**AI-Based Drowsiness Detection and Alert System to Enhanced Road Safety using YOLOv8**

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DEDICATION

This portion is optional but perhaps you have someone or some people who have inspired you to push on with your studies. A dedication would be a fitting way to acknowledge their impact on your success.

ACKNOWLEDGMENTS

The road to this point in your studies couldn’t have been travelled alone. Along the way, someone somewhere helped you. This is your chance to thank them.

By the way, exercise the liberty to be personal to reflect the sincerity of your gratitude.

TABLE OF CONTENTS

**[APPROVAL SHEET ii](#_30j0zll)**

**[DEDICATION iii](#_1fob9te)**

**[ACKNOWLEDGMENTS iv](#_3znysh7)**

**[TABLE OF CONTENTS v](#_2et92p0)**

**[LIST OF TABLES vii](#_tyjcwt)**

**[LIST OF FIGURES viii](#_3dy6vkm)**

**[ABSTRACT ix](#_1t3h5sf)**

**[1](#_4d34og8).**1

**[1.2](#_3rdcrjn)**

**[2](#_44sinio)**7**0**

**[2.1](#_2jxsxqh)**7**0**

**[2.2](#_z337ya)**18**6**

**[2.3](#_28h4qwu)****Error! Bookmark not defined.0**

**[2.4](#_nmf14n)****Error! Bookmark not defined.2**

**[3](#_2bn6wsx)**26**[25](#_3j2qqm3)**

**[3.1](#_qsh70q)**26

**[3.1.1 Software 33](#_3as4poj)**

**[3.1.2 Hardware](#_49x2ik5)** 26

**[3.1.3 Data](#_147n2zr)** 28

**[3.2](#_3o7alnk)**29

**[3.2.1 Research Design](#_37m2jsg)** 29

**[3.2.2 Process Model 3](#_1mrcu09)9**

**[3.2.3 YOLOv8 Algorithm 4](#_46r0co2)5**

**[3.2.4 Evaluation 4](#_2lwamvv)**7

**[4](#_32hioqz)**43

**[4.1](#_1hmsyys)**43

**[4.2](#_41mghml)****Error! Bookmark not defined.**

**[5](#_2grqrue)****Error! Bookmark not defined.**

**[5.1](#_vx1227)****Error! Bookmark not defined.**

**[5.2](#_3fwokq0)****Error! Bookmark not defined.**

**[5.3](#_1v1yuxt)****Error! Bookmark not defined.**

**[REFERENCES 53](#_4f1mdlm)**

**[APPENDICES 57](#_2u6wntf)**

**[CURRICULUM VITAE 58](#_19c6y18)**

LIST OF TABLES

**Table 1-1.** ML approaches focusing on drowsiness detection **5**

**Table 2-1.** Comparison Matrix **23**

**Table 2-2.** Conceptual Framewrok IPO Model **30**

**Table 3-1.** Software Utilization **34**

**Table 3-2.** Hardware Utilization **36**

LIST OF FIGURES

**[Figure 3-1. Agile Methodology 3](#_111kx3o)9**

**[Figure 3-2. Activity Diagram. 4](#_3l18frh)2**

**[Figure 3-3. Use Case Diagram. 4](#_3l18frh)3**

**[Figure 3-4. Overview of how YOLO detects objects. 4](#_3l18frh)6**

ABSTRACT

Insert your abstract here. This portion is not to be indented and should be clear, concise, and complete. As much as possible, limit the introductory part to a few sentences and make sure that the last sentence reiterates the achievement of the general objective of the research.

# INTRODUCTION

## Background of the Study

Driving while drowsy is a serious safety risk that can lead to accidents, injuries, and fatalities (MedlinePlus). Drowsiness occurs when someone feels unusually sleepy and can sometimes lead to unexpected sleep, even during important activities that require full alertness, like driving. This lack of alertness can be as impairing as being legally drunk, making it harder to stay focused, react quickly, and make safe decisions on the road (Suni & Suni, 2023a). Even without falling asleep, drowsy drivers are more easily distracted and slower to respond to hazards, leading to risky situations. Sleep deprivation also disrupts mental functions, making it harder to remember steps and follow instructions, which further increases the dangers of driving while drowsy.

The National Highway Traffic Safety Administration estimates that driver errors cause 94% of car crashes. Mechanical problems or road conditions cause very few accidents. Common driver mistakes include not paying enough attention and not watching carefully. In 2021, NHTSA reported that drowsy driving caused 684 fatal crashes, while drunk driving led to over 13,000 deaths, making up about 30% of all traffic fatalities. Drunk and drowsy driving remain critical issues affecting road safety (*Drowsy Driving | NHTSA*).

Drowsy driving is a major but often underestimated factor in fatal road accidents. Falling asleep or even momentarily nodding off behind the wheel can have devastating consequences. Estimates suggest that each year in the U.S., drowsy driving contributes to approximately 328,000 crashes, leading to 109,000 injuries and 6,400 deaths (Martin, 2024). This high number highlights how dangerous it is to drive when fatigued. In the Philippines, fatigue-related accidents are also common, though the exact number of incidents caused by drowsy driving remains unclear due to limited data. Despite this, the impact of road fatigue is well-known and has led to many preventable accidents each year. Awareness about the dangers of driving while tired has only recently started to gain public attention, lagging behind issues like drunk driving or distracted driving, which have received more consistent focus (Buban, 2020). This growing awareness underscores the need for more education on drowsy driving and preventative measures to reduce its impact on road safety.

