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Comprehensive review of data exchange in vehicle-to-pedestrian communications: State of the art

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ABSTRACT

Pedestrian safety is a serious problem in transportation systems because pedestrian and vehicle crashes often result in fatalities amongst vulnerable road users. A vehicle-to-pedestrian (V2P) communication system allows data exchange between pedestrians and vehicles to prevent or minimise potential dangers of accidents from happening. This work aimed to analyse and review the previous work associated with information exchange in the V2P communication system and classify the existing technology utilized for this purpose. Motivation, accessible problems confronting researchers, and suggestions posed to researchers to develop this critical area of study have been among the reasons considered to enhance awareness of the field's numerous qualitative facets in reported investigations and properties. All of the papers have been divided into four categories: growth, analysis, and survey, FRAMEWORK, and data exchange in the V2P communication system. V2P communication is an area that necessitates automated solutions, instruments, and techniques that allow pedestrian detection and prediction. Pedestrian identification and data sharing on V2P have been the subject of several experiments in order to support pedestrian protection techniques. The reasons, open barriers that hinder the technology's usefulness, and authors' suggestions have been used to identify the essential characteristics of this evolving sector. This study is intended to provide researchers with new resources and enable them to focus on the holes that have been found.

Keywords: **Data** Exchange, Vehicle-To-Pedestrian Communication, Pedestrian safety, VANET, Traffic Condition.

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1. Introduction

The growing number of cars has resulted in a significant rise in road injuries and health problems [1]. The regulation of traffic injuries is a delicate and complicated problem. At the moment, there is a clear shortage of technical options to minimize the amount of collective casualties, and those that are possible are costly, invasive, complicated, and involve additional power sources or machines, computers, or interfaces [1]. Given the challenges faced by road traffic's effect on the environment, urban traffic management schemes must adapt to better understand non-polluting forms of transportation, as well as vehicle, rider, and pedestrian protection, which is a major challenge for the automobile industry and policymakers in many countries. The rising amount of traffic injuries is one of the most compelling reasons to prioritize protection. Other advantages of the internet of things (IoT) include digital health control, tracking ingestible sensors, mobile health monitoring utilizing a vehicular communication unit, and pilgrim monitoring [2-5]. The usage of intelligent transportation system

(ITS) and vehicular ad-hoc network (VANETs) to enhance road safety thru real-time contact between vehicles comes under this scope. This is accomplished by beaconing, a frequent sharing of data between automobiles in which information from the driver, including direction, distance, and acceleration, is shared so that the cars could construct a chart of the nearby vehicles [6]. In VANETs, safety knowledge is specifically correlated with the period and regional region where the information is transferred. Since the first automobiles have been made, automotive technology has obviously advanced, and the primary focus of potential vehicle production will be on protection and accident avoidance. V2X communication is described as "the knowledge exchange between a vehicle and different components of an intelligent transportation system, such as other pedestrians, vehicles, Internet gateway, and transportation infrastructures" (for example, signs and traffic-lights). This system seems to have a lot of promise in terms of facilitating new solutions in the areas of road protection, passenger infotainment, automotive production facilities, and automobile traffic optimization." [7]. The key cause of collisions is human error in recognition and judgement, or the failure of road users to identify and perceive oncoming threats, as well as pedestrian misbehavior on the roadway. Information transfer between pedestrians and vehicles to detect pedestrians and predict the possibility of collisions is a challenging task. And Since, Pedestrians tracking and detection are more complex than that for moving rigid bodies. Therefore, the effective measure to prevent accidents is by making each driver notice the behaviour of risky pedestrian and correctly recognising the related risks by informing the driver with existence of pedestrian in the street and warning him with the aggressive behaviour of the pedestrian. However, in pedestrian behaviour the transforming of a composite trip from an origin to a target and goal should be involves finding the best way to send pedestrian information to the vehicles whilst considering several critical problems, such as device cost and quality of connection between moving pedestrians and passing vehicles [8, 9]. Therefore, this articles present a suggested method that analyse pedestrians walking behaviour and identify the aggressive one to inform drivers with a warning message. While only a few cars are fitted with this device today, safety distance measurement and warning systems would be standard equipment in vehicles in the future. Since warning devices are too costly, they are only used in new luxury cars. The majority of these interventions, on the other hand, are designed to create and reflect pedestrian protection, traffic accident prevention, and an alert system. As a result, vehicle-to-pedestrian (V2P) connectivity is needed to facilitate wireless exchanges of numerous protection and operational messages between vehicles and pedestrians utilizing a combination of cellular infrastructure and direct Wi-Fi communication. Pedestrians may send real-time warnings to vehicles about dangerous situations. This thesis aims to summarize previous studies in response to the critical need for improving data sharing in V2P communication for pedestrian safety system, identify measurement techniques and standards, suggest a taxonomy of current literature, and discern the numerous facets of this related research field. The following is a breakdown of the structure of this article. Section 1: present the findings of your study. Section 2: show the outcome of the literature taxonomy. Section 3 delves into the problems, motives, and suggestions gleaned from the articles under study. The substantial overview of the examined papers is presented in Section 4. The alternative solution is presented in Section 5. Section 6 identifies the study's shortcomings. Section 7 brings the study to a close.

2. Comprehensive Review

The data sharing of V2P networking systems has been the subject of several investigations. These papers have been read in order to create a universal analysis chart on this new field[10]. These investigations have been deemed to have unique goals based on a collection of investigations focused on the same subject. The taxonomy has been utilized to classify the papers, as well as a broad number of highlights and remarks. All of the papers from different outlets have been thoroughly examined so as to give readers a whole picture of the subject. The papers have been classified according to the study's intent before being utilized to establish a taxonomy. The taxonomy utilized to study the research papers based on data sharing in V2P contact as seen in Figure 1. This taxonomy displays the entire substance of different investigates and implementations, which are divided into four categories. The first category involves experiments that have attempted to create data sharing in V2P communication networks in real-time or by simulation. The second category of papers contains reviews and surveys on data sharing in V2P correspondence. The FRAMEWORK experiments are in the third category, and investigates on V2P communication systems are in the fourth. For statistical research, the identified groups are mentioned in the sections below.

