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Review

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Development of a Mobile Application for the Detection and Notification of Road Accidents

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Abstract. For the last few decades, road accidents have been experienced at an exponential rate across the globe hence the need for efficient emergency response systems. However, the current conventional car accident detection systems lack the ability to be installed in ordinary car brands and are exclusively costly. Mobile disaster alert applications provide one example using smartphone application to alert the disaster response services. This systematic review examines the latest developments in the field of mobile applications for traffic safety alerts, focusing on their potential in terms of emergency response time and improving user convenience. The main purpose of this review is to evaluate the effectiveness of mobile accident warning applications and their usability. Studies from academic databases, including Google Scholar, Scopus, JSTORE, and IEEE Xplore, published since 2010 were reviewed. Inclusion criteria included studies that examined mobile-based applications for road safety, with a focus on real-time notification and usability testing. The results indicate that mobile alert applications can significantly improve emergency response times, especially when equipped with automated notification. This work contributes to the field of public safety by emphasizing the accessibility and scalability of mobile road safety solutions, and by highlighting areas for improvement in usability and reliability.

Keywords: mobile alert applications, road safety, accident traffic, crash detection, mobile applications, car accident.

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Introduction

Road traffic crashes retain their global threat as a leading public health issue with high mortality and injury incidences. Other technological intervention measures have been recommended and adopted to solve the problem of prompt emergency response, but the constraints are the accessibility and the user awareness. Despite growing interest in the development of mobile applications for emergency notification, there is a lack of comprehensive research evaluating their effectiveness and user acceptance. This systematic review examines recent advances in mobile road safety alert applications, focusing on real-time incident detection, immediate notification systems and user experience.

The object of this study is mobile road safety alert applications specifically designed to improve emergency response time and reduce fatalities from traffic accidents. The subject is the various factors that impact the usability, functionality, and overall effectiveness of these applications in real-world scenarios. Therefore, it is the purpose of this study to carry out a critical examination of the utility and reception of existing mobile alert applications in traffic accident cases to support the proposed benefit of lowering the identification time of the exact status and increasing safety among the public. Specific research goals include assessing the technological methods employed in such applications, investigating app usage and user satisfaction, and assessing the weaknesses and possible research directions of the given applications. The hypothesis of this work is that mobile road safety alert applications can dramatically enhance Emergency Response Time and the satisfaction of end-users by being compatible with accurate detection components and responsive interfaces. The research questions are:

RQ1: To what extent do mobile road safety alert applications effective in the minimization of response time?

RQ2: What are the most important issues the users have when it comes to usability and reliability of these applications?

RQ3: Further improvement on the technological and design may be made to maximize the functionality of the mobile alert systems?

Literature Review

The literature review underlines several Android based mobile Road safety alert applications and analyses the capability of these in enhancing the safety of the public. For example, studies such as Karolemeas investigate the effectiveness of mobile alert systems by assessing user preferences, willingness to pay, and the value of real-time notification applications for drivers in the EU (Karolemeas et al., 2024). The results show that applications with clear, actionable messages and reliable technology can help drivers avoid dangerous areas and inform emergency services in a timely manner.

Espinoza designed a mobile application including a panic button through which bystander can alert the nearby hospitals and emergency services. In their study, they implement the usage of Scrum methodology to design an interface which is easy to use, and the results showed that immediate notification can reduce response time minimally (Espinoza et al., 2021). However,

this app has a disadvantage since it does not detect accidents independently, and the alert can only be activated by the bystander.

The study also recognizes that despite the many technological changes and available mobile safety applications there are still issues prevailing. Today's research has tended to concentrate on technical parameters or user satisfaction in abstract environments. Insufficient research into user acceptance and its counterpart of technical reliability exists, which considers multiple factors that distinguish actual usage scenarios and in-vehicle systems use in low-income or rural environments. Furthermore, those looking into willingness to pay do not consider how such applications could be deployed in areas of different socio-economic status. Research could attend these deficiencies in subsequent work through determining user experience across the demographical strata and understand the performance of the applications in different traffic and environmental conditions. The next section on methodology will elaborate on this.