A study used data derived from in-depth crash investigations conducted for the National Highway Traffic Safety Administration to develop and validate a model to impute driver drowsiness in cases when the driver’s pre-crash alertness or drowsiness could not be ascertained. The model was then used to impute the involvement of drowsiness in all fatal crashes nationwide that involved at least one car, pickup truck, van, minivan, or sport utility vehicle. Results show that an estimated 17.6% of all fatal crashes in years 2017–2021 involved a drowsy driver. These drowsy driving crashes resulted in 29,834 fatalities and accounts for about 328,000 crashes annually on the roadway, 109,000 injuries and 6,400 fatalities each year. [(](https://www.zotero.org/google-docs/?broken=xLxMRD)AAA Foundation for Traffic Safety 2024[.)](https://www.zotero.org/google-docs/?broken=xLxMRD). Drowsy driving is a significant safety concern on roads worldwide. Several factors contribute to drowsy driving incidents.

Research shows that solo drivers are more prone to drowsy driving, with no passengers to help keep them alert. Lack of sleep is the primary cause, as well as certain sleep disorders, medications, and alcohol, which increase the likelihood of drowsy driving. These factors all heighten accident risks due to impaired alertness and slower reactions (UCLA Health *Drowsy Driving*).

Advances in technology have led to various drowsiness detection methods. These systems fall into three main categories: vehicle dynamics (tracking how the vehicle moves), physiological monitoring (using biosensors to measure the driver’s condition), and facial recognition (analyzing eye movement, yawning, etc., to detect signs of fatigue). Each method has its advantages and challenges for improving driver alertness (Siddiqui et al., 2021). The effectiveness of vehicle dynamics drowsiness detection is limited due to various environmental factors. For example, the geometry of the road—such as curves, inclines, or declines—can affect how the vehicle handles and how the detection system interprets the driver's behavior (Sahayadhas, A., Sundaraj, K., & Murugappan, M. 2020). Physiological and facial monitoring on the other hand had been referred to as viable in drowsiness detection with only a difference of cost and efficiency.

The newest version of the YOLO object detection model, known as YOLOv8, provides powerful upgrades in real-time image processing, making it well-suited for detecting signs of drowsiness in drivers. This version can quickly identify critical indicators such as yawning, head tilting, and eye closure, all of which are common signs that a driver might be getting tired or losing focus. By detecting these signs early, YOLOv8 can make driver monitoring systems more effective, allowing them to respond immediately and potentially prevent accidents before they occur. The technology relies on neural networks, which are designed to mimic the way the human brain processes information. This structure makes it especially effective for real-time driver assistance, as it can analyze images at high speeds and with impressive accuracy. Overall, YOLOv8’s advanced capabilities are helping to make our roads safer by improving the quality and reliability of driver monitoring systems and reducing the risks associated with drowsy driving (Taleti, 2021).

Drowsy driving is one of the major causes of accidents on the road today, leading to thousands of crashes, injuries, and even fatalities each year. Recognizing how serious this issue is, this study focuses on using YOLOv8—a highly advanced object detection model—to detect signs of drowsiness in drivers before it’s too late. What makes this study so important is its goal to create a non-intrusive, real-time alert system that can effectively watch for signs like eye closure, yawning, or head tilting without disrupting the driver. By accurately reading these facial cues, the system can quickly identify when a driver is showing early signs of fatigue and immediately alert them, potentially helping them avoid an accident. This approach could prevent countless crashes and injuries each year, making the roads safer for everyone and saving lives. Such technology represents a critical step forward in road safety, highlighting the importance of innovation in preventing drowsy driving-related accidents (Keylabs, 2024).

## Statement of the Problem

Drowsy driving is a growing public safety issue, significantly contributing to road accidents, injuries, and fatalities globally. While behaviors like speeding and alcohol impairment are well recognized, drowsy driving has only recently gained attention as a critical risk factor. According to the AAA Foundation for Traffic Safety, an estimated 328,000 crashes occur annually in the United States due to drowsy driving, resulting in 109,000 injuries and 6,400 fatalities.

Despite technological advances in drowsiness detection, there remains a significant gap in cost-effective and accessible solutions. While existing technologies can help detect signs of drowsiness, many of them are limited to luxury vehicles or require expensive, intrusive hardware. These solutions are not feasible for the majority of drivers due to their high cost and inconvenience, highlighting the urgent need for affordable, non-intrusive technologies that can be widely used. Developing a reliable, real-time detection system that is accessible to all drivers is essential to addressing this pressing issue.

## Objectives of the Study

This study generally aims to develop an application-based system that can detect early signs of drowsiness in drivers using YOLOv8 and alert mechanisms to prevent critical situations and reduce risks of road accidents.

Specifically, this study aims to:

1. to design a system that monitors drowsiness of drivers, delivers a timely alert when early signs of drowsiness are detected and generates reports after every recording session.
2. to develop drowsiness detection using the YOLOv8 algorithm.
3. to test the algorithm efficiency and performance of YOLOv8 in terms of intersection over union (IoU), Average precision (AP), mean average precision (mAP), precision and recall and F1 score.
4. to evaluate the developed system based on ISO survey standards in terms of technical performance, usability and user experience and user satisfaction.

## Significance of the Study

This study will be significant in its potential to enhance road safety and reduce accidents caused by drowsiness. As of now, drowsiness is a major factor of many road accidents, and this system addresses that issue by detecting early signs of drowsiness and alert mechanism, which can help prevent accidents from happening. With YOLOv8’s fast and accurate detection capabilities, the system can monitor the driver in real-time and provide immediate alerts when early signs of drowsiness are detected. The beneficiaries of this study include:

1. Drivers: By receiving real-time alerts, drivers can take necessary actions to prevent accidents caused by fatigue.
2. Transportation Companies: Commercial transportation companies can implement this system to ensure the safety of their drivers and reduce accident-related costs.
3. Road Safety Authorities: The findings of this study can help inform policies related to road safety and driver monitoring systems.
4. Bukidnon State university: This study will also benefit Buksu GSU Motorpol, which operates school buses to transport students. Ensuring the safety of students during transit is a top priority for educational institutions, and the implementation of a drowsiness detection system in school transportation vehicles can greatly enhance this safety.

Additionally, future researchers will benefit from this study by gaining valuable insights into the use of AI-based systems for real-time drowsiness detection, which can serve as a foundation for further research and innovation in driver assistance technologies, improving road safety even further.