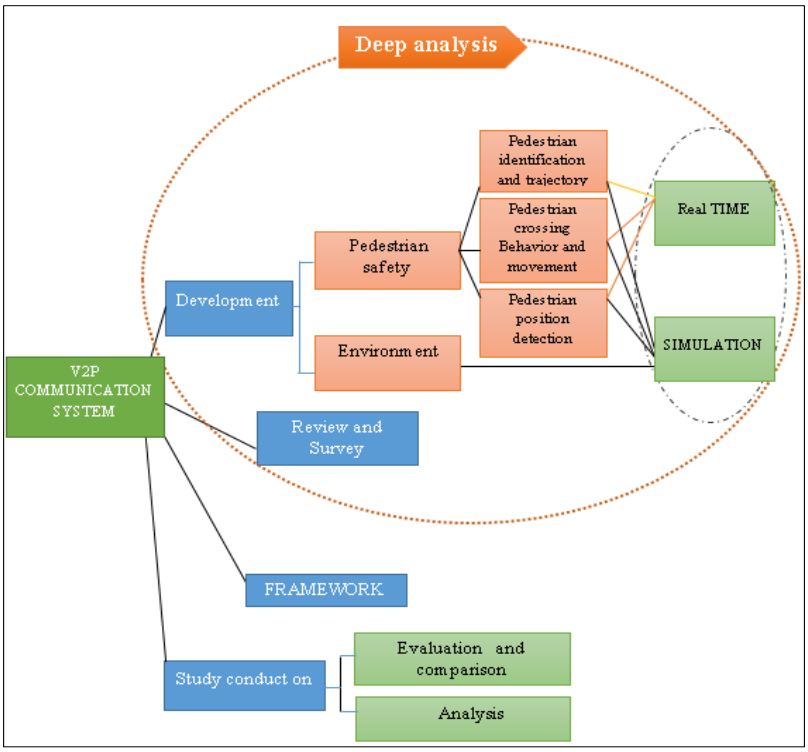

Figure 1. Taxonomy of Research Literature on Vehicle-to-Pedestrian Communication

2.1 Development articles

This section reviews the development articles that had data exchange on V2P communications as their main contribution. The common context of all works under this group has been the development. These articles have been categorized into two sets (Real Time and simulation) depending on the assessment technique utilized. The first set of development articles focused on REAL TIME development, which applied the suggested approaches in the actual test field with real data. These articles have been further categorised into four classes according to the purpose of the investigation, namely pedestrian position detection, pedestrian crossing behaviour and movement, pedestrian safety and pedestrian tracking. The second group concentrated on simulation development, in which certain types of simulators have been utilized to evaluate the work with or without real data. Articles in this group have been further sorted into five classes according to the purpose of the investigation, namely pedestrian position detection, pedestrian crossing behaviour and movement, pedestrian safety, pedestrian identification and trajectory and environment. The two groups (REAL TIME and simulation) have crossovers, as demonstrated in Fig. 1. Four common classes between REAL TIME and simulation development focused on similar topics, such as pedestrian position detection, pedestrian crossing behaviour and movement, pedestrian safety, pedestrian identification and trajectory. Pedestrian position detection, the first class, is concerned with the estimation or detection of pedestrian position. [2] proposed an online framework for pedestrian-crossing identification with traffic-oriented video sensors that would provide coarse observations on areas across a crossing in real-time progress. [3] proposes a scheme that combines an influential data association methodology for multiple objective monitoring (MTT) and joints probabilistic data associations (JPDA) to improve the advanced driver assistance system's (ADAS) confidence ability. [4] introduces a new fusion technique for enhanced identification and increased classical Advanced Driving Assistance (ADAS) implementation. A UFIR filtering-based pedestrian tracking scheme has been suggested in [11] by relating finites INS and Ultra-Wideband (UWB data. Other articles in simulation development suggested a method for detecting pedestrian positions through the multiple cars cooperation with directional projections [12] and utilized multiple-kernel learning to combine information from thermal and visible spectrum images in a pedestrian classification context [13]. The second class, crosswalk behavior and movement, considers pedestrian trip analysis in order of crossings behaviors to be a difficult process that is often hampered by a shortage of relevant and accurate data. The investigation in [8] suggested a Geographic information system approach for collecting and analyzing the data needed for the study of crosswalk behavior, while [9] suggested using 3-dimensional processing methods for ‘frame-to-frame' identification of dynamic artifacts. [10] explored the effectiveness of a fuzzy logic-based approach for modeling pedestrian guiding behavior using constructed

conditions under regular and non-panic circumstances. Agent-based models and relevant measures of behavior along urban trips were proposed in simulation growth [11]. In [12], the author proposes a novel detector–tracker feedback mechanism for data sharing based on the spatiotemporal correlation of detection and identification and trackless. [13] implemented a crowd modeling Method that integrated details on the complex world that facilitates knowledge dissemination and encourages virtual agents to respond depending on their individual desires when affected by their surroundings. [14] changed the social force model based on knowledge exchange to reflect the flow of roads users and their interactions. The social force paradigm basis, [14, 15] implemented a modern swarms optimization algorithms and a multi-layers solution. The authors in [16] suggested a new international standard called 'OGC moving features'. Pedestrian safety is the third development class. In [17], a method for efficiently establishing and disbanding groups of pedestrians and vehicles has been suggested. An ADAS has been described in [18] to prevent accidents involving a VRU detection system based on a standardised V2X communication system. An effective version of an integrated system combining vision-based object detection and VANETs has been presented in [19]. In addition, the investigation in [20] suggested a p prototype of a P2V communication system utilizing the 3G wireless network and wireless LAN, and the work in [21] addressed the issue concretely by formulating the requirement of distance support for minimum information exchange via Wi-Fi-based V2P communication. The authors in [22] suggested a VRU alerting system that goals to provide information exchange amongst road users (for example, pedestrians, cyclists and vehicles) utilizing commercial devices (i.e. smartphone) related to the existence of neighbouring entities that may cause dangerous situations and send standard compliance messages. These studies are sorted into a REAL TIME development group. [23] proposed a preliminary inquiry into the potential application of vehicular networks for protective VRUs using an intersection collision-avoidance system that falls under the simulation creation group.

