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Roadsense: An Android-Based Drowsiness Detection System for Preventive Safety Measures

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Abstract - *Drowsy driving significantly contributes to global road accidents, yet advanced detection technologies remain exclusive to high-end vehicles, limiting their accessibility in developing countries like the Philippines. To bridge this gap, the researchers developed this project, an Android-based application designed to detect driver drowsiness in real-time and provide auditory alerts. The study aimed to identify user requirements, develop the system using the Scrum Framework, and evaluate its usability, performance, and detection accuracy. The descriptive, developmental, and experimental research designs were used in this study, involving 20 respondents for requirements elicitation and 10 participants for performance testing. The researchers used (1) descriptive research to gather user requirements, (2) developmental research, specifically the Scrum Framework to ensure iterative software development, and (3) experimental research to test the system's performance under different lighting conditions. The findings showed that the system is highly usable, providing an application for drivers seeking preventive safety measures. Furthermore, it was determined that the drowsiness detection feature performs well in well-lit environments. However, its accuracy decreases in dim-lit conditions due to the limitations of smartphone camera sensors and environmental conditions. It was concluded that the application serves as a functional solution for alerting users of their drowsiness by combining AI-driven monitoring with navigation services. This project demonstrates the potential of mobile technology to improve driver awareness and road safety management.*

Keywords - *Drowsiness Detection, Drowsy Driving, Road Safety.*

INTRODUCTION

Drowsy driving is a serious and often overlooked cause of road crashes worldwide. According to the World Health Organization (2023), drowsiness contributes to a large number of traffic fatalities, especially among those involved in long-distance transport and travel during nighttime hours. As a part of the broader issue of human error, which remains the leading cause of road accidents globally, drowsiness poses a unique threat (Segun et al., 2024). Unlike speeding or driving under the influence, drowsiness is difficult to recognize and regulate, making it a hidden danger on the road.

Driving is a complex task that demands continuous attention and focus. Unlike sudden mechanical failures or reckless behaviors, drowsiness accumulates gradually, impairing cognitive functions such as reaction times and decision-making abilities. Factors like sleep deprivation, exhaustion, drug or alcohol use, certain medications, and health conditions such as sleep apnea all contribute to drowsiness, which significantly increases the likelihood of accidents (Soares, 2020).

Despite these risks, many drivers underestimate the severity of their drowsiness, believing they can push through drowsiness due to pressure to reach destinations on time or personal overconfidence. Studies have shown that drowsy driving is particularly common among commercial drivers, shift workers, and individuals with sleep disorders, as these groups often work irregular hours and experience disrupted sleep patterns. According to Bharadwaj et al. (2021), drowsy-related accidents are more likely to occur during long-distance or nighttime driving, when natural circadian rhythms cause drowsiness to peak, making it even harder for drivers to stay alert. Data from 1,892 driving events across six U.S. states showed that drivers with sleep disorders, particularly those with shift work sleep disorder (SWSD), exhibited significantly higher crash risks. The odds ratio for crashes among drivers with SWSD was 2.96, indicating nearly three times the likelihood of being involved in a crash compared to those without such disorders. This risk was even more pronounced among older drivers with SWSD, highlighting the compounded effect of circadian misalignment and age on driving safety. Supporting this, Davidović et al. (2023) identified that truck and bus drivers are at significantly higher risk for drowsiness-related crashes compared to private car drivers, highlighting the occupational hazards experienced by commercial drivers.

Drowsy driving significantly endangers public safety, contributing to thousands of crashes and fatalities each year. According to the National Highway Traffic Safety Administration (2022), drowsy driving was responsible for approximately 91,000 crashes, resulting in 50,000 injuries and 800 deaths in the U.S. However, these figures may be an underestimation, as drowsy driving-related accidents are often difficult to diagnose and frequently go unreported. This underreporting may be attributed to the difficulty in reliably identifying drowsiness as the cause, as drivers often do not admit to drowsiness or lack visible signs of impairment, which complicates the classification of these incidents (Delwar et al., 2025).

Similarly, in the Philippines, drowsy driving has emerged as a critical yet often overlooked factor contributing to road accidents. According to Pamintuan (2024), fatigue-related accidents remain underreported, a gap likely widened by the diagnostic prioritization of alcohol-related incidents. While 20-25% of accidents are attributed to alcohol (Baron, 2025), the biological mechanism of these crashes is frequently sedation. This discrepancy is critical because alcohol functions as a central nervous system depressant; even mild intoxication (BAC 0.01–0.07%) induces sedation and microsleeps that are biologically indistinguishable from fatigue (Tefft, 2024). Consequently, a significant portion of these accidents are mechanistically incidents of alcohol-induced drowsiness that go unrecorded in fatigue statistics.

Additionally, a study on road crash incidents highlights that inadequate enforcement and a lack of driver discipline reduce the effectiveness of existing safety measures (Delfin & Montano, 2022). Limited public awareness campaigns also fail to reach all road users, reducing the effectiveness of educational efforts (Cebu Daily News, 2024). Given these gaps, advanced real-time intervention systems have emerged to detect and mitigate risks like drowsy driving-related accidents.

Existing measures to prevent road accidents caused by driver-related factors include road signs, driver education programs, and vehicle safety features such as seat belts and anti-lock braking systems. Public awareness campaigns and educational initiatives emphasize the dangers of drowsy driving, advising drivers to take breaks every two hours or 100 miles (National Sleep Foundation, 2024). However, these measures rely heavily on voluntary compliance, making them ineffective in preventing drowsy driving-related accidents. Road signs serve as passive reminders, but they do not actively prevent drowsiness, and drivers may continue to push through exhaustion due to work demands or scheduling pressures.

Recent technological advancements have significantly enhanced driving safety by integrating sophisticated systems designed to assist drivers in preventing accidents and maintaining vehicle control. Advanced Driver Assistance Systems (ADAS), such as Automatic Emergency Braking (AEB), Lane Departure Warning (LDW), and Blind Spot Monitoring (BSM), have demonstrated substantial efficacy in reducing crash rates, with a study analyzing vehicles from model years 2015 to 2020 confirming their effectiveness in crash avoidance (MITRE, 2022). However, these advancements remain largely inaccessible to the Philippines, where a majority of vehicles are older models without embedded safety features.

Beyond ADAS, AI-powered driver monitoring systems are improving road safety by detecting signs of drowsiness and distraction in real-time. For example, Volvo's Driver Alert Control (DAC) monitors the vehicle's position within the lane and the driver's steering inputs to identify erratic behavior indicative of drowsiness or distraction. When such behavior is detected, the system alerts the driver with an audible signal and a message suggesting a break, activating at speeds exceeding 65 km/h or 40 mph and remaining active as long as the speed is above 60 km/h or 37 mph (Volvo Cars, 2024). Yet, this system is typically available only in premium or high-end vehicles, limiting its adoption among the broader driving population, especially in lower-and middle-income regions.

These technological innovations pave the way for more intelligent driving solutions, incorporating real-time monitoring and proactive safety measures to further enhance road security and driver awareness.

Despite ongoing safety road measures, drowsy driving-related crashes persist due to current interventions not being universally accessible to traditional vehicles. Many existing measures, such as road signs and public awareness campaigns, rely heavily on driver self-awareness and voluntary compliance, which limits their effectiveness. Meanwhile, advanced safety systems like Driver Alert Control (DAC) or other AI-powered driver monitoring tools are typically built into premium or high-end vehicles, making them financially and technologically inaccessible to the majority of drivers, especially in low- and middle-income countries like the Philippines.

This lack of accessibility creates a significant gap in road safety. The very drivers most at risk, such as commercial drivers, public utility vehicle operators, and those using older-model cars, are the least likely to benefit from modern, proactive warning systems.

To address this gap, the researchers propose a mobile-based AI-driven safety application designed to detect signs of drowsiness and distraction in real time using the smartphone's front camera and built-in sensors. Unlike traditional in-vehicle systems, which are often limited to high-end vehicles, this solution leverages the accessibility of smartphones. Using the phone's front camera and sensors, it tracks indicators such as eye closure, gaze deviation, and erratic head movements to assess driver alertness. Built-in gyroscopes analyze steering-like motions, and when signs of drowsiness are detected, the app issues auditory alerts and suggests nearby rest areas via integrated navigation.