## Scope and Delimitations

The study will use a deep learning model called YOLOv8 to develop a drowsiness detection system. It will use live video input to examine drivers' tiredness in order to track visual indicators such as eye closure, head tilting, and yawning. Drivers are the target population. Over the course of one month, the system will be tested using real-time input data from a smartphone camera. This study encompasses vehicles except motorcycles, motorela and tricycle. The system will encompass drivers of all ages and genders of BUKSU GSU Motorpol. The developing detection system will have an alarm mechanism that would provide drivers with immediate notifications when they exhibit any indications of drowsiness. The system also dynamically adjusts the device's brightness in no so well-lit environments

This study does not include physiological measures such as heart rate or brain activity, which are sometimes used in drowsiness detection. Additionally, it will not explore the impact of environmental factors such as weather conditions, road types, or traffic intensity on driver alertness. The study also excludes long-term effects of drowsiness detection on driving behavior beyond the immediate alert.

# REVIEW OF RELATED LITERATURE

## Related Literature

Review of related studies has significantly contributed to the study in terms of contextualizing the study, meaning it gives readers an idea of the context of the study based on existing knowledge, adds validity by citing scholarly studies, identifying the gaps or limitations of existing studies, and helps the accuracy and validity of the research.

### Human Errors in car crashes

According to a study by the National Highway Traffic Safety Administration (NHTSA), an estimated 94% of motor vehicle accidents were caused by driver error. Accidents caused by vehicle problems and environmental conditions accounted for very few traffic accidents. The most common human factors reported for causing accidents include: Improper lookout and inattention. The NHTSA study categorizes common driver-related errors that can lead to car accidents.

Recognition errors happen when drivers are distracted, like using a phone or adjusting the radio. Decision errors involve risky driving behaviors, such as speeding, tailgating, or failing to adjust to road conditions. Performance errors occur when drivers struggle with vehicle control, like oversteering. Non-performance errors include situations where the driver fails to act, such as falling asleep. Each error type affects road safety by reducing driver focus or control. Non-performance errors include issues like impaired (drunk) driving and drowsy driving, which slow a driver’s reaction time and are linked to many fatal crashes in the U.S. In 2021, drowsy driving caused 684 fatal crashes, according to the NHTSA.

### Drowsiness Behind the Wheel Threatens Road Safety

Feeling more sleepy than usual during the day is referred to as drowsiness. People who are drowsy may fall asleep when they don’t want to or at times which raises concerns to their safety (MedlinePlus). Being in a state of drowsy during the day while engaging in activities that require complete alertness and attention may threaten an individual's safety. Drowsy driving is the act of operating a motor vehicle while sleepy. Driving while drowsy greatly raises the danger of road collisions, which results in an alarming number of injuries and fatalities each year. Drowsy driving poses serious dangers even when the driver doesn’t fall asleep. Studies reveal that sleep deprivation can impair mental function as much as alcohol, with 24 hours without sleep roughly equal to a blood alcohol level of 0.10%. This lack of alertness reduces attention, increases distractions, and slows reaction time, making it difficult to respond to road hazards. Additionally, inadequate sleep impairs decision-making, which can lead to risky driving behaviors (Suni & Suni, 2023).

The cognitive effects of poor sleep can lead to significant safety risks, including an increased likelihood of drowsy driving. Lack of sleep can significantly reduce a person’s attention span and ability to process information, affecting learning and memory. Studies indicate that sleep deprivation can impair cognitive function to a degree similar to alcohol intoxication, slowing down both thinking and reaction times (Suni & Suni, 2023a). Additionally, poor sleep disrupts "placekeeping," which is the ability to remember and follow a sequence of steps. This means that tasks requiring focused, step-by-step actions become harder to perform accurately, which is especially dangerous in high-stakes activities like driving (Stepan et al., 2019).

### Drowsy Driving as one of the Leading Contributor to Road Accidents

Drowsy driving has been a major issue and is estimated to be contributing to the annual records of fatal road crashes, approximately 328,000 crashes, 109,000 injuries, and 6,400 fatalities occur annually due to drowsy driving. While speeding, drunk driving, and distracted driving have long been recognized as major contributors to road accidents, the dangers of drowsy driving have only recently gained attention (Martin, 2024).

Each year, hundreds of car accidents in the Philippines are caused by road fatigue—when drivers gradually lose focus, sometimes nodding off or even falling asleep. With about 90,000 road accidents happening annually in the country, it’s difficult to say exactly how many are due to fatigue and drowsiness, according to data from the Department of Public Works, the Metropolitan Manila Development Authority, and the Philippine National Police-Highway Patrol Group (Buban, 2020).

Determining how much drowsy driving causes car accidents is challenging. Although police officers occasionally note that a driver seemed drowsy when documenting a crash, these reports likely overlook many instances. Consequently, the recorded data probably underrepresents the actual number of crashes related to drowsy driving. According to the National Highway Traffic Safety Administration (NHTSA), approximately 56,000 drowsiness-related accidents occur annually in the United States, resulting in 1,550 fatalities and 40,000 injuries.

### Drowsy Driving Is Deadly Toll on Roads

A recent study by the National Highway Traffic Safety Administration (NHTSA) used a model to estimate how often drowsy driving contributed to car accidents, especially in cases where it was not possible to directly confirm a driver’s alertness at the time of the crash. The results show that between 2017 and 2021, approximately 17.6% of fatal car accidents involved a driver who was likely drowsy. This percentage translates to roughly 29,834 people who lost their lives in crashes linked to driver fatigue over those years. The study further estimated that drowsy driving is involved in about 328,000 crashes every year, leading to serious consequences not only for those directly involved but also for their families and communities. Tragically, more than 6,000 people lose their lives each year due to accidents where drowsy driving was a factor. These alarming numbers emphasize the critical need to address the risks associated with drowsy driving, a preventable cause of death on the roads. The study’s findings reinforce the importance of finding effective solutions to detect and mitigate drowsiness in drivers, which could play a significant role in saving lives and reducing the overall impact of traffic accidents (AAA Foundation for Traffic Safety, 2024).