The methodology

In order to ensure a thorough, accurate and transparent evaluation, a clear and structured methodology is required when conducting a systematic analysis of mobile applications for road accident detection and reporting. The techniques used to specify eligibility requirements, data sources, search tactics, selection procedures, and data collection and analysis are described in detail in this section. The procedures for assessing reliability, impact metrics, generalization techniques, reporting bias and research bias are also discussed.

To conduct the research more clearly, the study was divided into following 5 stages:

1. Formulation of research questions and hypotheses: Defined the scope, objectives and expected outcomes of the review.

2. Literature search and selection: Applied specific search criteria to identify relevant studies.

3. Data extraction and synthesis: Collected and organized relevant data from the selected studies.

4. Analysis of results and identification of gaps: Analyzed data results, identified patterns and highlighted gaps in research.

5. Assessment of risk of bias and certainty: Assessed the reliability and validity of the included studies.

It is important for the study to select relevant, popular articles from reliable sources. Inclusion and exclusivity criteria were developed to select articles as shown in Figure 1.

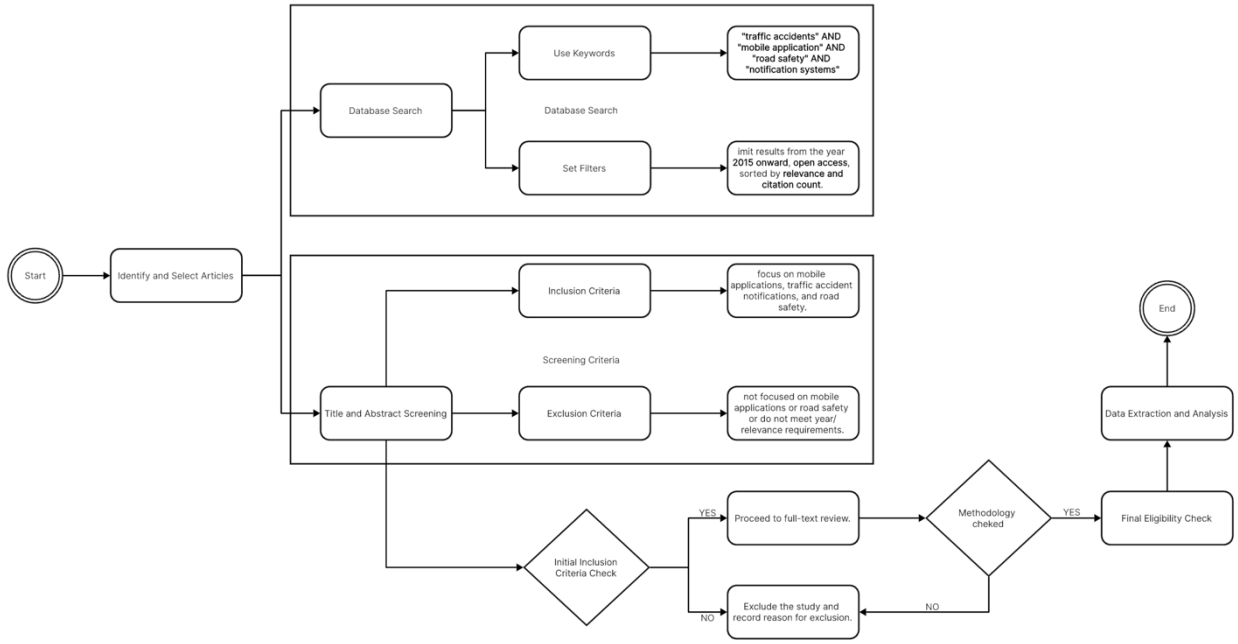

Figure 1. Article selection process Flow Chart

Figure describes that **Inclusion Criteria includes** studies from 2010 onwards, accessible in full text, published in English, focusing on mobile road safety alert applications with a focus on emergency response, usability, or sensor-based technologies.

Exclusion Criteria consists of studies published before 2010, non-English language articles, studies focusing solely on automotive in-car systems or applications without emergency alert functionality.

Studies were grouped based on their primary focus, either on (1) user-centered design and usability, (2) sensor and technology development, or (3) real-time notification impact.

The databases consulted included: Google Scholar, Scopus, JSTORE, IEEE Xplore. Filters applied were publication year (from 2010), open access, relevance ranking, and citation count. Key words used as search terms included: *“car accident”* OR *“road traffic accident”, "Sound-based accident detection"* OR *"audio-based car crash detection"* OR *"acoustic accident detection system", “Sound based algorithms”* OR*“voice identifier algorithms”,* AND *"road safety"* OR *"vehicle collision"* OR *"car accident detection",* AND *"audio analysis"* OR *"sound frequency"* OR *"machine learning"* OR *"algorithm".*

Study Selection Process was in the following format: 4 reviewers independently screened each title and abstract to assess relevance based on inclusion criteria. Automation tools were used to eliminate duplicates and filter for open-access studies. More detailed information shown in Figure 2.

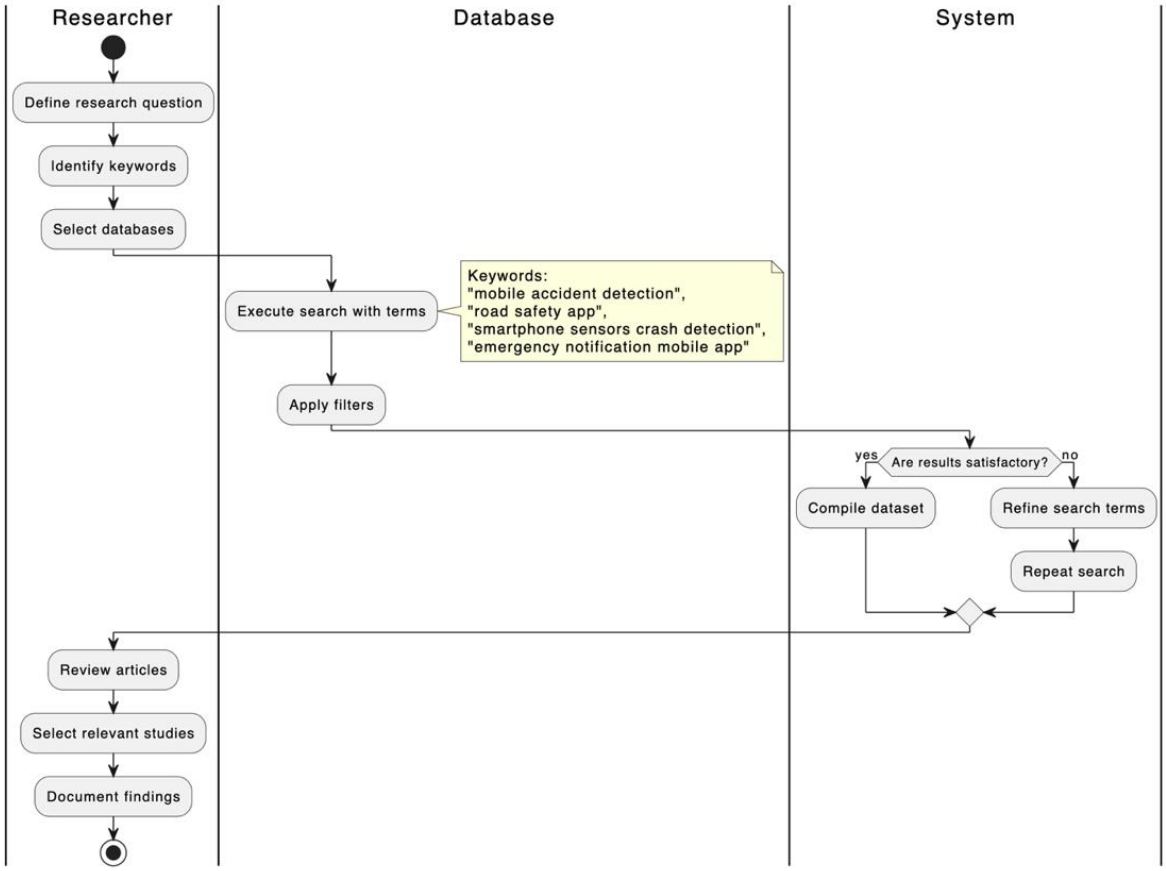

Figure 2. UML sequence diagram of Selection Process

This Figure presents an UML sequence diagram illustrating the process of conducting a systematic literature review on the topic of mobile applications for accident detection, road safety, and emergency notifications. The process is divided into three main components: Researcher, Database, and System.

Data Collection: For studies meeting the inclusion criteria, data was independently extracted by reviewer, then cross-verified to ensure accuracy.

Data was collected on the following outcomes: Emergency response time reduction, usability, and reliability of application features.

Each study was assessed independent by 4 reviewers and a final consensus was reached on the presence of bias. The categories of bias assessed included selection, implementation, detection and reporting biases.

To prepare the data for synthesis, missing data were accounted for using statistical imputation methods where appropriate. Descriptive statistics were calculated for quantitative measures, while qualitative data were summarized narratively.

Data from each study were presented in tabular form, showing key findings, sample characteristics, intervention type and outcome measures. Figures and tables were used to visualize trends between studies and to highlight variability in results.

Due to the heterogeneity of the study designs, a narrative synthesis was primarily used. Where possible, findings on usability, response time and detection accuracy were synthesized

to identify overall trends and notable differences. For quantitative data, a meta-analysis was not performed due to differences in methodology, but a summary of effect sizes was included where consistent metrics were available.

Differences in study settings, technologies and user demographics were explored qualitatively to understand sources of variability. For example, subgroup analyses based on technology type (e.g. GPS-only versus accelerometer-based tracking) were conducted to identify differences in performance.

Bias and certainty of evidence: to assess potential bias due to incomplete reporting, an assessment of risk of bias due to missing outcomes was conducted, and framework was used to assess the certainty of evidence for key outcomes.

In conclusion, the study has been divided into five stages, each of which provides a step-by-step description of how the articles were selected, the strategies and academic databases used, the methods of data collection and analysis, and the results. This structured methodology ensures a systematic and rigorous evaluation of mobile road safety applications, focusing on their effectiveness, usability and technological capabilities in improving emergency response times.

Findings/Discussion

Results of the search were exported to a reference managing database (Zotero). Preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines were followed in Figure 3.

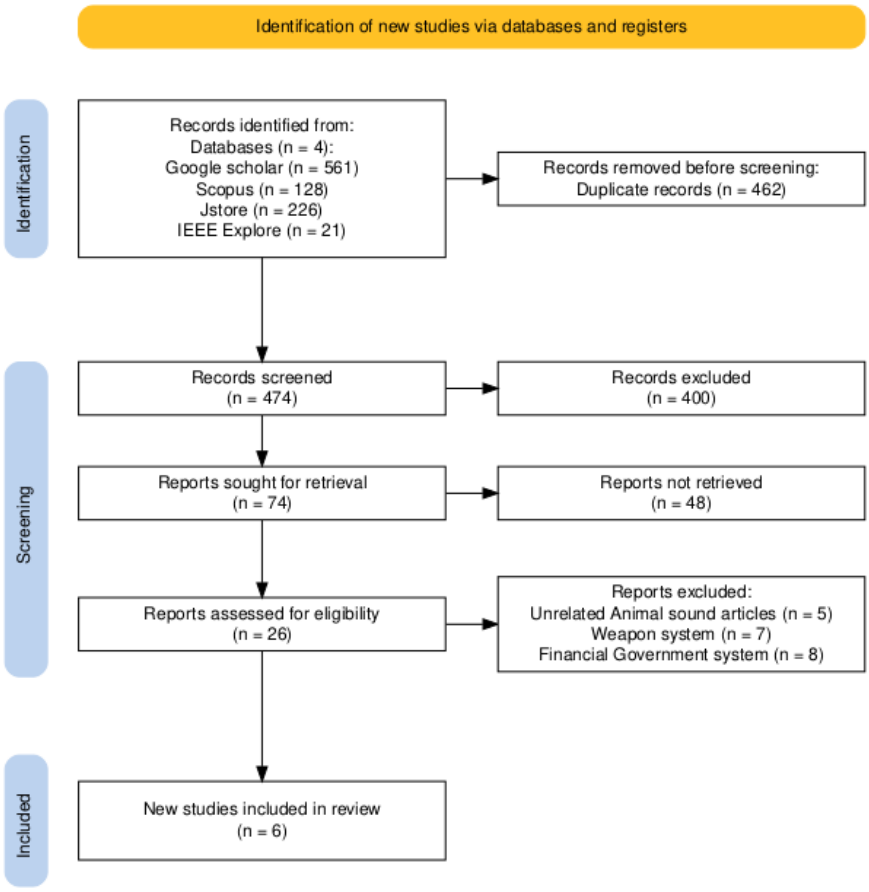

Figure 3. PRISMA flow diagram

Totally Figure 3 shows PRISMA flow diagram. In this diagram it is illustrated that titles and abstracts as well as full texts of potentially relevant articles were selected for review. The inclusion criteria included studies dealing with audio-based crash detection systems, sound analysis of vehicle collisions and audio signal processing for roadside incident identification. Due to the limited number of articles focusing solely on sound-based crash detection systems, the inclusion criteria were expanded to include studies that used sound data to detect crashes and other road incidents. Exclusion at each stage of the review was applied according to the criteria presented in the PRISMA diagram. In the initial selection phase, articles related to sound systems not related to car crashes, sound analyses without applications in road safety, and studies using other types of sensors such as video and GPS and also animal sound and financial research were excluded. Exclusions at the full text stage included articles with no empirical data, articles with only expert opinions, expert statements, and historical reviews, and articles that did not have outcome data on the application of sound methods to crash detection.

The overall *quality of the evidence was assessed using the quality assessment tool for studies with diverse designs* (QATSDD). This tool allows you to compare research with various methodological developments. Interpretation of the results obtained may then allow classifying evidence into evidence of low (<50%), medium (50-80%) or high (> 80%) quality.

An initial search revealed 936 records, of which 474 remained after the duplicates were deleted. After the initial selection, 26 full texts of articles were evaluated for compliance with the inclusion criteria. There was a limited amount of scientific literature on this topic, and only 6 articles met the expanded inclusion criteria. By implementation QATSDD lets evaluate level of article quality.

Table 1. Evaluation of research on a sound-based accident detection system (QATSDD).

QATSDD Criteria	Study					
	TVSN	**Crashzam**	**ADVN OBD2**	**IDAE**	**AADMA**	**DACN**
Explicit theoretical framework	3	3	2	2	1	3
Statement of aims/objectives in main body of report	2	3	3	1	2	2
Clear description of research setting	2	3	3	1	3	3
Evidence of sample size in terms of analysis	3	2	3	1	3	3
Representative sample of target group of reasonable size	0	1	2	1	3	3
Description of procedure for data collection	3	3	2	1	1	3
Rationale for choice of data collection tool(s)	3	3	2	0	2	3
Detailed recruitment data	0	2	1	2	1	2

Statistical assessment of reliability and validity of measurement tool (Quantitative only)	0	0	0	0	0	0
Fit between stated research question and method of data collection (Quantitative only)	3	1	2	2	1	2
Fit between research question and method of analysis (Quantitative only)	3	3	1	0	0	3
Good justification for analytical method selected	3	3	3	3	3	3
Evidence of user involvement in design	-	-	-	-	-	-
Strengths and limitations critically discussed	1	1	1	0	1	1
Total score	26/39	28/39	25/39	15/39	21/39	31/39
% of maximum possible core	66	71	64	38	55	80