The fourth group of development is pedestrian identification and trajectory. In REAL TIME development, [24] suggested a new robust method integrating information on spatial position, shape and colour and a set of algorithms on the basis of an SNN model to identify specific persons, whilst [23] put forward fused multiple features and classifiers to make decisions for pedestrian tracking. In the simulation development group, a multi-model agents-based simulations method depending on the fusion of multi-modules has been suggested in [24], along with agents-based simulations models introduced in [25, 26] for pedestrian dead reckoning (PDR) systems in agent collaborations when two agents are detected near to each other. A multi-agent system architecture of cooperative surveillance extended to incorporate dynamic coalition formation and simulations-based possibility investigation on tight (UWB) and inertia data integrations have been introduced in [27] and [28], respectively. All the four classes are common and labelled similarly in the development groups which is REAL TIME and simulation.

The fifth and last class of development articles for simulation development is the environment class. It involves [29], which looked into whether the dedicated short-ranging communications (DSRC) output in a foggy atmosphere is affected by air density differences. Credits-based reward mechanisms for delays-tolerant networks (DTNs) that allow machine knowledge sharing without the assistance of conventional Internet services provider have been proposed in [30].

2.2 Survey and review articles

The review and survey papers condensed the current state of research on V2P communication systems in data exchange, wireless networks, positioning and location systems and information management techniques. [31] summarized communication through wireless network techniques, such like device-to-device (D2D) communication, which is anticipated to play a significant role in future cellular networks due to its ultra-low latency for consumer communication, while [32] analyzed possible DSRC and cellular interworking solutions for effective V2X communication. Furthermore, [33] defined existing investigations on knowledge management strategies for safety-related VANET implementations, and [34] proposed a coherent design for place systems that uses configuration and implementation layers as the key framework blocks.

2.3 Framework

A few articles designed a FRAMEWORK for data exchanging in communications of V2P. For instance, [29] described the demands on the architectural FRAMEWORK and introduced three new standpoints that must be considered in future architectural decisions, whilst Ref. [30] explored the performance organisation national transportations safety assistance system with techniques of qualitative. A FRAMEWORK for producing

warnings and control support for dangerous events and those communicable by V2V and V2I applications has been suggested in [31]. The authors in [32, 33] suggested a set of design variations and improvements to the 3GPP C-V2X architecture to fully enable NDN(Named Data Networking) amongst the other non-IP networking results already supported.

2.4 Study focusing on V2P communication

This last group in the taxonomy is classified into (1) evaluation and comparison and (2) analysis. The first class focuses on the researchers who compared previous works and estimated or evaluated previous results through different validation techniques for data exchange in V2P communication system. Via on-site inspections and three Webs-based resources, a well-known audit tool was used to approximate 84 street sections at the urban area of suburban Boston, Massachusetts, in [39]. An autonomous driving test was proposed in [40] along roadways and freeways accessible to daily traffic. A cross-comparison has been conducted in [34] on various assessment methods to model pedestrian and bicycle crashes. Meanwhile [42] looked at two types of forwarding strategies: i) a minimal, provider-blind formulation of a strategy and (ii) a supplier strategies and tactics and efficiency assessment by ndnSIM. The writers of [43] proposed a series of real-world tests to determine the feasible transmission speeds and transmission ranges, as well as to verify the previous analytical findings. This method was also used to evaluate the efficiency of floating material in particular. For the analysis class, this section summarised the analytical studies on subjects conducted with network and communication issues on data exchange in the V2P communication system. The study in [44] introduced the idea of smart transport spaces (ITSp) and examined potential network technology candidates for ITSp, with an emphasis on wireless communication technologies' lower layers. [45] describes a platform in which mobile phones may provide network services to other nearby devices and thereby perform as service endpoints or mobile cloudlets. In [46], the impact of antenna characteristics on MAC address information in form of travel-time valuation for pedestrians and bicycles was studied. [47] describes ICeDiM, a middleware developed for ICN connectivity in next-generation scenarios. In [48], the function of urban Internet connectivity in supporting evolving vehicle apps was identified, as well as the Core Internet service providers that correlate to the networks in the vehicle grid. A fundamental concept has been presented in [35] and a model of microscopic traffic simulation for vehicles containing a robust protocol for exchanging data. Another investigation in [36] focused on establishing a network-based carpooling scheme by analysing the feasibility and related issues in taxi carpooling on the basis of GPS traces of real taxis. In [37], the use of wireless techniques and different computing and technological systems has been investigated for REAL TIME navigation purposes and location-based information transfer for pedestrians. In a nonvisual simulation environment, the impact of holding practical voice and text mobile phone communications on the participants' auditory monitoring for approaching automobiles and crossing thresholds were investigated [52]. Other studies highlighted safety issues, human crowds and walkability on the data exchange in V2P communication systems. For example, [53] proposed a multimodal approach to investigating safety at crossings by examining the safety and flow results of both motorized and non-motorized traffic at the same time. Furthermore, [54] provided a broad definition of combination dynamics among categories, as well as a classification of these dynamics in terms of not just the way the data is moved between entities, but also mutual knowledge processing. [55] investigated the applicability of a composite walkability map (Pedestrian Index of the Environment [PIE]) to the Greater Montréal Area (GMA). In [56], the writers proposed a technique for calculating the impact of bus stations on the rate of other motorized vehicles in a variety of traffic situations. Finally, [57] proposed new solutions for New York City, including the implementation of cost-effective and productive DMS.

3. Discussion

The most relevant research on data sharing in V2P communication systems were presented in this survey. The aim of this project is to bring attention to the current exploration patterns in this field. Where a taxonomy of related literature was proposed to include various benefits. The first is that it has planned a large number of articles. A new investigator in this field could be overwhelmed by the large number of studies available on the topic and the absence of any kind of framework, making it difficult to locate a study of the field. The taxonomy, on the other hand, can reveal research holes. The poor and powerful characteristics in terms of study scope were highlighted by mapping the research study on V2P apps into separate collections. i.e., the taxonomy used in this study demonstrated how classes of different applications received disproportionate consideration in terms of implementation activities and FRAMEWORKS, and feedback and assessments, over integrated solutions. Also, the taxonomy highlighted the absence of studies on the behaviour analysis of pedestrian walking. The proposed

taxonomy used a shared vocabulary for scholars to collaborate and analyze emerging works such as comparative experiments, progress reports, and critiques, analogous to taxonomies used in other fields. The study revealed seven characteristics of literature material in the interpretation of databases included in the articles, reasons for the implementation of the V2P framework, obstacles to the effective usage of these systems, suggestions to solve this problem, and substantial research, assessment tools used, and parameters used for the performance assessment of the processes.