### Key Factors Leading to Drowsy Driving

A study found that 82% of drowsy-driving crashes involved solo drivers. When driving alone, there’s no one to help keep the driver alert or notice signs of sleepiness. Additionally, solo drivers can’t share driving duties, unlike those with passengers who can take turns at the wheel (UCLA Health *Drowsy Driving*).

One of the main problems with recognition and threat is sleep deprivation and Insufficient rest is one of the primary causes of drowsy driving. Studies show that drivers who haven't had enough sleep are more likely to fall asleep at the wheel [(Moradi et al., 2019)](https://www.zotero.org/google-docs/?broken=XnuhCu)

Certain sleep disorders, like obstructive sleep apnea, disrupt sleep quality, leading to daytime drowsiness. Many of these disorders go undiagnosed, which can worsen fatigue. Alcohol can also induce sleepiness and impair reaction time and judgment, increasing accident risks. Additionally, numerous medications, including sleep aids and drugs for various conditions, may cause drowsiness or lingering grogginess, heightening the risk for drivers (Suni & Suni, 2023).

### Technological Solutions for Drowsiness Detection

Over time, several advancements have been noted that attempt to prevent driver weariness and enhance road safety by determining the cause of drowsiness. Drowsiness detection systems are divided into three main categories: vehicle dynamics, physiological signals and driver facial characteristic recognition (Siddiqui et al., 2021).

*Vehicle Dynamics*

The effectiveness of vehicle dynamics-based drowsiness detection systems is limited because they are influenced by various unpredictable factors. For example, the geometry of the road—such as curves, inclines, or declines—can affect how the vehicle handles and how the detection system interprets the driver's behavior (Sahayadhas, A., Sundaraj, K., & Murugappan, M. 2020).

*Physiological Monitoring*

The physiological approach measures a driver’s condition by looking at biological signals like brain activity (EEG), eye movements (EOG), muscle activity (EMG), and sweat levels. To do this, sensors or electrodes are placed on the driver’s body. Then, signal processing or machine learning is used to analyze these biological signals for patterns and features.

Electroencephalography (EEG)

An EEG is a test that checks for problems with your brain's electrical activity or brain waves. During the test, small metal disks called electrodes are attached to your scalp. These electrodes pick up tiny electrical signals from your brain cells. The signals are made stronger and shown as a graph on a computer screen, or they can be printed on paper. Your doctor then looks at the results to understand what they mean (Electroencephalogram (EEG), 2024).

Electrooculography (EOG)

A method used in labs to track eye movements during various sleep stages as part of a sleep study called polysomnography. An EOG measures eye movements using electrodes placed near the eyes. According to AASM guidelines, these electrodes are positioned about 1 cm from the outer corners of each eye. EOG signals help detect when a person is awake or in REM sleep because there is a lot of eye movement during these stages. Generally, the depth of sleep is linked to eye movements, with movements slowing down when a person is in deeper sleep (ScienceDirect).

Electromyography (EMG)

Electromyography (EMG) records muscle activity by measuring electrical signals produced when a nerve stimulates the muscle. This test helps identify nerve and muscle issues. During the test, small needles (electrodes) are inserted into the muscle to detect electrical signals, which are shown as waves on a monitor and can be heard through an amplifier. EMG checks muscle activity when at rest, during slight movement, and during strong contractions. Muscles typically don’t produce electrical signals when they’re relaxed (*Electromyography (EMG)*, 2023).

However, a key drawback of physiological monitoring systems is it is not only very expensive but also they require the driver to wear various sensors or electrodes directly on the body to gather data, which can feel invasive and uncomfortable (Li & Chung, 2022). This setup can interfere with the driver’s natural movement or concentration, making it impractical for daily use. Additionally, these sensors may require precise positioning, frequent adjustment, and upkeep, which limits their feasibility for real-world driving situations where comfort, ease of use, and minimal intrusion are essential (Orban et al., 2022; Zhao et al., 2020).

*Behavioral Observation*

Another classical approach to detecting drowsiness relies on observation of the driver's behavior. Examples of observations are eye movements, yawning, or head position. For example, camera-based systems can widely monitor eye closure rate, duration of blinks, or frequency of yawns. These systems are non-invasive and easier to integrate into a vehicle (Pratyush Agarwal & Rizul Sharma, 2019). A non-intrusive approach, a camera is used for drowsiness detection by identifying yawning patterns, eyelid movement and head inclination. To spot drowsy driving, researchers mainly focus on how often the driver blinks and how long their eyes stay closed (PERCLOS), which are further analyzed using machine learning and deep learning techniques. Other signs, such as yawning and head movements, can also help in detecting drowsiness. These techniques are popular because they don’t interfere with the driver and can be used in both simulated and real driving situations. Current research shows that these behavioral methods are more accurate than those that rely on vehicle data [(Bajaj et al., 2023b).](https://pmc.ncbi.nlm.nih.gov/articles/PMC9920860/" \l "sec3-sensors-23-01292)

### YOLOv8 in Drowsiness Detection

Drowsy driving has impacted road safety globally and is one of the vital factors contributing to road accidents. The rise of employing modern technology as a tool for improving efficiency in almost every possible task today has led to advancements in driver safety. YOLOv8 is an object detection algorithm capable of detecting early signs of drowsiness in real-time and implementing safety mechanisms after drowsiness is detected (Keylabs, 2024, March 19).

YOLO works using neural networks, which are advanced algorithms designed to find patterns, much like our brains do. Neural networks are powerful for tasks like recognizing objects in images. YOLO specifically uses a type of neural network called a Convolutional Neural Network (CNN). CNNs are excellent at identifying patterns in visual data, making them ideal for object detection tasks. This is why YOLO can quickly and accurately detect objects in images, helping with real-time applications like identifying obstacles for driver safety (Taleti, 2021).