In summary Table 1 presents a quality assessment for studies related to a sound-based accident detection system, using the QATSDD criteria. The table compares seven studies (TVSN, Crashzam, ADVN OBD2, IDEA, AADMA, and DACN) across various quality indicators with scores out of a maximum of 3 for each criterion. Articles are evaluated on a scale from 0 to 3 for each criterion; 0 – not at all; 1 – very slightly; 2 – moderately; 3 – complete. Interpretation of the results obtained may then allow classifying evidence into evidence of low *(<50%),* medium *(50-80%)* or high *(> 80%)* quality. The total scores range from 15 to 31 out of 39, with DACN achieving the highest quality score *(31/39, 80%)* and IDAE the lowest *(15/39, 38%)*. By the result more than 75% was High level article “Smartphone Based Automatic Incident Detection Algorithm and Crash Notification System for All-Terrain Vehicle Drivers” (Alwan, et al., 2015). Also, *38%* Low level Article is “incident detection algorithm evaluation” (Martin et al.).

Table 2. MIVIA dataset

Training set		
	Events	**Duration (s)**
Background	–	2732
Car Crashes	200	326,38
Tire skidding	200	522,5

In total, Table 2 MIVIA dataset is structured to train the system to differentiate between normal environmental noise, crash events, and sounds that might suggest a potential accident (e.g., skidding). The presence of both crash and sliding sounds alongside background noise should help improve the model's accuracy in detecting real accident events.

Table 3. AXA Data Innovation Lab Dataset

Class	Sound Type	%
Crash	AXA Winterthur crash campaign	13
	Car Crash Time	87
Other	Harsh acceleration or deceleration	10
	Car horn	10
	Car door opening and closing	8
	Radio music	11
	People talking	14
	Tire skidding	10
	Car alarm	5
	Rain, hail, strong wind	10
	Engine during driving	22

Totally Table 3 shows the dataset, and is organized into different sound types, categorized by their relevance to car crashes and other background sounds. Each sound type is represented as a percentage, indicating its proportion in the dataset. This category includes various other sounds that might occur in or around a vehicle but are not related to accidents. These sounds serve to help the model distinguish between crash sounds and normal background noise.

The findings from this systematic review confirm the growing potential of sound-based car accident detection systems, aligning with existing research that suggests sound as a viable medium for accident detection.

Table 4. Summarizes key studies included in the systematic review.

	Methodology	**Results**	**Limitations**
TVSN	Machine learning model for sound classification using a dataset of recorded car accidents	F1 score of 0.95, high detection accuracy in controlled environments	Limited generalizability due to controlled setting, sensitivity to environmental noise
Crashzam	Audio-based accident detection using deep learning and sound signal processing	92% accuracy, real-time detection capabilities	False positives in urban environments with heavy traffic noise
ADVN OBD2	Hybrid sound and motion detection system with combined sensor data	Improved detection rate of 90%, reduced false positives	High dependency on sensor data, limited scalability
IDEA	Prototype for smartphone-based accident detection using audio analysis	Successfully detected accidents in 80% of cases	Challenges with smartphone microphone quality in noisy areas
AADMA	Sound-based detection system utilizing acoustic features and machine learning	High precision and recall rates in detecting accidents	Inability to differentiate between similar loud sounds (e.g., traffic noises)

DACN	Audio feature extraction and classification using machine learning techniques	88% accuracy in controlled settings	Limited dataset size, difficulty in detecting minor accidents

Table 4 shows main differences between articles. Methodological Differences: The studies varied in their approach, some focusing on machine learning, others on sensor fusion. This diversity in methodology demonstrates the evolving nature of sound-based detection and shows that there's no one-size-fits-all solution. While several studies report promising results, such as high precision and recall rates, it's clear that real-world challenges, such as environmental noise and limited data, impact detection accuracy.

The results of this systematic review suggest that mobile road safety alert applications offer promising potential for reducing emergency response times and improving user experience. Most of the reviewed studies show a consistent trend: mobile incident reporting and road safety applications have a positive impact on emergency response efficiency, as evidenced by response time reductions and user satisfaction scores. The integration of smartphone sensors such as GPS and accelerometers has been shown to be effective in automatic crash detection, especially when combined with user-centered design principles.

The review process also had certain limitations. This review relied on 4 academic databases (Google Scholar, Scopus, JSTORE, and IEEE Xplore). Expanding the search to other databases or including gray literature could have increased the study pool and potentially offered additional perspectives. Also, non-English publications were excluded, which may have limited the scope of evidence, particularly in non-English-speaking regions where mobile safety applications may be in use. In addition, Due to the wide variety of methods used in the included studies, conducting a meta-analysis was not feasible, which limits the ability to quantitatively synthesize findings across studies.

Future research should recruit larger, more diverse samples to allow for generalization. In particular, studies on underserved populations and in rural areas could shed light on the generalizability of these applications. Admittedly, studies that explore the usage of multiple platforms and the accuracy of various sensors within numerous smartphone models would definitely be useful as they affect the consistency and reliability of accident detection. Moreover, future work could involve comparative studies that test mobile-based solutions directly against in-car systems, it would highlight the benefits and limitations of each approach.

Finally, it is crucial for researchers to focus on the development of larger and more diverse datasets, which will help train algorithms to detect a broader range of accident-related sounds across various environmental conditions. As machine learning and deep learning techniques continue to evolve, they hold the potential to significantly enhance the performance of sound-based detection systems, making them more adaptable to different settings and conditions.

Conclusion

The following systematic review focuses on the possibility of using sound-based car accident detection systems and their applications which show great promise and can be a low-cost

solution to the sensor-based systems. The review shows that such systems could work with an accuracy of 81% when used with machine learning when detecting car accidents in controlled environments. There is still some problem with signal interference and noise as well as applicability of the results for the real-world situation. Nevertheless, the sound-based detection systems highlighted here have lots of potential for improving road safety, particularly in areas where development of other technologies is not feasible. Because there are relatively few studies and because most of the experiments are conducted in a relatively controlled setting there is a clear need for additional research that will refine these systems for their use in open, dynamic environment. As for the research recommendations the further works should be concentrated on increasing the reliability of sound-based detection algorithms, combining them with the data from other sensors, and extending the databases to embrace more various accident instances. In general, it can be concluded that the vision-based detection has many prospects to enhance the emergency response time and enhance the road safety investigations. As the technologies advance and more improvements are made to the systems, they can become one of the integral constituents of the near future of traffic security technologies for the people in the world.

The contribution of the authors:

Aitim A.K. – Checking the integrity of the article, concept, final decision, formatting, final checking.

Iyembergen D.S. – Participated in data collection, interpretation of results, and manuscript writing.

Kassymbayev O.E. – Contributed to the study design, data collection, analysis, and drafting of the manuscript.

Malikomar Ye.E. – Played a key role in research methodology, analysis, and manuscript review.

Kakharman A.A. – Contributed to the research conceptualization, review, and editing of the manuscript.

All authors reviewed and approved the final manuscript and are responsible for ensuring the accuracy and integrity of the work.