By offering proactive alerts and drowsiness intervention through an affordable, portable platform, this tool enhances current road safety efforts and extends protection to a broader population, especially in regions with limited access to advanced vehicle technologies.

The system also integrates navigation assistance, allowing drivers to locate nearby rest areas when drowsiness is detected, as well as proactive safety alerts to prevent accidents caused by drowsy or inattentive driving. By combining real-time drowsiness detection with smart intervention strategies, this solution bridges the gap between conventional vehicle-based safety systems and modern mobile-driven approaches. This innovation enhances current road safety monitoring efforts, offering an AI-powered solution to improve driver awareness and mitigate drowsy driving-related accidents.

MATERIALS AND METHOD

The descriptive, developmental, and experimental research designs were used in this study. To gather insights, questionnaires are used as a data collection tool. As stated by Jovancic (2021), descriptive research design is applied in case studies, naturalistic observations, and surveys, involving data collection, analysis, and presentation.

Additionally, the study employed a developmental research design, which focused on the systematic process of designing, developing, and evaluating technological solutions. Developmental research involved the structured creation of programs, processes, or products that meet internal consistency and effectiveness standards. Specifically, this research design guided the development of the system, including its drowsiness detection system and integrated navigation features.

Scrum was used as the development framework. Scrum followed an agile and iterative approach, enabling continuous improvements based on feedback and testing. The key phases of Scrum that were applied in this study are as follows:

1. Planning and Requirement Analysis

In this initial phase, the researchers defined the specific vision for the system to create a cost-effective drowsiness detection system accessible on standard smartphones. Data gathered through user requirement surveys guided the determination of essential features and functionalities. They also considered any potential limitations, dependencies, and possible challenges. This phase helps set the foundation for the development process.

2. Product Backlog Preparation

During this phase, the researchers formulated the system requirements based on the study's primary objectives. Rather than gathering subjective user requests, the team synthesized specifications from existing literature on drowsiness detection. The researchers then selected specific tasks to be worked on in a sprint, which usually lasts two to four weeks. They broke tasks into smaller steps and assigned them to the team. This planning ensures that each sprint has a clear goal and contributes to the overall project.

3. Sprint Planning

The system development was divided into several sprint cycles. Each sprint focused on specific modules and functionalities to ensure an organized and manageable system development.

4. System Development

In this phase, the actual development of the system takes place. integrating the selected tasks. The researchers will translate the design prototypes into functional code using the Flutter framework and Dart programming language. Meetings are held at least three times a week to check progress, discuss challenges, and make adjustments if needed. Best coding practices are followed to maintain efficiency and quality.

5. Testing and Evaluation

Review and Retrospect. Once a sprint is completed, the researchers would review the work and test each part to make sure it functions correctly. Performance, accuracy, and usability are assessed. The researchers installed the prototype APK, and feedback from stakeholders was collected, and any needed improvements were made. A retrospective is also conducted to discuss what went well and what can be improved for the next sprint.

6. Deployment and Final Revision

Once the system achieved a stable F1 Score and met the minimum safety requirement, the final version of the system was compiled into a release-ready APK. The system was then deployed to the selected respondents (drivers) for the final usability testing using the System Usability Scale (SUS), marking the transition from development to data collection.

Finally, an experimental research design is adapted to evaluate whether the system's performance meets the predefined requirements and intended functions. This involves testing the system in controlled conditions, measuring performance metrics such as f-score and its fps.

RESULTS AND DISCUSSION

The development of the Student Organization Portal for PSU successfully addressed the major challenges encountered by student organizations in communication, collaboration, and resource management. The developed system provided a centralized platform where organizations could efficiently manage announcements, events, membership information, and organizational documents.

The development of RoadSense accomplished the requirements of the users. The developed mobile system provided users with a cost-effective alternative for real-time detection of signs of drowsiness and distraction. Furthermore, integration of navigation assistance is integrated upon showing signs of severe drowsiness.

A. System Interface

The following plates are then the final interface of Roadsense: An Android-Based Drowsiness Detection System for Preventive Safety Measures.

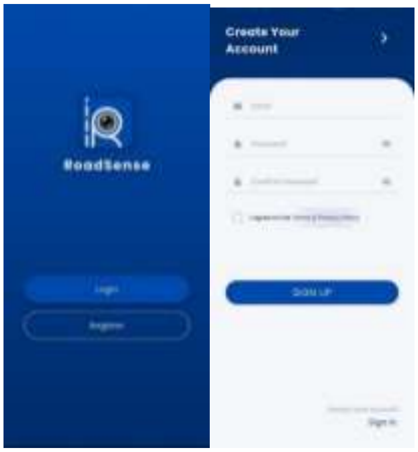

Figure 1. Log-in Screen

The figure 1 displays a selection for the user, allowing them to choose between logging in to an existing account and registering a new account.

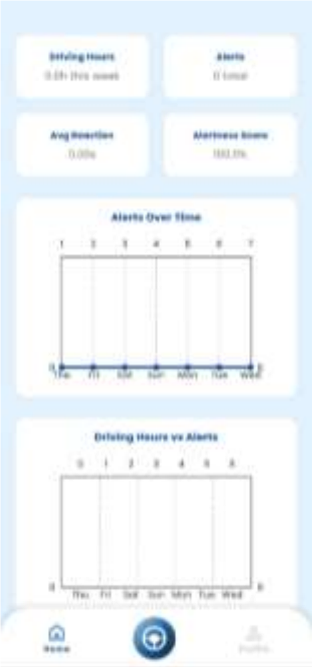

Figure 2. Dashboard Screen

The figure 2 shows the statistics of their driving hours, alerts, average reaction time, alertness score, driving history, and precautions before driving.

Figure 3. Recording Screen

The figure 3 displays an image of the front camera of the user. In which the system checks if the user's face is visible from the camera. This is the part where the app alerts the user whenever their face is not visible within the camera, or the user is displaying signs of drowsiness.

Figure 4. Map Screen

The figure 4 displays the user's location on the map. A search bar will also be seen above, where the user can enter their target destination before the trip. Upon selecting a destination, it will navigate to the former presented figure. Additionally, this screen shows whenever severe signs of drowsiness are detected, asking the users to rest at a nearby rest stop.

B. System Usability Scale (SUS) Result

After developing the mobile system, an evaluation of its usability is conducted before it is released. There are multiple ways to conduct a usability test, one of which is by collecting target users' feedback using a usability questionnaire. To measure the usability level of RoadSense among potential target users using the System Usability Scale Questionnaire (SUS).

To assess the system's overall usability, a SUS questionnaire was administered to a total of 10 respondents. The SUS is a widely used tool for measuring user perception of system usability based on a 10-item Likert scale.

Table 1. SUS Evaluation Results

Questions	SUS Score	Descriptive Equivalent	Descriptive Interpretation
1. I think I would like to use the app frequently.	70.00	Good	Usable
2. I found the app unnecessarily complex.	72.50	Good	Usable
3. I thought the app was easy to use.	87.00	Excellent	Highly Usable
4. I think I would need the support of a technical person to be able to use the app.	97.50	Excellent	Highly Usable
5. I found the various features of the app well integrated.	100.0	Excellent	Highly Usable
6. I thought there was too much inconsistency in the app.	70.00	Good	Usable
7. I imagine that most people would learn to use the app very quickly.	72.50	Good	Usable
8. I found the app very cumbersome to use.	77.50	Good	Usable
9. I felt very confident using the app.	75.00	Good	Usable

10. I needed to learn a lot of things before I could get going with this system.	85.00	Excellent	Highly Usable
Average	**80.75**	**Good**	**Usable**

Table 1 shows the data gathered from the usability testing survey questionnaire. To which the system has reached an overall mean of 80.75 with an adjective rating of "Good" with a descriptive capability of "Usable," indicating that the system is useful and easy for the users to understand and navigate.

Further analysis reveals that users rated the feature integration with a score of 100.0, indicating that the user flow was perceived as smooth. However, it shows that users found an inconsistency within the system since it scored 70.00, which likely correlates to the hardware performance, where the detection lag and accuracy may be perceived by the users as an inconsistency.