### Importance of Conducting This Study

Drowsy driving has impacted road safety globally and is one of the vital factors to road accidents. The rise of employing modern technology as a tool for giving efficiency to almost every possible task today. YOLOv8 is an object detection algorithm that is capable of detecting early signs of drowsiness in real-time and implementing safety mechanisms after drowsiness is detected Keylabs. (2024, March 19). Consequently, our study of AI-based drowsiness detection and alert systems would serve to find great significance in proving a solution to one of the foremost causes of road accidents, drowsy driving. Every year, thousands of crashes, injuries, and fatalities occur because of drivers falling asleep at the wheel or experiencing impaired alertness. Traditional methods of detecting drowsiness, based on physiological monitoring and behavior-based observations, are marked by major limitations in the forms of invasiveness and susceptibility to environmental factors like poor lighting or occluded facial features.

This study introduces an accurate and reliable solution that can be easily integrated into vehicles by developing real-time detection systems and alert systems powered by such advanced deep learning models as YOLOv8. The facial cues and behavior will be evaluated in real time under certain conditions, thus saving lives greatly by minimizing accidents driven by drowsiness. Moreover, the findings could further the development of smarter driver assistance systems, improve the standards of road safety, and avoid loss of life. This study is going to open advances in technology to innovations in managing driver fatigue on the roads; hence, road environments are going to be safer for everyone.

### Gap in the Literature

In examining the literature on drowsiness detection systems, several gaps emerge that provide opportunities for further research and development

Limited real-world testing, While many sleepiness detection technologies work well in controlled settings, there is still a dearth of extensive real-world testing. Challenges from real driving include things like shifting lighting, uneven roads, and driver behavior, all of which are difficult to replicate in a lab context. More study is needed on the real-world validation side including talks regarding environmental issues that may affect system accuracy.[(Biswal et al., 2021; Zhao et al., 2020)](https://www.zotero.org/google-docs/?broken=SOYZiF)

Most of the literature is directed at the difficulties in getting large and diverse datasets for training AI and deep learning models. Present datasets may either be not broad enough in scope or fully representative of various driving scenarios. Besides, the quality of video or sensor data can appear different in real-time applications according to camera angles, resolution, or sensor reliability.[(Orban et al., 2022; Zhao et al., 2020)](https://www.zotero.org/google-docs/?broken=Jt6Q4g)

Efficiency of computation deep learning models, such as YOLO and CNNs, generally computationally demanding, hence challenging to deploy in real time, especially on low-power devices like in-vehicle embedded systems. There is a need for research into how best to optimize these models for real-time deployment without affecting their accuracy.[(Ibrahim et al., 2024)](https://www.zotero.org/google-docs/?broken=kkWi1U) YOLO algorithm is a widely used object detection technique that has been implemented for several drowsiness detection studies. However, some studies specify drowsiness detection for safety purposes but lack the mechanism to actually prevent accidents. Moreover, there is also an outdated use of algorithm versions, particularly versions of YOLO technique. while the use of YOLO is effective in real time object detection using outdated versions may significantly impact the detection’s accuracy, speed and latency.

### Synthesis of Literature Comparison and Contrast

Upon reviewing the literature on drowsiness detection systems, several common themes emerge, while notable differences highlight distinct approaches and innovations in the field.

One key similarity is that they both use facial feature analysis in their methods of sleep detection.[(Ibrahim et al., 2024; Kannan et al., 2023)](https://www.zotero.org/google-docs/?broken=0tPNj1) The system uses a YOLOv8 object detection algorithm in classifying two main states-awake and drowsy-using facial cues as input through real-time video recording such as eye closure or head movement, which is quite common in most related works. Throughout various studies, the trend has been to construct a drowsiness detection system by using computer vision and deep learning methods for tracking driving behavior. One of the consistent methods that can be found in the literature is through the use of facial feature analysis to track signs of drowsiness, such as the closure of eyes, tilts of the head, and yawning. This technique is then put to wide use both in the study of [(Biswal et al., 2021)](https://www.zotero.org/google-docs/?broken=TSTYAb)that incorporated facial recognition for head movements and in the project of [(Kannan et al., 2023)](https://www.zotero.org/google-docs/?broken=KZTg80), who employed facial feature extraction to detect drowsiness with high accuracy. Both prove to what extent visual clues could determine the onset of fatigue reliably.

The other comparison point relates to the deep learning model variants chosen for the respective studies. For example, the CNN-based model by [(Zhao et al., 2020)](https://www.zotero.org/google-docs/?broken=hvDN9G)produced 92.86%, while in [(Kannan et al., 2023)](https://www.zotero.org/google-docs/?broken=r8dmjP), the selected machine learning-based model reached an accuracy of 95.7%. In contrast, I[(Ibrahim et al., 2024)](https://www.zotero.org/google-docs/?broken=03nmX8) and the capstone project are focused on YOLOv8 because this model is optimized specifically for object detection and goes well in real-time applications. YOLOv8 allows processing video frames faster and hence better real-time performance in detecting drowsiness compared to other models. However, unlike [(Orban et al., 2022)](https://www.zotero.org/google-docs/?broken=DWKiGQ), which does incorporate other biometric measures such as EEG or ECG, adding system complexity provides a multi-modal detection framework.

While deep learning has the key to accuracy and real time, the literature also points out the limitation in those environmental factors such as poor lighting conditions or occlusions of parts of the face. These are discussed by[(Biswal et al., 2021)](https://www.zotero.org/google-docs/?broken=EzhFYp), where effectiveness in systems that depend on face detection might be compromised due to external factors. Indeed, a number of systems, including the capstone project, try to make sure such effects are minimized through better algorithms and training datasets that would consider the environments in which such applications are necessary.

By comparing the studies, it can be realized that all the drowsiness detection systems have deep learning facial recognition at their core. Though models such as CNNs and YOLOv8 were effective in providing results, future development needs to take place concerning environmental challenges and the integration of multi-modal data, as demonstrated by [(Orban et al., 2022)](https://www.zotero.org/google-docs/?broken=ghqUtX). This is in line with most of these developments but, on the other hand, uses smartphones for data gathering; it renders detection user-friendly as it keeps its accuracy intact. The changes that have taken place in such systems lie in realizing real-time performances, widening the scale for detection, and making detection more accessible to improve road safety. Similarly to the mentioned studies this capstone project aligns with the implementation of two classes namely awake and drowsy for training and testing our model. Additionally, the project uses video recording capturing real-time footage of drivers during various conditions (alert, drowsy) is common.

The review of literature essentially reflects that YOLOv8 is an effective way of using it for real time object detection, particularly in signs of drowsiness that involves yawning, closing of the eyes for a certain duration and other facial expressions that show early signs of sleepiness. However, in order to enhance road safety measures and prevent accidents from occuring an action should be done after drowsy driving is detected. This capstone project presents an opportunity to have a contribution in enhancing road safety measures in Malaybalay City Bukidnon.

Advancements in technology may become even more effective with the further development of machine learning and deep learning algorithms in use. The works by [(Kannan et al., 2023)](https://www.zotero.org/google-docs/?broken=UfSWz6)and [(Zhao et al., 2020)](https://www.zotero.org/google-docs/?broken=AxNoQ3) on face feature extraction and convolutional neural network usage for drowsy features detection from a driver have shown high accuracy rates-95.7% and 92.86%, respectively-and give a hint about the possible ways of non intrusive methods for real-time driver alertness monitoring. However, some challenges still remain, such as data quality and availability, environmental factors, and computational resources to process in real time. Research by [(Pratyush Agarwal & Rizul Sharma, 2019)](https://www.zotero.org/google-docs/?broken=QGm5sj)and [(Ibrahim et al., 2024)](https://www.zotero.org/google-docs/?broken=lgHoU3) underlines the importance of developing strong datasets and integrating drowsiness detection with ADAS for improvement in overall driving safety. Future directions must include the integration of AI-based in-vehicle drowsiness detection with other in-vehicle safety technologies, real-world testing of systems to ensure effectiveness, and addressing the limitations highlighted from prior studies.

**Table 2-1 Comparison Matrix**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Features/Systems*** | ***Melcher et al. (2021) - DMS System*** | ***Biswal et al. (2021) - IoT Drowsiness System*** | ***Kannan et al. (2023) - YOLO-Based System*** | ***Rajeev (2023b) - HAR System*** | ***Ibrahim et al. (2024) - YOLOv8 System*** | ***Orban et al. (2022) - Multimodal System*** | ***Proposed System*** |
| *Real-time facial feature analysis* | ***✔*** | ***✔*** | ***✔*** | ***✔*** | ***✔*** | ***✔*** | ***✔*** |
| *Deep learning algorithms (e.g., YOLO)* |  | ***✔*** | ***✔*** | ***✔*** | ***✔*** |  | ***✔*** |
| *Drowsy Detection* |  | ***✔*** |  |  | ***✔*** | ***✔*** | ***✔*** |
| *Alert system (audio/visual/haptic)* | ***✔*** |  | ***✔*** |  | ***✔*** | ***✔*** | ***✔*** |
| *Driver feedback system (e.g., steering wheel vibration,Audio and Visual alert)* | ***✔*** |  |  |  |  |  | ***✔*** |
| *Use of IoT sensors for data collection* |  | ***✔*** |  |  |  | ***✔*** |  |
| *Smartphone-based detection using a camera* |  |  |  |  |  |  | ***✔*** |
| *User-friendly interface* |  |  | ***✔*** |  | ***✔*** |  | ***✔*** |

The comparison matrix presented here has been showing the primary and important features and differences distinguishing one drowsiness detection system from another, including those developed by Melcher et al. (2021), Biswal et al. (2021), Kannan et al. (2023), Rajeev (2023b), Ibrahim et al. (2024), Orban et al. (2022), and the proposed system. Several of these systems incorporate real-time facial feature analysis, a critical component for detecting signs of drowsiness such as eye closure, yawning, and head movements. Systems like those of Kannan et al. (2023) and Ibrahim et al. (2024), which utilize deep learning algorithms like YOLO, stand out for their ability to efficiently process video data and provide more accurate drowsiness detection.

Alert systems, which are vital for notifying drivers when signs of drowsiness are detected, are present in many of the systems, with audio or visual feedback to prompt immediate action. Another unique feature is the data acquisition using IoT sensors for data collection, found in Biswal et al. (2021) and Ibrahim et al. (2024), which integrate external sensors to enhance monitoring accuracy. However, systems like Rajeev (2023b) and the proposed system focus on smartphone-based detection using a camera, offering a more accessible and user-friendly solution without the need for external sensors.

The proposed system aligns closely with those of Kannan et al. (2023) and Ibrahim et al. (2024), making it suitable for both commercial and personal use. Its reliance on widely available technology like smartphones increases its potential for widespread adoption, while maintaining the ability to deliver real-time, accurate detection of drowsiness. This flexibility and accessibility distinguish the proposed system from traditional sensor-heavy systems, making it a more practical solution for enhancing road safety.

## Related System

Overview of Existing Systems

1. Monitoring Systems

These are systems that are designed at the forefront in detecting behavior related to driving when drowsy. These systems generally work with advanced sensors and AI algorithms to analyze driver conditions in real time. DMS uses face detection to define degrees of fatigue based on parameters such as eye closure duration and head position. For instance, a study by Melcher et al. (2021) shows how AI-powered DMS works effectively in forecasting an oncoming drowsiness status well in advance, enabling timely alerts upon the detection of tiredness.

2. Attention-Enhancement Systems

Alertness enhancement systems are those designed to mitigate, in an proactive way, the risks of driving in a drowsy state. Feedback mechanisms of various types include vibrating steering wheels, auditory alerts, and haptic feedback systems acting together upon indication of a driver becoming drowsy. As such, note that these systems have been effective in reducing accident rates due to immediate situational-specific responses that get drivers to regain alertness.

3. Predictive and Adaptive Systems

Predictive systems transcend traditional monitoring through their use of both historic driving data and machine learning algorithms to predict the onset of drowsy driving. Indeed, a study has shown how such systems can evaluate driving behavior along with contextual aspects of the environment to provide predictive warnings to trigger timely intervention before drowsiness worsens.

The purpose of Rajeeve is to detect driver fatigue and notify them in time to avoid accidents. The task at hand is to record the driver's face images with an image sensor and determine whether or not they are drowsy. The deep learning algorithm is designed to forecast whether you'll be tired or awake. The study employs a YOLOv5 model to determine if a person is tired or not based on whether their eyes are closed or open, and whether or not a yawn is detected. The project immediately benefits the automobile industry, increases driving safety, and reduces the number of fatalities caused by drowsy driving.

Systems Features and Functionalities

Rajeev's (2023) refers to HAR (Human Activity Recognition) that is gaining a lot of attention in ML (Machine Learning) and AI community (Artificial Intelligence). This dataset can be collected in two ways: sensor-based and vision-based. The study integrates a vision-based strategy for all data that was derived from video footage. Furthermore, the study employs the YOLOv5 model, datasets are identified and used to train their model in order for it to predict if drivers are drowsy or not. The study has four classes. Specifically: open eye, closed eye, yawn, unidentifiable. Initially, we took sample photos using a webcam and manually labeled each one as open eye, closed eye, and with or without a yawn. The main shortcoming of this training sample was that it only included 200 photos and was not exhaustive. However, the project lacks an alert mechanism that intends to alert the driver for consciousness retention which this capstone project aims to address.

Generally, real-time sensor and camera monitoring tracking driver alertness continuously; an embedded alert system alerting the driver via immediate audio or visual signals upon detection of drowsiness; and visualized dashboards displaying data visualization of fatigue levels and trends over time are some of the features offered by some IoT-based drowsiness detection systems [(Biswal et al., 2021)](https://www.zotero.org/google-docs/?broken=RGx1R7). These technologies are typically more complicated and less user-friendly for lone drivers. Our capstone project is application based and also promotes a user-friendly UI, it can detect if a person is alert or sleepy, which would improve immediate awareness and promote safer driving practices.

Technologies and Tools Used

You Only Look Once (YOLO) is a real-time object detection technique. During training and testing, the network examines the entire image, implicitly encoding contextual information about classes as well as their appearance, and comprehends generalized object representations. The related system employs a YOLOv5 model to determine if a person is drowsy or not based on whether their eyes are closed or open, and whether a yawn is detected. The system uses a single Fully Convolutional neural network (FCNN) to process the entire image, then separates it into regions, with each cell responsible for predicting a bounding box and probabilities for each region. These bounding boxes are weighted according to the estimated probabilities (Rajeev, 2023b). On the contrary, this capstone project system applies YOLOv8 for real-time object detection, implementing the latest deep learning methodology to make decisions on whether the facial features are showing fatigue or not. While YOLOv5 is effective for identifying whether a driver’s eyes are open or closed, it falls short compared to the more advanced YOLOv8 which this study will be using. YOLOv8 offers improved accuracy and faster processing speeds, which could enhance the detection of drowsiness and potentially lead to timely alerts for drivers, making it a more advantageous choice for this critical safety application (YOLOv8 Vs. YOLOv5: Choosing the Best Object Detection Model). In back-end processing [(Ultralytics, n.d.)](https://www.zotero.org/google-docs/?broken=IbkJIO), it involves the use of Python language integrated with OpenCV for video analysis to ensure the accuracy of the observation[(Sivkov et al., 2020)](https://www.zotero.org/google-docs/?broken=0W91xK) .”

Strengths and Weaknesses

There are many systems that are now available and have the advantages of being very user-friendly, providing highly accurate drowsiness detection results, and being scalable for a wide range of applications, all of which significantly increase road safety[(](https://www.zotero.org/google-docs/?broken=TBUddu)*[Road Traffic Injuries](https://www.zotero.org/google-docs/?broken=TBUddu)*[, n.d.)](https://www.zotero.org/google-docs/?broken=TBUddu) . Frequently, their shortcomings entail intricate data visualization processes and inadequate attention to user engagement. This capstone project addresses this shortcoming by providing a more straightforward interface that indicates whether the driver is alert or asleep [(](https://www.zotero.org/google-docs/?broken=EYeMbY)*[Drowsiness Detection Using Python OpenCV](https://www.zotero.org/google-docs/?broken=EYeMbY)*[, n.d.)](https://www.zotero.org/google-docs/?broken=EYeMbY)y.

Comparison with the Proposed System

Our system will use cameras of smartphones for efficient driver drowsiness detection by assessing eye closures, yawning and head positions. This is highly advantageous compared to most IoT-based solutions that require expensive external sensors [(Biswal et al., 2021)](https://www.zotero.org/google-docs/?broken=7RekJq). This would not only avoid financial costs related to special hardware but also make application usage much easier, since it can be applied to any device and in any place. Thus, real-time detection using our approach gives consumers timely alert signals to help them stay attentive while driving [(Kannan et al., 2023)](https://www.zotero.org/google-docs/?broken=YApqJ3).

The relevant literature assessment of the current systems emphasizes the need for many approaches to address the issue of tired driving. Our innovative application-based solution is more flexible and more affordable than conventional IoT-based solutions, which promise highly accurate sensors but often come with high costs and limitations that limit wearability and user convenience[(Biswal et al., 2021)](https://www.zotero.org/google-docs/?broken=YRAedh). Our solution relies on the widespread availability of smartphone cameras to effectively monitor a user's state. This research thesis adds to the increasing corpus of work by examining how well AI-driven systems can prevent tired driving while taking ethical and user acceptability into account. We provide examples of how new technologies could improve road safety and suggest future developments that strike a balance between monitoring and predictive power.The ultimate objective is to integrate monitoring, predictive capability, and immediate alerts within a single system to ensure road safety

## Concept of the Study

**Table 2-2 Conceptual Framework IPO Model**

|  |  |  |
| --- | --- | --- |
| **INPUT** | **PROCESS** | **OUTPUT** |
| * **Driver’s facial Landmarks (eye, outh and head)** | * **YOLOv8 -Based Drowsiness Detection** * **Deep Learning & AI Analysis** * **Real-Time Monitoring** | * **Drowsiness Alert Mechanism** * **Improved Road Safety** |

This is based on the Input-Process-Output (IPO) model, by which every phase contributes to the overall effectiveness of the AI-based drowsiness detection system. In the Input, the system gathers such critical data as facial features of a driver, such as eye closure and blinking frequency, head movements as well as video footage in real-time. Also, it takes into account external environmental factors such as lighting conditions or face occlusions, which may obstruct the line of view, for instance, by sunglasses or hats. All these inputs are vital to ensuring accuracy in the model's detection of drowsiness symptoms in different scenarios.

The YOLOv8 deep learning algorithm, in the Process phase, analyzes input data to detect in real time early symptoms of drowsiness. This system applies the principles of advanced object detection where it uses video frames and observes driver behavior while tracking that makes it possible to note drowsiness patterns when occlusions or fast head movements are applied. Deep learning enables the system to continuously learn from various driving scenarios as a primary aid.

The Output phase provides immediate feedback mechanisms in the form of visual, audio, or haptic warnings to give instant feedback once signs of drowsiness have been identified. The system warns the driver to take remedial measures and thus avoid accidents. Overall, this improves road safety since the system actively guards against dangerous situations that may be brought about by drowsy driving.

**Why YOLOv8?**

|  |  |  |
| --- | --- | --- |
| **MODE** | **SPEED (GPU Latency)** | **Accuracy(mAP@50)** |
| **YOLOV8** | **Single-Pass Detection – simultaneously process all necessary processes for detection in one go. (Predict bounding boxes, class probabilities and object confidence)**  **YOLOv8 achieved 1.3ms** | **Optimized Accuracy-Speed Trade Off.**  **(mAP@0.62)** |
| **Faster R-CNN** | **Two-staged Object detection – has two stages of object detection which make it more accurate.**  **Faster R-CNN achieved 54ms** | **Since it processes images in two-staged manner making it more accurate.**  **(mAP@0.41)** |

Ultimately, drowsiness detection systems require accurate and fast models making YOLOv8 a fitting choice for this project.

## Definition of Terms

**YOLOv8** *(You Only Look Once)*

YOLOv8 is the newest in a series of models that belong to a family of models known as "You Only Look Once," which have rapidly gained favor worldwide due to their efficiency in performing real-time object detection tasks. Ultralytics enhanced its operating speed and accuracy, building on a foundation created by its predecessors[(](https://www.zotero.org/google-docs/?broken=JONQcv)*[YOLOv8 Documentation](https://www.zotero.org/google-docs/?broken=JONQcv)*[, 2024)](https://www.zotero.org/google-docs/?broken=JONQcv).

**Machine Learning Algorithm**

A machine learning algorithm is a set of rules or processes used by an AI system to perform tasks, most commonly to uncover new data insights and patterns or to anticipate output values based on a given set of input parameters (IBM, *what is machine learning algorithm?)*. Algorithms allow machine learning (ML) to learn.

**AI**

Artificial Intelligence: It can be defined as the making of a machine in the form of a human being to act and think like a human being. In other words, it may solve problems, learn, reason, and adjust to new information that comes along[(](https://www.zotero.org/google-docs/?broken=iCyXaL)*[What Is Artificial Intelligence (AI)?](https://www.zotero.org/google-docs/?broken=iCyXaL)*[, Google Cloud 2024)](https://www.zotero.org/google-docs/?broken=iCyXaL).

**Drowsiness**

Drowsiness refers to feeling more sleepy than normal during the day. People who are drowsy may fall asleep when they do not want to or at times which can lead to safety concerns especially when you are driving.

**Drowsiness Detection**

Drowsiness detection, to put it another way, is the process of recognizing and keeping an eye out for signs of driver fatigue in order to prevent accidents and improve safety. It involves analyzing the behaviors of eye movement, facial expressions, and head posture using computer vision in conjunction with sensors and machine learning. Based on the assessment of eyelid closure, blink frequency, and head-tilting behaviors taken into consideration as a measure of attentiveness, real-time tracking keeps a watch on driver activities. To prevent mishaps, alarms or other visual alerts are triggered whenever it senses tiredness. To further enhance safety when it comes to transportation, such devices are currently placed in cars[(](https://www.zotero.org/google-docs/?broken=KDC4fd)*[The Case for Drowsiness Detection Systems Using Python OpenCV](https://www.zotero.org/google-docs/?broken=KDC4fd)* [)](https://www.zotero.org/google-docs/?broken=KDC4fd) .

# METHODOLOGY

## Materials

This section explains the main materials needed to develop the drowsiness detection system. It includes both software and hardware that work together to make the system run smoothly in real-time. The software processes the driver’s video feed, while the hardware helps capture data and send alerts. The data used to train the system is also important for improving its accuracy. All these materials are essential for building an effective and reliable drowsiness detection system.

### Software

**Table 3-1** Software utilization

|  |  |
| --- | --- |
| Name of Software | Software Description |
| YOLOv8s | Serves as the core deep learning model, capable of detecting specific facial features such as eye closure, yawning, and head tilting to identify early signs of drowsiness in real time. |
| OpenCV 4.8.0 | A computer vision library, facilitates video processing and integrates with YOLOv8 to handle live video feeds from a camera, enabling seamless monitoring |
| