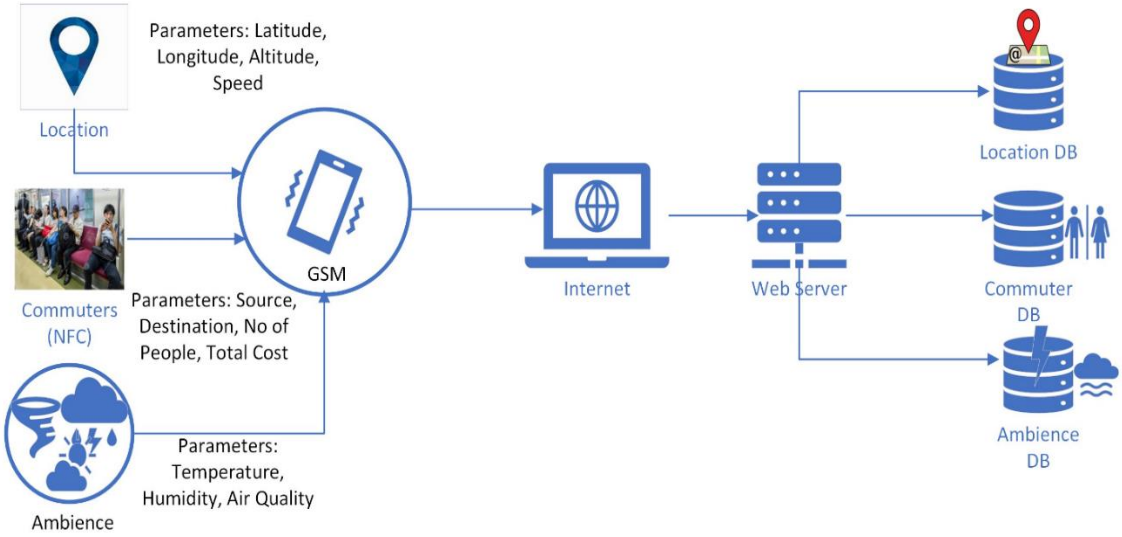

Figure 9. a: System Architecture [119]. b: Storage Process Model [119].

A system that tracks/detects vehicle location, commuter information and the ambience was successfully developed.

An IoT-based smart transportation system was considered by the authors in [120]. The study's main objective was to deploy IoT technologies to build intelligent transport systems in improving urban transportation system. For the methodology, the study used wireless sensors to obtain real-time traffic information. The study successfully developed a real-time traffic controlling and monitoring system that reduced traffic congestion in the urban area.

In [121], literature review illustrating the application of trajectory data in six (6) areas of road transportation systems was presented. Twenty (20) million GPS traces illustrating existing applications of trajectory data and suggesting new applications of trajectory data were explored. A density-based clustering machine learning algorithm was applied on the GPS trajectories dataset of 20 million trips in Maryland which was recorded during February, June, July and October 2015. V-Analytics software was used for visual data exploration, analysis and modelling. The study was able to demonstrate both existing and new applications of trajectory data in transportation system. However, issues relating to sampling rate, spatial precision, division of trajectories into trips, population bias, and device identification needed to be considered before purchasing and using trajectories data.

The authors in [122] considered an 'Intelligent Transportation System using IoT'. The study aimed at designing a smart information system that provides all relevant interconnecting information about a bus, with focus on seating information. The authors proposed a framework based on IoT using touch sensor, which detects occupied and empty seats. The study successfully implemented a system that provides real-time information about exact location, arrival time, and seat availability of a bus. However, waiting time and traffic congestion were not taken into consideration.

The authors in [123] predicted traffic congestion based on LSTM through the correction of missing temporal and spatial data (Figure 10a). The model achieved higher prediction accuracy for suburban areas in comparison with other relevant models (Figure 10b).

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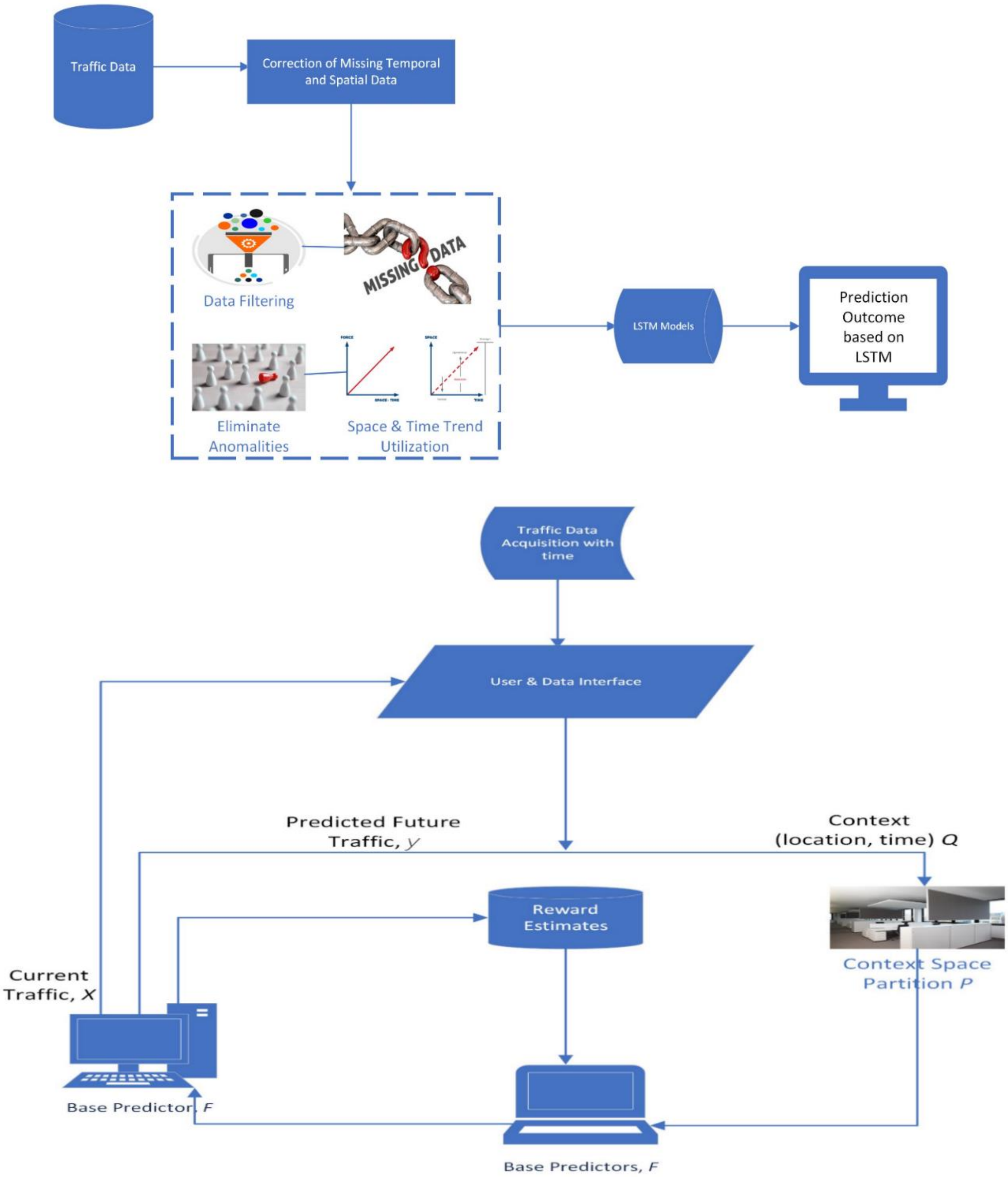

Figure 10. a: LSTM Process Architecture [123]. b: System Prediction Architecture [123].

However, the model was not implemented for predicting low-speed regions and urban areas.

The study in [124] centered on designing an intelligent real-time public transportation monitoring system based on IoT. The study aimed at designing a system that reduces passengers' waiting time. The system was implemented based on IoT technology using GPS and microcontrollers. The implemented system was able to compute real-time information about buses (e.g. current location, arrival time, speed etc.)(Figure 11).

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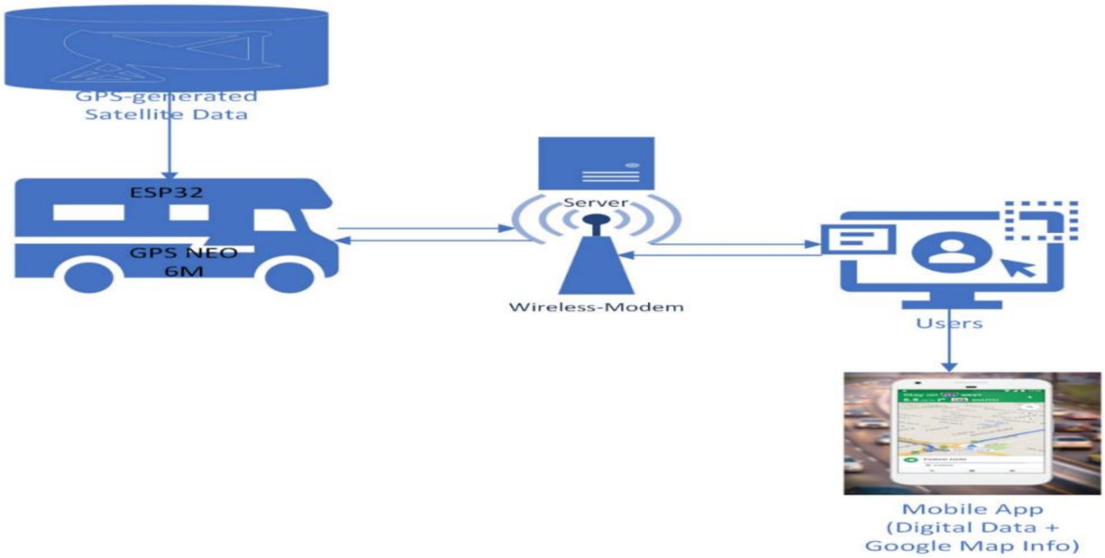

Figure 11. System Architecture [124].

The study was however unable to implement passenger count and e-ticketing.

In [36], a prototype model approach was adopted for developing an IoT-based system called Smart Vehicle Assistance and Monitoring System (SVAMS) that solves most traffic related issues. The developed prototyped smart transportation system (Figure 12) was able to solve traffic related issues such as vehicle location, speed, and emergency notification.

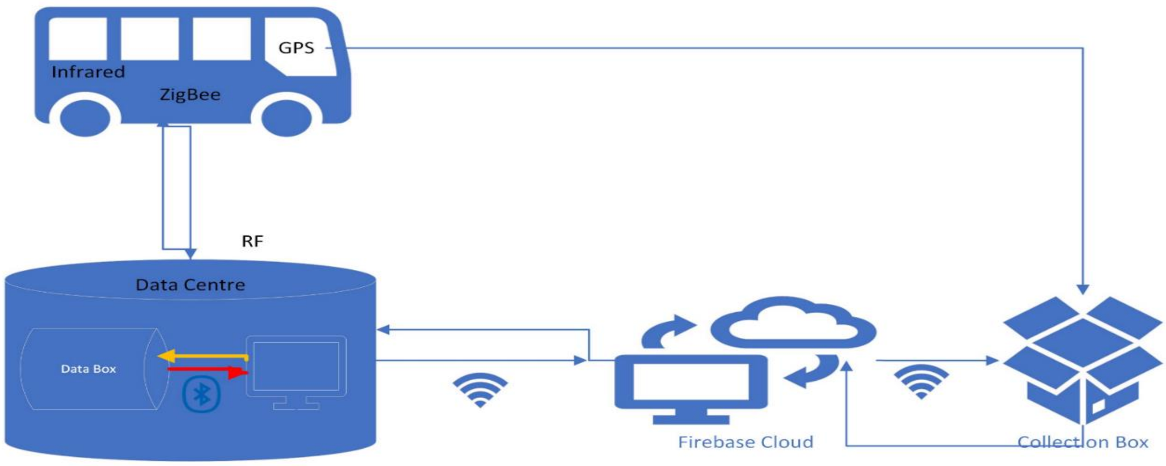

Figure 12. Model Architecture [36].

The aim of the study in [125] was to model, monitor and control traffic. The work which utilized an STMS model showed superior results in the modeling of traffic congestion. [126] presented an enhanced intelligent transport system with Road-Side Units (RSU) that made use of IoT. The study used a Raspberry Pi Board as the main component for real-time data/information collection, while ZigBee wireless technology was used for communication (Figure 13). The study implemented IoT-based road-side units for intelligent transport system with the aid of OpenCV library. However, precise vehicle counts for overlapping of vehicles was not achieved.

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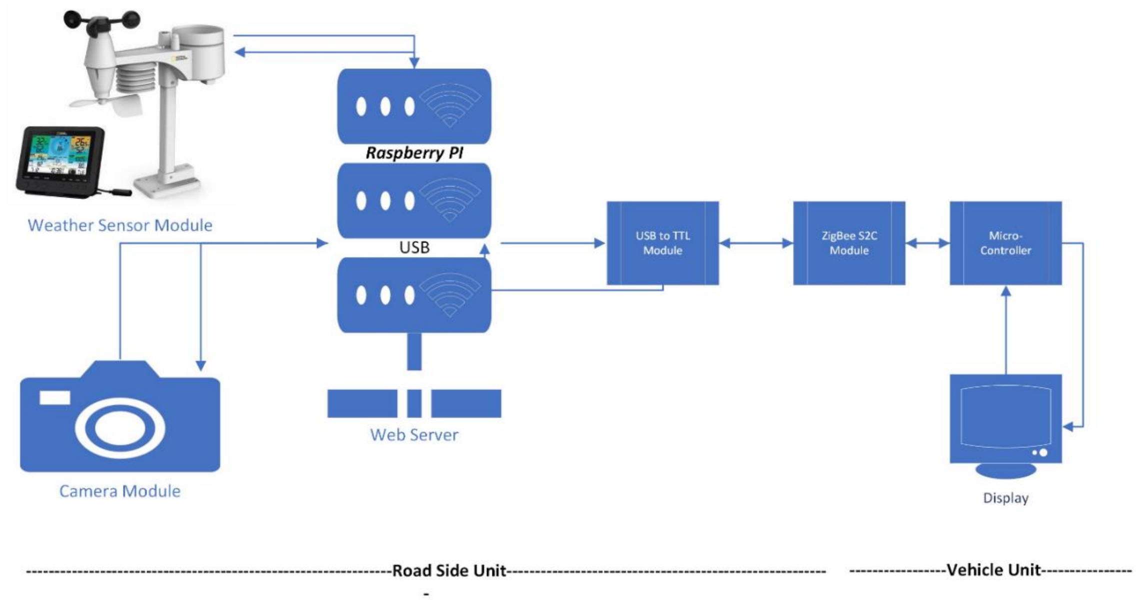

Figure 13. Model Architecture [126].

The study in [114] considered an architecture for IoT-based smart transportation security systems to address several IoT challenges in relation to cyber-physical security etc. The study, which applied geospatial modelling approach, was able to successfully simulate a set of geospatial indicators that support master planning of IoT networks in facilitating the running of smart transportation security system.

The study in [127] worked on smart transportation in developing countries. The study highlighted the challenges and consequences of existing transportation system in response to rapid population growth. The study adopted an IoT-based framework for busy traffic junction which was successfully implemented to reduce travelling time, fuel consumption and environmental pollution. However, the framework was limited in the number of actors used, which might have possible effects on the effectiveness of the system on highly congested traffic scenario.

Parking occupancy prediction and traffic assignment in a university environment was considered in [128]. The goal of the work was to investigate traffic assignments based on parking prediction. In the study, ensemble machine learning models were deployed to predict the parking space after data were collected from accumulated copy of the parking availability posted on digital signs at the garages' entrances. The work successfully applied ensemble machine learning models in accurate and precise prediction of ITS (Figure 14).

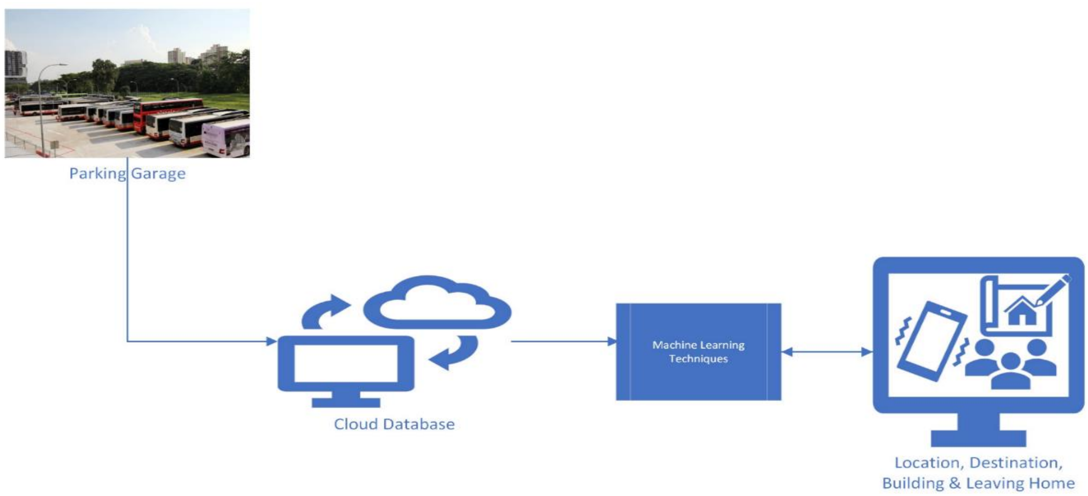

Figure 14. Study Architecture [128].

The authors highlighted however that the deployment of deep learning models could yield a more accurate and precise prediction of ITS.

The work considered in [129] considered the 'Selection of emerging technologies: A case study in technology strategies of intelligent vehicles'. The study investigated key factors in order to identify effects on ET selection. The work proposed a preliminary PTM framework for ET selection. Qualitative analysis of factors that affect ET selection were carried out. The result proves the need for more detailed criteria of PTM factors and corporate internal capabilities to be established.

The authors in [130] worked on IoT-based emergency vehicle services in intelligence transport systems. The study was aimed at obtaining a better clearance time and lower response time for emergency vehicles, adopted unmanned aerial vehicle (UAV) guided priority-based incident management model.

Digital transformation of the automotive industry through an integrating framework to analyze technological novelty and breadth was the focus of [131]. The study which aimed at identifying digital technology topics that are transforming the automotive industry utilized integrating frameworks to illustrate the value of digital technologies. The result of the study using library pyLDAvis to visualize shows that digital technologies in the automotive industry have incremental characteristics to achieve potentials in transforming the industry. The study recommended a combinatorial radical (hybrid) application for implementing automotive control system such as collision prevention assistance technology.

The study in [132] researched the real-time implementation of machine learning-based data collection protocols for intelligent transport systems using Dublin M50 as case study. The goal of the study was to induce learning within vehicles to operate on the basis of previously processed data. A lightweight machine learning-based data collection protocol was proposed. The methodology was aligned with Apache Spark data processing engine coordinated with Dynamic Segmentation Switching (DSS) that enables road segments division (Figure 15).

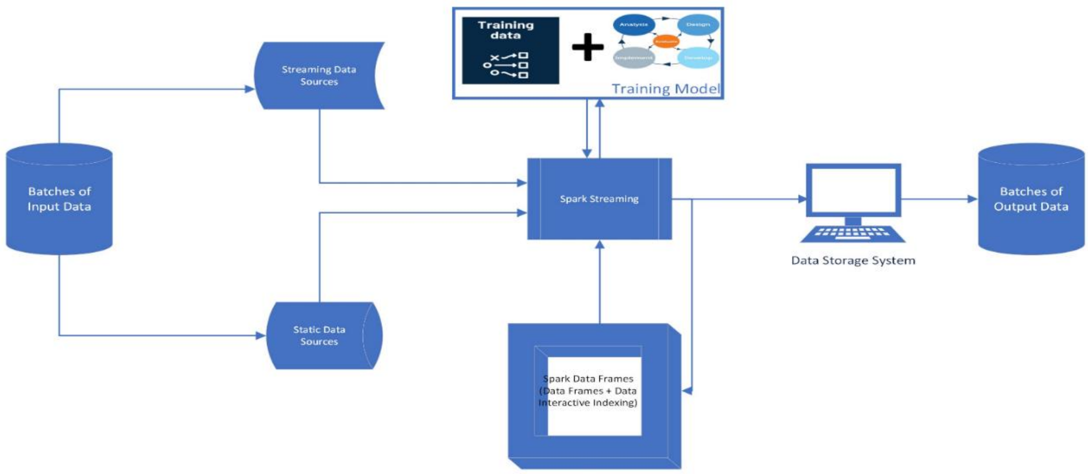

Figure 15. System Model [132].

The proposed model proved useful in handling huge traffic flows, bulk data processing and in analyzing real-time communication. However, there is a need for enhancement of the model using different machine learning framework to improve time, storage, energy, and communication efficiency with possible security factors incorporated.

4. Appraisal of Literature

Table 5 provides the summary of the reviewed closely related works, while Figure 16 shows the bar chart representation of the publication year range.

Table 5. Summary of Reviewed Closely Related Works.

S/N	Author(s)/Year	Article Title	Aim	Approach	Article Contribution	Article Limitation (Research Gap)
1. [119]	Bojan et. al. (2014)	An Internet of Things based Intelligent Transportation System.	To develop a prototype ITS that tracks vehicles, enables payment ticket, analyze crowd and ambience inside the bus.	Prototype model approach using sensor, monitoring and display systems	Successfully developed a system that tracks/detects vehicle location, commuter information and the ambience.	Measures implemented to safeguard the CIA of data and information were not discussed.
2. [120]	Sherly and Somasandareswari (2015)	Internet of things based smart transportation system	The study's main objective was to deploy IoT technologies to build ITS in improving urban transportation system	The study used wireless sensors to obtain real-time traffic information.	The study successfully developed a real-time traffic controlling and monitoring system that reduced traffic congestion in the urban area.	The authors did not approach the issue of RFID's data reading range and data security privacy.
3. [121]	Markovic et al. (2018)	Application of Trajectory Data from the Perspective of Road Transportation Agency: Literature Review and Maryland Case Study	The paper aims to assist transportation agencies in assessing the value of trajectory data for their specific needs and decision-making processes.	ML and GPS Trajectory Data using V-Analytic Software for Visual data Exploration, Analysis and Modelling	The study contributed to advancing the understanding and utilization of trajectory data in road transportation systems analysis.	Grounds for consideration before purchasing trajectory data.
4. [122]	Sachin et. al. (2020)	Intelligent Transportation System using IoT	The study aimed at designing a smart information	Proposed a framework based on IoT using touch sensor, which	The study successfully implemented a system that provides real-	Waiting time and traffic congestion were not taken

			system that provides all relevant interconnecting information about a bus (especially seating information)	detects occupied and empty seats.	time information about exact location, arrival time, and seat availability of a bus.	into consideration.
5. [123]	Shin et al. (2020)	Prediction of traffic congestion based on LSTM through correction of missing temporal and spatial data	Predict traffic congestion	Adopts LSTM-based traffic congestion prediction approach based on the correction of missing temporal and spatial values	The model achieved higher prediction accuracy for suburban areas, and in comparison with other relevant models.	The model was not implemented for predicting low-speed regions and urban areas.
6. [124]	Salih and Younis (2021)	Designing an Intelligent Real-Time Public Transportation Monitoring System based on IoT	The study aimed at designing a system that reduces passengers' waiting time	The system was implemented based on IoT technology using GPS and microcontroller.	The implemented system was able to compute real-time information about buses (e.g. current location, arrival time, speed etc.)	The study was unable to implement passenger count and e-ticketing.
7. [36]	Jan et al. (2019)	Designing a Smart Transportation: An Internet of Things and Big Data Approach	The study propose a framework for designing a smart transportation system by leveraging Internet of	The authors design a system divided into four layers: data collection and acquisition, network, data processing, and application.	A model that integrates IoT, big data analytics, and named data networking for smart transportation systems was	Challenges relating to data privacy and security concerns were not discussed.

			Things (IoT) technologies and big data analytics.	Each is optimized for processing and managing data effectively. They utilize Hadoop and Spark in the data processing layer to handle real-time transportation data efficiently.	proposed. The proposed model offers solutions to challenges such as processing big data in real time and disseminating information to citizens efficiently.	
8. [125]	Singh and Vimal (2021)	An Intelligent Transport System for Traffic Management over the IoT	Modelling to monitor and control traffic	STMS Model	Superior results in models of traffic congestion.	Challenges involved in implementing on a large scale was not discussed or advised.
9. [126]	Morkhandikar et al. (2021)	IoT-Based Road Side Unit for Intelligent Transportation System	Presents an enhanced Intelligent Transport System with Road Side Unit (RSU) using IoT	The study used Raspberry Pi Board as the main component for real-time data/information collection, while ZigBee wireless technology was used for communication.	Implemented IoT-based road side unit for ITS with the aid of OpenCV library.	Precise vehicle count for overlapping of vehicles was not achieved.
10. [114]	Zhang et. al. (2021)	An Architecture for IoT-Enabled Smart Transportation Security System: A Geospatial Approach	Addresses several IoT challenges with relative to cyber-physical security etc.	Applied geospatial modelling approach.	The study simulated a set of geospatial indicators that support master planning of IoT networks in facilitating the running of Smart	Availability and Quality of Data. Also, the work is limited in generalization and may also face integration challenges

					Transportation Security System	
11. [127]	Farman et al. (2022)	Smart transportation in developing countries: An internet-of-things-based conceptual framework for traffic control.	The study highlights the challenges and consequences of existing transportation system in Peshawar in Pakistan in response to the rapid growth in population.	IoT-based framework for busy traffic junction.	The implemented framework was able to successfully reduced travelling time, fuel consumption and environmental pollution.	The framework was limited in the number of actors used, which would have possible effects on the effectiveness of the system on highly congested traffic scenario.
12. [128]	Farag et al. (2022)	Parking Occupancy Prediction and Traffic Assignment in a University Environment	Investigation of traffic assignment based on parking prediction	Ensemble Machine Learning Models were deployed to predict the parking space after data were collected from accumulated copy of the parking availability posted on digital signs at the garages' entrances	Successful applicability of ensemble machine learning models in accurate and precise prediction of ITS	Deployment of deep learning models for a more accurate and precise prediction of ITS
13. [129]	Zhao et al. (2022)	Selection of Emerging Technologies: A Case Study in Technology Strategies of Intelligent Vehicles	The article emphasizes the importance of technology selection in corporate ET strategies	PTM framework for emerging technology selection	It provides a structured approach to guide engineering managers in making strategic decisions about ET adoption.	Non-establishment of a more detailed criteria for PTM factors and corporate internal capabilities.

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14. [130]	Chowdhurry et. al. (2023)	IoT-Based Emergency Vehicle Services in Intelligence Transport System	Obtaining a better clearance time and lower response time for emergency vehicles.	Adopted unmanned aerial vehicle (UAV) guided priority-based incident management model	The proposed system has the potential to significantly enhance emergency response capabilities within urban transportation systems while minimizing disruption to other road users.	Real life implementation challenge, and scalability to handle larger dataset.
15. [131]	Lopez-Vega and Moodysson (2023)	Digital transformation of the automotive industry: An integrating framework to analyze technological novelty and breadth.	The study targeted at identifying digital technology topics that are transforming the automotive industry.	Uses integrating frameworks to illustrate the value of digital technologies.	The result of the study using library pyLDAvis to visualize, shows that digital technologies in the automotive industry have incremental characteristics to achieve potentials in transforming the industry.	The call for a combinatorial radical (hybrid) application for implementing automotive control system such as collision prevention assistance technology.
16. [132]	Gillani and Niaz (2023)	Machine Learning Based Data Collection Protocol for Intelligent Transport Systems: A Real-Time Implementatio	Proposes a lightweight Machine Learning-based data collection protocol called ML-TDG.	Lightweight ML-based data collection procedure	Presents ML-TDG as an innovative solution to address challenges in data collection and communicatio n in urban	Better machine learning framework needed to improve time, storage, energy, and communication efficiency with possible

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		n on Dublin M50 Ireland			traffic environments.	security features incorporated.

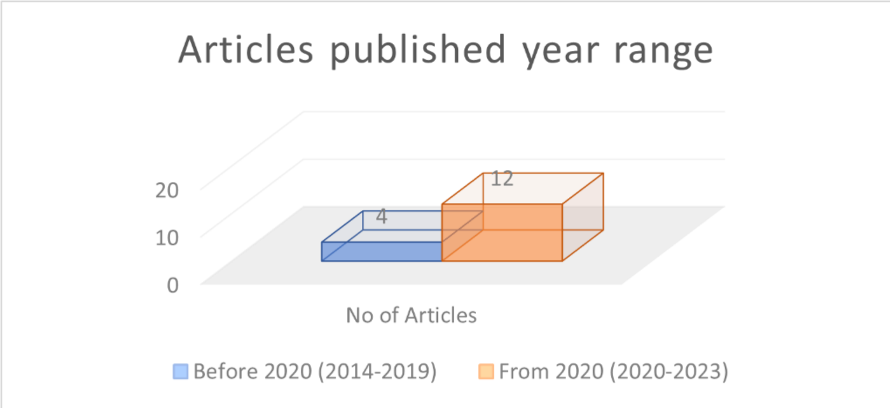

Figure 16. Articles Published Year Range.

5. Conclusions and Recommendations

Throughout the discussion of the development and significance of transportation systems, the Fourth Industrial Revolution (4IR) technologies—such as Artificial Intelligence (AI), the Internet of Things (IoT), Machine Learning, Big Data, and Cloud Computing—are highlighted for their revolutionary potential. It emphasizes how important these technologies are to enhancing the transportation industry's sustainability, safety, and efficiency. Undoubtedly, the field of intelligent transportation systems requires the collection, analysis, and use of vast volumes of data. The data gathering topic is crucial since the results of any planned analysis are determined by the data processing principle. The study intends to methodically dissect the mechanics of data processing and gathering made possible by these technologies.

The methodology section describes a methodical process that includes selecting sources, using a search key strategy, choosing papers that are closely connected, and methodically analyzing articles that are highly related. The authors focused on studies released between 2014 and 2023 after obtaining pertinent literature from reliable publishing houses and repositories. To find pertinent papers, search phrases associated with 4IR technology and data collection/processing were used.

Numerous uses of these technologies in data collecting and processing within the transportation sector have been investigated through a methodical assessment of pertinent literature. The analysis that follows explores different uses of 4IR technologies in the transportation sector, with an emphasis on methods for gathering and analyzing data. Numerous scholarly works are referenced, each focusing on distinct facets of intelligent transportation systems. These research cover a wide range of topics, including real-time public transit monitoring systems, prediction models for traffic congestion, and Internet of Things-based systems for tracking automobiles and studying crowd dynamics. Every referenced study offers a different strategy for utilizing 4IR technologies to enhance transportation networks. For instance, whereas some studies investigate machine learning-based prediction models for traffic congestion, others concentrate on real-time traffic monitoring using IoT sensors. There are also discussions about the application of intelligent vehicle systems and the incorporation of digital technology in the automotive sector, as well as geospatial system support for intelligent transport system.

Recommendations from the majority of the research articles accessed however indicated challenges of processing data at real-time, problem of data quality, and reliability of data collection instrument. This study therefore recommends a 4D approach to sustainable intelligent transportation system through industrial revolution. First is Data Collection Method and Protocols, stipulating more robust data collection approach like Ethnography and Focus Group. Also and part of the protocols,

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pilot test could be conducted to ascertain clarity and effectiveness of the data collection instrument. Second is Data Security and Privacy. Secured data security method such as encryption, data masking, tamper detection and prevention should be adopted, while homomorphic encryption, security patching update, and multi-party computation could be thought of as regards secured processing approach, while consideration could be given to virtual private network (VPN) and data loss prevention (DLP) as transmission techniques.

This study has demonstrated the numerous investigations focused on the collection and handling of data in the use of 4IR in transportation management. The work essentially consists of a systemic review of the most advanced data collection and processing techniques used in the application of 4IR in the transportation sector. In the proposed future research work, the authors intend researching into the possible integration of these data with analysis of route planning using machine learning approach.

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