C. Evaluation of Drowsiness Detection Performance

To determine the optimal operational configuration for the system, a benchmarking was conducted across ten mobile devices. The study measured Frame Rate (FPS) and Detection Accuracy (F1 Score), both under natural light and low light conditions. Natural light refers to light being emitted from the sun and moon, while low light refers to an area where there isn't much available natural light. But to ensure the reliability of the findings, different test devices were used to evaluate the system's performance across the spectrum of hardware. This helps us determine which hardware can run the most optimal performance. The table below shows the hardware specifications.

Table 2. Hardware Specifications of Test Devices

ID	Processor	RAM	Camera Resolution
1	Snapdragon 7 Gen 3	8GB	50MP
2	Snapdragon 7 Gen 3	8GB	50MP
3	Unisoc Tiger T616	4GB	8MP
4	Unisoc Tiger T616	4GB	8MP
5	Snapdragon 8s Gen 3	8GB	50MP
6	Snapdragon 720G	4GB	32MP
7	Exynos 1480	6GB	32MP
8	Unisoc T620	6GB	32MP
9	Helio G99	8GB	32MP
10	Google Tensor G2	8GB	10.8MP

Following the hardware characterization, the system's performance was evaluated. Table 3 presents the comparative performance data across four resolution settings (240p, 480p, 720p, 1080p). The accuracy is represented by an F1 Score ranging from 0.00 to 1.00, where 1.00 indicates perfect detection of drowsiness events.

Table 3. Performance Metrics and F1 Interpretation

Device	240p			480p			720p			1080p		
	Natural Light	Low Light	FPS	Natural Light	Low Light	FPS	Natural Light	Low Light	FPS	Natural Light	Low Light	FPS
1	1.00	0.50	59.05	1.00	0.80	29.95	1.00	0.80	12.65	0.50	0.50	10.30
2	1.00	0.80	59.50	1.00	0.80	29.00	1.00	0.50	10.50	0.80	0.50	9.20
3	1.00	0.80	57.20	1.00	0.80	16.05	0.50	0.50	10.20	0.50	0.50	8.45
4	1.00	1.00	57.35	1.00	1.00	16.55	0.80	0.80	10.10	0.50	0.50	9.50
5	1.00	0.80	59.15	1.00	0.80	58.45	0.80	0.50	31.05	0.80	0.80	27.65
6	1.00	1.00	56.40	1.00	0.80	22.05	0.50	0.50	9.50	0.50	0.50	7.65
7	1.00	0.80	53.95	1.00	1.00	10.85	0.80	0.50	15.20	0.80	0.50	10.30
8	1.00	0.80	56.40	1.00	1.00	27.20	0.50	0.50	9.50	0.50	0.50	7.65
9	1.00	0.80	57.90	1.00	0.80	20.40	0.50	0.50	10.45	0.50	0.50	9.65
10	1.00	0.80	58.90	1.00	0.80	57.50	0.50	0.50	9.20	0.50	0.50	9.20
Average	**1.00**	**0.81**	**57.58**	**1.00**	**0.86**	**28.80**	**0.69**	**0.56**	**12.83**	**0.59**	**0.53**	**10.95**

Note: Columns labeled 'Natural Light' and 'Low Light' represent detection accuracy measured in F1 Score (0.00–1.00).

In Natural Light environments, the system demonstrated optimal stability at the 240p and 480p settings, achieving a perfect F1 Score of 1.00 across all devices. This confirms that as long as the frame rate remains above the safety threshold of ~16 FPS, the algorithm effectively captures drowsiness events. However, shifting to 720p caused a significant drop in performance; the average frame rate dropped to 12.83 FPS, causing the Natural Light F1 Score to fall to 0.69. This confirms that while higher resolution provides more image detail, it imposes a computational load that introduces significant latency, as rapid blink events are physically missed between frames at low speeds.

In low-light environments, it can be observed that there is a significant drop in performance. Even at 240p, where the system maintained a smooth average of 57.58 FPS, the F1 Score in Low Light dropped significantly to 0.81. This degradation proves that high frame rates alone cannot compensate for Subject Underexposure, where digital noise and shadowing obscure facial landmarks. Interestingly, the study observed that 480p performed marginally better in the dark (F1: 0.86) than 240p (F1: 0.81), suggesting that slightly higher pixel density helps define features in dim conditions, but only if the device can handle the computational load.

Among the test units, Device 5 emerged as the Optimal Reference Hardware. It demonstrated superior processing capabilities, maintaining a real-time frame rate of 58.45 FPS at 480p and remaining the only device to sustain usable speeds at 720p (31.05 FPS) and 1080p (27.65 FPS). This suggests that devices with specifications similar to Device 5 (refer to Table 2) represent the ideal hardware standard for running the system with minimal latency.

CONCLUSION

After obtaining the results of the analysis, the researchers have arrived at the following conclusions:

Based on the gathered user requirements, the users prefer an application that functions both as a safety tool and navigation assistant. This means that users view the system not just as an alarm system for drowsiness, but also as an assistant that helps them find a safe place to stop when fatigue sets in.

The use of Scrum Methodology is excellent for developing this type of system. Due to its iterative capabilities, the researchers were able to improve the system and enhance drowsiness detection continuously. This ensures that the app is not just compliant with its requirements but is also adaptable to the suggested needs of the user.

Based on the conducted usability testing using the System Usability Scale (SUS), the developed system is considered usable in terms of general ease of use and overall user satisfaction.

The drowsiness detection of the system is reliable under natural lighting conditions, since it achieved a good F1 Score. However, its performance dropped when tested under low-light conditions. This concludes that the standard cameras of smartphones are insufficient for night driving without external light sources.

The study concludes that 480p is the most viable resolution for the application, while 240p can also perform well; a significant drop in accuracy was found when compared to 480p under low light conditions. While higher resolutions like 720p and 1080p can offer better image quality, they impose an excessive computational load on the tested devices. This increased computational load caused a drop in frame rate, resulting in increased system latency. Additionally, among the test units, Device 5(Snapdragon 8s Gen 3, 8GB of RAM, 50MP) emerged as the optimal hardware. It demonstrated superior processing capabilities, maintaining a real-time frame rate of 58.45 FPS at 480p and remaining the only device to sustain usable speeds at 720p (31.05 FPS) and 1080p (27.65 FPS). This suggests that devices with specifications similar to Device 5 represent the ideal hardware standard for running the application.

RECOMMENDATION

Based on the conclusions made in the study, the following recommendations are hereby given:

The researchers recommend the adoption of RoadSense as a primary driver assistance tool. The study confirms that the system effectively alerts to drowsiness-related risks in real-time, making it a viable, low-cost safety alert for public utility and private vehicle drivers.

The researchers recommend integration of haptic feedback; future developers are recommended to explore the integration of wearable technology, such as smartwatches. While the auditory alarms are effective, implementing a smart watch with a vibration alert on the driver's wrist can provide a physical stimulus that is harder to ignore.

The use of the Scrum Framework is strongly recommended for any future iterations of this project, since refinement of its AI technologies is needed. Continuous refinement of its drowsiness detection will be needed.

It is highly recommended to use the System Usability Scale (SUS) for testing the usability of a system in terms of general ease of use and user satisfaction.

It is recommended that future researchers focus on making the model or algorithm more efficient rather than simply restricting the resolution. Since higher resolutions have better image quality, this could improve detection range and accuracy.

It is recommended to integrate the application into a dashcam, preferably one that has an active infrared (IR) sensor to address the limitations observed in low-light environments; future development should investigate integrating the system into a dashcam with a dedicated night vision sensor. This allows the algorithm to accurately detect the face even in darkness.

Device 6 (Snapdragon 720G, 4GB of RAM, 32MP) emerged as the baseline hardware. It demonstrated reliable processing capabilities, maintaining a stable frame rate of 22.05 FPS at 480p and providing a critical performance buffer significantly above the 15 FPS safety threshold. This suggests that devices with specifications similar to Device 6 represent the recommended minimum hardware standard for running the application.

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