3.1. Data types and sources

This section presents various sources of data that some researchers have utilized to collect several types of REAL TIME information for V2P communication systems. These sources include location, number and age of vulnerable road users (pedestrians and cyclists). Other sources are the location and the vehicle's speed. Table 1 presents a detailed description of numerous factors involving the Real Time data type of research experiments designed towards developing hardware and simulation projects in V2P communication.

Other studies utilized public datasets and ignored REAL TIME data, such as data in previous literature or virtual data generated by a simulator. The researchers generated their own datasets through experiments.

3.2. Performance measurement

In our review, each work in REAL TIME and simulation development has been measured utilizing specific features. The evaluation criteria represent a practical way of assessing various works. In this survey, we found that the performance of the development (REAL TIME and simulation) studies has been evaluated utilizing three measurement criteria, namely environment, time and data measures, and the accuracy measurement of each criterion involved several features or parameters. All these parameters are discussed in this section. Tables 2(a-b) illustrate the measurement criteria utilized in the reviewed articles on the development studies of data exchange in V2P communication systems.

Table 1. Dataset type utilized in the reviewed studies

References	REAL TIME dataset										
	Sample type										
	Vulnerable road user								Crash data	Location of bus stops	Vehicle speed and position
	Motorcyclist and cyclist position	Pedestrian location	Pedestrian age	Pedestrian number	Pedestrian trajectory	Image of pedestrian	Distance to pedestrian	Speed of motorised vehicles			
[18]	*										
[20]		*									
[38]			*		*						
[39]		*				*					
[40]		*									*
[41]		*									*
[42]			*		*						
[21]		*									*
[43]		*			*		*				
[44]				*		*					
[17]		*		*							
[45]	*	*					*		*		
[46]			*	*	*						
[19]		*				*			*		*

[21]	*							*		*	*
[27]		*					*				
[47]						*					
[48]						*	*				

Table 2A. Measurement criteria utilized in the survey paper

Environment measure																			
References	**Pedestrian density**	**Distance for warning**	**Influence region of bus stops**	**Number of pedestrian receiver**	**Crowd pressure**	**Paths**	**Scalability**	**Length of trip**	**Walking speed crossing the road**	**Number of trips**	**Obstacle detection**	**Collision risk**	**Mean weight distribution**	**Pedestrian location**	**Free-flow trajectory**	**Road user reaction**	**DSRC performance**	**Quality of service**	**Average speed of motorised vehicles**
[18]		*		*				*											
[20]		*		*															
[38]					*		*	*	*										
[39]										*									
[40]										*									
[41]																			*
[42]					*		*												
[21]		*									*								
[43]																			*
[49]												*							
[50]															*		*		
[16]																*			
[25]																		*	
[51]	*																		
[46]					*														
[19]											*								
[52]														*	*				
[27]					*														
[24]				*		*													
[12]																			*
[28]			*																
[13]												*	*						
[53]						*													
Total	1	3	1	3	4	2	2	2	1	2	2	2	1	1	2	1	1	1	3
Per %	4 %	13 %	4 %	13 %	17 %	8 %	8 %	8 %	4%	8 %	8 %	8 %	4%	4 %	8%	4%	4 %	4 %	13%

Table 2B. Measurement criteria utilized in the reviewed paper

Performance measures																											
Time and data measure																		Accuracy									
Reference	Frame rate	Packet loss rate	Misdetection frames	Data-sending rate	Throughput	Disseminated data	Evacuation time	Average	Delivery rate	Isotropic deliveries	Delay time	Collision rate	Time for warning	Detection rate	Walking time	Mean time	Running time	Error detection	Localisation error	Statistical error	Resolution	Absolute error	Average recall	Average precision	Bhattacharyya	Error of pedestrian	Robustness of the
[18]													*														
[20]													*														
[38]															*												
[39]			*																								
[40]			*															*									
[41]																		*									
[21]											*			*													
[43]														*													
[44]						*									*		*										
[17]				*																							
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[16]		*	*																								
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[51]					*																						
[46]																			*		*						
[26]												*						*									
[19]		*	*																	*							
[54]										*																	
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[13]																*										*	
[48]									*			*														*	
[53]																							*	*			
[11]																			*								
Total	1	2	4	1	1	1	1	1	2	1	1	3	2	2	2	1	1	4	2	1	1	3	1	1	1	2	1
Per %	4%	8%	24%	4%	4%	4%	4%	4%	8%	4%	4%	12%	8%	8%	8%	4%	4%	24%	8%	4%	4%	12%	4%	4%	4%	8%	4%

The features utilized to evaluate the environment measure are pedestrian density, distance for warning, influence region of bus stations, number of pedestrian receivers, crowd pressure, path scalability, length of trip, walking speed whilst crossing the road, number of trips, obstacle detection, collision risk, sending rate, throughput, disseminated data, evacuation time, average recognition rates, delivery rate, isotropic delivery delay time, collision rate, time for warning, detection rate, walking time crossing the road, mean time and running time. The evaluation features of time and data measurement are quality of service, average speed of motorised vehicles, frame rate, packet loss rate, misdetection frames (vehicles and pedestrians), data-sending rate throughput, evacuation time of disseminated data, average recognition rates, delivery rate, isotropic deliveries, delay time,

collision rate, time for warning, detection rate, walking time crossing the road, meantime, running time. The last criterion of performance measurement is accuracy. Its evaluation features are error detection, localisation error, statistical error, resolution, absolute error, and Bhattacharyya error, error of pedestrian position and robustness of the algorithm., the percentage of each criterion is 4%, 13%, 4%, 13%, 17%, 4%, 8%, 8%, 4%, 8%, 8%, 8%, 4%, 4%, 8%, 4%, 4%, 4%, 13%, As demonstrated in Tables 2a. 4%, 8%, 24%, 4%, 4%, 4%, 4%, 4%, 8%, 4%, 4%, 12%, 8%, 8%, 8%, 4%, 4%, 24%, 4%, 4%, 4%, 12%, 4%, 8% and 4% of the studies, respectively. As exposed in Table 2b, no investigation utilized all the kinds of criteria measurement. The changing usage of these calculation standards makes it difficult to follow new forms for V2P communication device assessment.

4. Assessment methods

Several types of evaluation techniques or methods are utilized to analyse the results of investigates on the data exchanging in V2P communication systems. In our survey, three evaluation methods have been utilized for development work: evaluations by hardware, software and comparison. Some papers utilized more than one evaluation method. Table 3 lists these three evaluation methods.

Table 3. Evaluation methods utilized in the reviewed studies

Evaluation Method	References
Hardware	[18, 20, 38-42, 21, 43, 44, 17, 46, 19] [18, 20, 21, 19]
Software	[45, 49, 50, 16, 25, 51, 46, 26] [56, 52, 54, 27, 47, 55, 24] [12, 28, 13, 48]
Comparison	[40] [42] [43, 17, 16] [51, 46] [52, 54, 27, 47] [12, 28, 13, 48]

5. Review analysis

This section summarises the various kinds of survey and review study associated with V2P systems of communication. Table 4 illustrates that these papers have been review several topics such as data management techniques in VANET, type of communication in wireless network. In contrast with data exchange in V2P systems, where it's partially covered it.

Table 4. Survey analysis utilized in the reviewed studies

Ref.	Covered area	Discussed topics on V2P communication
[57]	(1) Review of existing constructions for positioning and location systems and their technologies, also reviewed the challenges in the lower layers of such systems; (3) decouple the positioning algorithm, positioning method, and positioning hardware from one another by introduce Concept proposal of position providers.	Focuses on the positioning and middleware layers which is the lower layers of the architecture, such as navigation services for pedestrians
[58]	Presents and discusses the corresponding challenges and main features of D2D communication in wireless networks, containing architecture", scenarios that has been utilized, technical architectures and the areas of active research	Conducts additional research to understand how efficiency extends in complex situations (from pedestrian to vehicular speeds), as well as what disturbance handling and handover processes are needed as UEs travel inside and around cells.
[59]	Examines "potential DSRC–cellular integrated systems of V2X networking, as well as the key interworking problems" posed by vehicle mobility, such as vertical handover and network connectivity.	Highlights the boundaries of each tools in supportive V2X applications, containing cellular mobile terminals utilized by passengers travelling in vehicles.
[60]	Examines VANET data management strategies, focusing on safety application systems and vehicle/driver secure. "Data	Classifies techniques on the basis of characteristics and in-depth analysis

	management" primarily entails methods for data acquisition, aggregation, validation, and distribution. Every other method has its own set of characteristics and specifications."	of several researches solution; discusses the concept of and need for information management, especially safety, because ensuring the safety of drivers, passengers and pedestrians is a major challenge faced by the automotive industry.

This table comprises two columns and four survey papers. The first column illustrates the covered area and topic that each survey discusses in general, and the second one shows the focused topics related to V2P communication systems. The table illustrates that no review article or survey conducted or discussed all the kinds of measurement criteria. The current survey presented a whole view of the studies, from which guidelines for future research and development have been suggested. The survey outcomes helped create a new organization system for recent works on the basis of the data analysis providing by diverse studies. To include a systematic overview for this study field, the examination also relies on numerous features such as "coherent taxonomy, data sources, output metrics, assessment approaches to investigate emerging pattern problems, reasons correlated with V2P programs, suggestions, and substantial interpretation." None of these survey or review papers presented all the trends that provide mapping and an in-depth analysis of all the previous works in this field.

5.1. Benefits related to V2P communication systems

This section presents some of the benefits and motivations reported in the literature. The studies are classified into three groups according to their advantages. The matching references have been cited for extra discussion, as demonstrated in figure below.

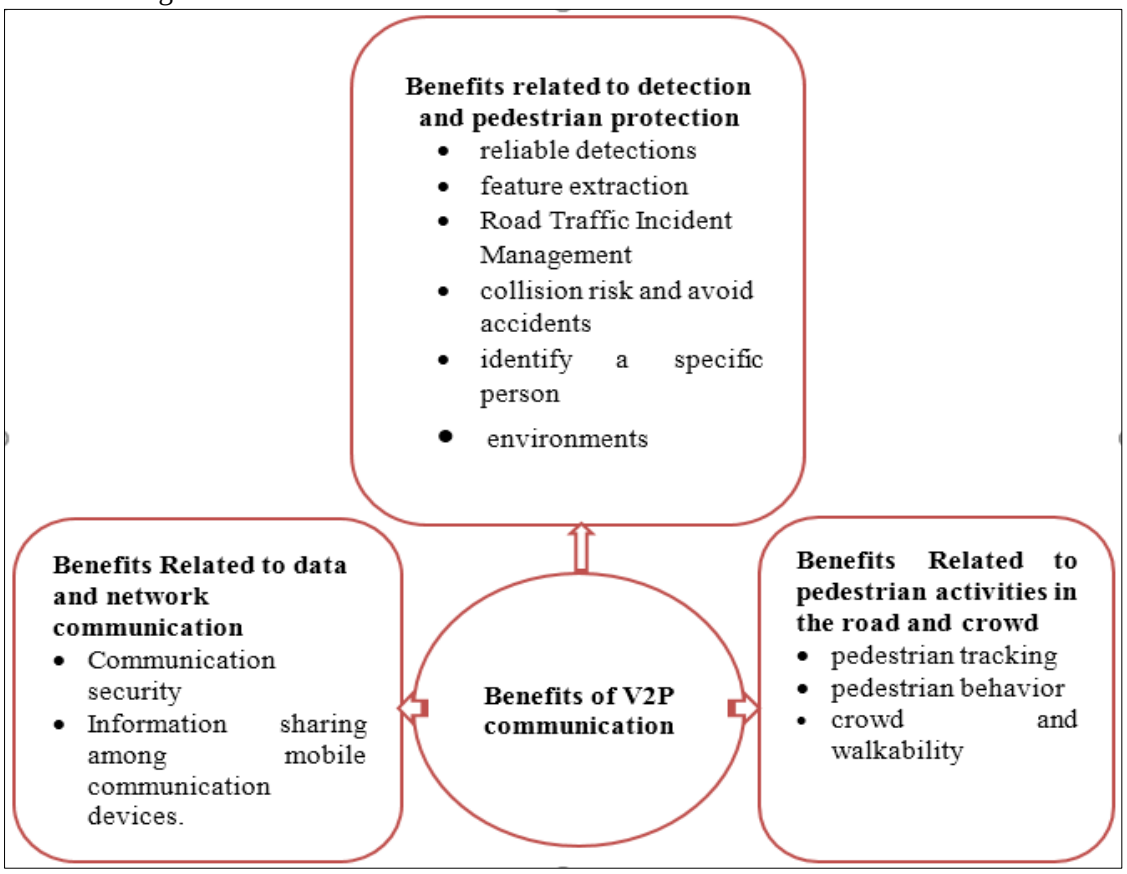

Figure 2. The advantages of V2P system communication classifications

5.2. Benefits related to detection and pedestrian protection

In this section, some enhancements are discussed for the detection of pedestrians with high accuracy. These enhancements include reliable detection, feature extraction, management of road traffic incident, collision risk

and accident avoidance, identification and tracking a specific person and environment. Improving pedestrian safety, vehicles–pedestrian communications and applying models for pedestrians and cyclists groups have been the advantages obtained in [21, 52, 61]. The capability of sensors with non-dedicated to identify pedestrians has been enhanced in [48]. Classic ADAS systems have been enhanced by merging various technologies of sensing, such as lasers scanners and computers vision [40]. The risk for all road users has been estimated in [62]. The low-level approaches have been enhanced and the positive rate has been increased to ensure the reliable detection and enhancement of classical ADAS applications [39]. The dead angle problem has been solved, and the precision of detection results increased [12]. VRUs have been protected by an application of intersection collision avoidance [54]. Detection rate has been enhanced with respect to the mono-modal strategies [13, 63]. The enhanced performance in [27] has been illustrated by the obliging tracking of 2 cameras with various technologies. Two other studies, [20] and [18], enhanced the detection and reduced the risk. The information for transmitting video and image data and miscellaneous information to adjacent nodes has been utilized to enhance the detection algorithm performance [19]. The findings of these studies could be effectively applied for gathering effective and efficient databases to monitor cyclists and pedestrians [64]. This persistence helps compensate for the loss in human visibility on foggy roads. The finding of [50] targets to indorse benign operations for highway under foggy situations and enhance driver safety.

5.3. Advantages related to pedestrian activities in roads and crowds

Crowds and walkability, pedestrian tracking and pedestrian behaviour are the advantages emphasised in this section. Long-term stability and positioning solution have been enhanced, and the output data have been merged in [28]. The fuzzy logic model in [46] could accept constant and variable speeds and step lengths to simulate the walking behaviour and prevent track losses caused by temporary occlusions of LIDAR. The accurate detection schemes in [41] designed effective and robust algorithms for solving highly complex problems through the social force model discussed in [49]. Multiple features and classifiers have been fused to make decision enhancements on the algorithms to identify specific people [44], and the method worked robustly in real scenes of single- or multiple-pedestrian tracking [43]. The approach in [52] integrated a model for the movement of bicycles and combined realisable avoidance strategies considering the possible maximum centripetal acceleration. Efficiency has been enhanced and the damage in evacuations has been minimised in [51]. The quality of crowd simulation has been enhanced by incorporating dynamic area information [47]. The disadvantage in the traditional UWB- and INS-based localisation methods has been overcome, and the tightly coupled INS/UWB pedestrian tracking has been designed in [11].

5.4. Advantages related to data and network communication

Communication security and information sharing amongst mobile communication and DTNs are the topics processed and enhanced by the studies included in this section. The investigation in [55] developed an incentive mechanism to encourage the cooperation of users by storing replicas of messages in the DTN. In [56], a strong positive relationship has been determined between the length of influence region and the average speed in the influence region. The performance of auditory vehicle detection in the presence of a secondary vehicle has been significantly worse than in the absence of a secondary vehicle [65]. ITSp adopts multiple communication technologies and standards [30]. An application of the measure at the metropolitan scale has been provided and trip data from a large-scale transportation survey has been disaggregated in [66] to enhance mobility, safety, energy consumption and the environment. Energy consumption has been linked to the choice of algorithm and hardware [57]. The last motivation in [58] shows that as new and increasingly demanding applications emerge and the subscriber base increases exponentially, novel techniques are urgently required to boost data rates and reduce latency.

5.5. Challenges and issues associated with V2P communication

Though V2P communication offers various advantages, these technologies are not the ideal solution in communication network delivery. The reviewed works specify that researchers are concerned with the challenges related with the data exchange in V2P applications and their communication systems. The challenges are classified into three categories according to their trends, which are road safety approach and detection, communication and information management and pedestrian movement, as demonstrated in Fig. 3.

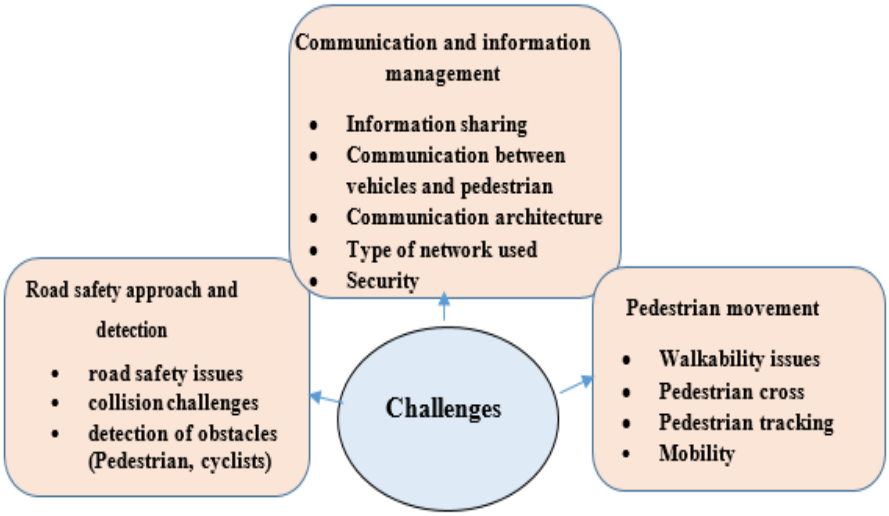

Figure 2. Categories of challenges related to V2P communication

The chief challenges in adopting data exchange in V2P communication are listed in Table 5.

Table 5. Challenges discussed in papers reviewed

Ref.	Challenges and issues in V2P communication systems
Regarding road safety approach and detection Considering a strong require for technologies for protecting VRUs, this section presents the challenges and concerns related to road safety issues, collisions and detection of obstacles (pedestrians and motorists).	
[39]	The Robust requirements for road safety applications and exciting difficulty in ensuring trustworthy detection cause to the combining requirement diverse sets of sensors.
[12]	A key problem is the dead angle of sensors, which requires extra cost in the installation of devices in crossroads.
[54]	Concerns include collision warnings to drivers and challenges in the improvement of active systems of safety to implement independent emergency braking and enhanced detecting algorithm.
[19]	As pedestrian protection is a challenging topic, the detection of obstacles on the road, which is important particularly for pedestrians, should be enhanced.
[67]	Avoiding or mitigating collision with dynamic obstacles and being consistent with road speed limits are necessary.
[24]	Informational planning, navigation and collision avoidance subsystems.
[57]	Position systems, applications, and middleware of the lower layers are faced by location systems.
[56]	No investigation has explicitly analysed the effect of bus stations on the traffic streams speed.
[18] [20]	The enhancement of VRU safety is a challenge.
[25]	The average error monotonously increases as a functional of walking distance. Thus, the PDR location error increases as the user moves farther.
[44]	Finding a precise person in the surveillance videos systems.
[65]	Poor of investigation in the distractive potential posed by intrapersonal distractors based on pedestrian auditory perception.

[53]	The capability to identify all relevant traffic users and The objects of complex occlusions and diversity frequently requires setting a very low recognition threshold
Regarding pedestrian movement In this category, the challenges consist of walkability issues, pedestrian crossing, pedestrian tracking and mobility.	
[49]	Pedestrian movement towards a target is a process of searching in the decision spaces of optimisation issues.
[41]	Object tracking and collision avoidance are key challenges.
[42]	Which algorithm as suitable proxies for people movement in agent-based models and the reasons behind these choices.
[46]	Walking path prediction during a normal and a non-panic situation.
[43]	Tracking pedestrians is more complex than tracking the movement of rigid bodies. A major difficulty with pedestrian tracking is the occlusion problem.
[17]	The relevant challenges caused by an extreme variance in mobility feature between pedestrians and vehicles have to be addressed.
[66]	Evaluating the spatial transfer and transferability of walkability measures is a serious step for research and practice.
Regarding communication and information managementTechniques utilized in sharing information, communication between vehicles and pedestrians, communication architecture, type of network utilized and security are the issues summarised in this section.	
[45]	REAL TIME control is required to enhance the mobility and safety of all users of street networks and support the timely response for managing random incidents.
[68]	Special requirements for traffic-related information, doubly selective fading channels in the delay and Doppler domains, and reliability.
[13]	Reduces detection errors.
[64] [69]	Capturing higher rates with Wi-Fi MAC addresses than with Bluetooth does not necessarily correspond to a higher number of enabled Wi-Fi devices compared with Bluetooth-capable equipment.
[30]	Decision of implementation and efficient information exchange have to be ensured to address the challenges of road transportation.
[62]	Data collection, data integration and modelling approaches.
[70]	The main challenges are mobility and radio portability.
[59]	The main interworking challenges, is vertical handover and network selection issues.
[27]	High-performance processors and multimedia communication systems are required in surveillance.
[57]	Numerous technical aspects and corresponding challenges exist in D2D communication in wireless networks.
In the last part of this section, other concerns regarding various aspects are discussed individually, like the real-world protection issues, such as crashes caused by unexpected hard braking and fast lane altering [31], enable preliminary reviews of precisely from remote positions, possibly save time and cost and growth the effectiveness of subsequent on-site visits [31, 71, 72].	

6. Recommendations associated with data exchange in V2p communication.

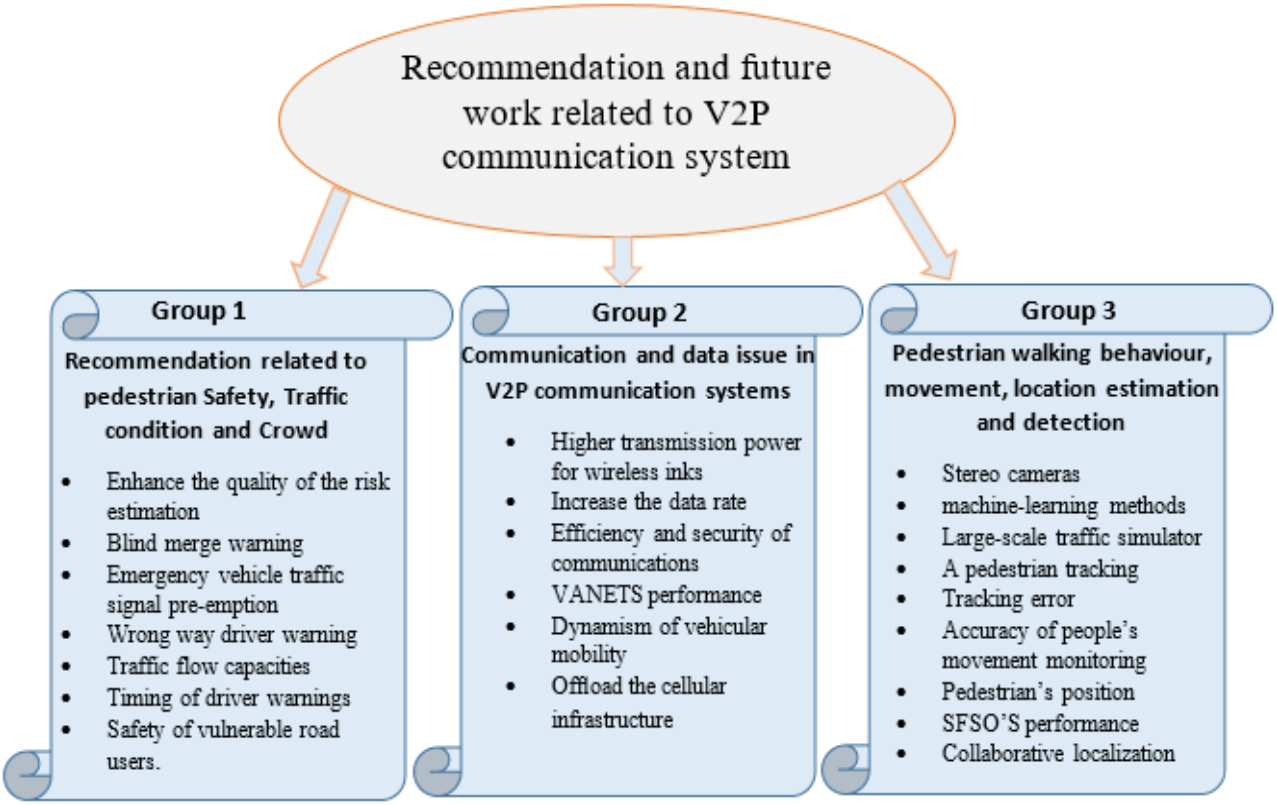

Figure 3. Groups of recommendations associated with V2P communication

Three groups of important recommendations in the literature summaries are discussed in this section to reduce the problems and facilitate the safe and effective use of V2P communication, as demonstrate
d in Fig. 4

6.1. Recommendations related to pedestrian safety, traffic conditions and crowds

The development of an ADAS is especially appropriate in rural or mountain roads, in which accidents involving the use of such systems are common [18]. The author in [21] recommended to use the improving algorithm for judging the best timing of data support. The multimodal analysis method must be enhanced by simultaneously modelling the injury occurrence and flows of cyclists, pedestrians and motor vehicles in a single FRAMEWORK. further explore to the effect of correlation amongst injury outcomes [62]. The findings of a data analytic methodology for extracting critical information are relevant in incorporating alerts, warnings and control assists[31]. A methodology should be developed to catch a relationship between theoretical and actual traffic flow capabilities [56]. A realistic modelling of car drivers and cyclists has been recommended in [54].

6.2. Recommendations related to communication and data issues in data exchange on V2P communication systems

This section introduces recommendations associated with the new standard and technologies for V2P communication systems. A channel is planned for use with broadband fixed wireless access, which allows high transmission power for wireless links [19]. The creation of ad hoc large databases with variable backgrounds (for example, taken from a car moving in an urban environment) is recommended to further validate the suggested system in pedestrian classification [13]. The authors in [69] recommended an extended ICeDiM to gather the past of encountered nodes and calculate the statistics on the spreading of IOs across the network. To offload the cellular infrastructure, the author in [68] recommended to select the outgoing radio interface by leveraging the ad hoc connectivity of nearby nodes. The interference issue in the non-ISM band should be investigated whilst considering the possibility of applying DSRC in V2P communication systems [20]. Other recommendations discuss the data issue such as the work in [16, 73] mentioned to use a data encoding standard which is 'OGC moving features', could assist the developments researchers who working in the field. The simulating functions of the biological visual system that could extract key data from limited samples is a future

area of investigation in [44]. The future work in [22, 74] is about the introduction of DENM and the evaluation of the scalability of CAM servers (for example, determining the number of CAM/-DENM messages).

6.3. Pedestrian walking behavior, movement, location estimation and detection

Pedestrian tracking could be functional to pedestrian tracking and detection at common road intersections. Multiple cameras could be utilized to reduce tracking errors [43]. Walkability indices have been transferred to GMA for comparing the performance of PIE to those of existing measures [66]. Assessing the effect of large and small antenna gains on following the movements of pedestrians and cyclists could be beneficial to enhance the accuracy of observing people's movement [64]. The investigation in [12] recommended considering the method of evaluating each pedestrian's accident risk for each driver and filtering out pedestrians with low accident risk to ensure that each driver could focus on pedestrians with high accident risk. In [24], an investigation into additional methodologies and metrics that should include altered protocols and their integration with cloud-based platforms has been suggested. The fusion process improving the quality of occupancy state patterns that leads to significant enhancements in pedestrian detection and false alarm reduction has been recommended in [49]. The system of pedestrian crossing detection will be utilized in INRETS experimental sites for traffic management researches pointing to analyse and enhance pedestrian mobility and safety [48, 75]. Collaborative localisation also presented a baseline case for the fusion of general collaborative knowledge [25]. Additionally in [65] recommended a fusion procedure combining information of the laser scanner and the camera to overawed the limitations of each sensor and provide enhanced detection [39]. A system providing REAL TIME detection of road users (pedestrians and vehicles) in real road situations enhanced the low-level results and provided enhanced performance. The scalability of the system allowed the easy integration of future sensing devices in [40]. The authors in [35] recommended a plan for designing machine-learning approach and developing optimum strategies in driving and traffic control [6.

6.4. Limitations

The identification of associated studies has been difficult, Though the database sources utilized in this survey have been reliable and extensive ranging, also due to the growing and quick progress in this area, the timeliness of the review has been limited. Furthermore, we confirm that investigates performed on this critical area over a given time frame do not often constitute real use. These investigations simply demonstrate the study community's reaction to the area, which is the survey's aim.

7. Conclusions

The data exchange in the domain of V2P communication systems is an emerging research area due to its potential positive influences on pedestrian safety. This work provided an indication of the current studies and trends in this domain with the scope of pedestrian safety. This work has been classified to provide future researchers with a comprehensive understanding of this area. The taxonomy has been drawn to organise the related literature found in our search to ease and provide an enhanced understanding of the topic. The taxonomy contained the four main categories: development, survey and review articles, framework and investigation focusing on the data exchange in V2P communication systems. A discussion on the challenges and issues as well as motivations and recommendations related to the data exchange in V2P communication domain with the scope of pedestrian safety has been presented after the relevant topics have been extracted from the related articles. The different issues related to safety, accuracy, pedestrian detection and data and devices have been identified. Various recommendations have been provided to resolve the current challenges in this area. A comprehensive analysis has been likewise presented to perform mapping of future research directions on the basis of the identified gaps. Investigation, constructing a structure for pedestrian protection schemes, investigation, review, and assessment were the four steps of our proposed approach. Our proposed methodology's findings will be presented in subsequent experiments, and a dataset will be made accessible to other researchers.

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