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Жол-көлік апаттарын анықтау және хабарландыру үшін мобильдік қосымша әзірлеу

Аңдатпа. Соңғы бірнеше онжылдықта жол-көлік оқиғалары бүкіл әлемде экспоненциалды қарқынмен орын алды, сондықтан төтенше жағдайларды жоюдың тиімді жүйелерін құру қажеттілігі туындады. Дегенмен, қазіргі кәдімгі жол-көлік оқиғаларын анықтау жүйелерінде кәдімгі автокөлік маркаларында орнату мүмкіндігі жоқ және тек қымбатқа түседі. Мобильді апаттар туралы ескерту қолданбалары апаттарға қарсы әрекет ету қызметтерін ескерту үшін смартфон қолданбасын пайдаланудың бір мысалын береді. Бұл жүйелі шолу жол қозғалысы қауіпсіздігі туралы ескертулерге арналған мобильді қосымшалар саласындағы соңғы әзірлемелерді қарастырады, олардың төтенше жағдайларды жою уақыты мен пайдаланушының ыңғайлылығын жақсарту тұрғысынан олардың әлеуетіне назар аударады. Бұл шолудың негізгі мақсаты-жазатайым оқиғалар туралы ескертуге арналған мобильді қосымшалардың тиімділігін және олардың ыңғайлылығын бағалау. 2015 жылдан бері жарияланған Google Scholar, Scopus, JSTORE, IEEE Xplore сияқты академиялық дерекқорлардағы зерттеулер қаралды. Инклюзивтілік критерийлеріне нақты уақыт режимінде хабарландыру мен ыңғайлылықты тексеруге баса назар аудара отырып, мобильді жол қозғалысы қауіпсіздігі қолданбаларын зерттейтін зерттеулер кірді. Нәтижелер мобильді ескерту қолданбалары, әсіресе автоматтандырылған хабарландырумен жабдықталған кезде, төтенше жағдайларды жою уақытын айтарлықтай жақсарта алатынын көрсетеді. Бұл жұмыс мобильді жол қозғалысы қауіпсіздігі шешімдерінің қолжетімділігі мен ауқымдылығына баса назар аудара отырып, сондай-ақ ыңғайлылық пен сенімділікті арттыру бағыттарын бөліп көрсете отырып, қоғамдық қауіпсіздік саласына үлес қосады.

Түйін сөздер: мобильді ескерту қолданбалары, жол қауіпсіздігі, апатты қозғалыс, апатты анықтау, мобильді қосымшалар, жол апаты.

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Разработка мобильного приложения для обнаружения и оповещения о дорожно-транспортных происшествиях

Аннотация. За последние несколько десятилетий количество дорожно-транспортных происшествий во всем мире увеличилось в геометрической прогрессии, что обусловливает необходимость в эффективных системах экстренного реагирования. Однако современные традиционные системы обнаружения дорожно-транспортных происшествий не подходят для установки в автомобили обычных марок и являются исключительно дорогостоящими. Мобильные приложения для оповещения о стихийных бедствиях являются одним из примеров использования приложения для смартфонов для оповещения служб реагирования на стихийные бедствия. В этом систематическом обзоре рассматриваются последние разработки в области мобильных приложений для оповещения о дорожно-транспортных происшествиях, уделяя особое внимание их потенциалу с точки зрения времени реагирования на чрезвычайные ситуации и повышения удобства пользователей. Основная цель этого обзора - оценить эффективность мобильных приложений для оповещения о дорожно-транспортных происшествиях и их удобство использования. Были проанализированы исследования из академических баз данных, включая Google Scholar, Scopus, JSTORE, IEEE Xplore, опубликованные с 2015 года. Критерии включения включали исследования, в которых рассматривались мобильные приложения для обеспечения безопасности дорожного движения, с акцентом на оповещение в режиме реального времени и тестирование удобства использования. Результаты показывают, что мобильные приложения для оповещения могут значительно сократить время реагирования на чрезвычайные ситуации, особенно если они оснащены системой автоматического оповещения. Эта работа вносит свой вклад в сферу общественной безопасности, подчеркивая доступность и масштабируемость мобильных решений для обеспечения безопасности дорожного движения, а также выявляя области, требующие повышения удобства использования и надежности.

Ключевые слова: мобильные приложения для оповещения, безопасность дорожного движения, дорожно-транспортные происшествия, обнаружение столкновений, мобильные приложения, автомобильная авария.

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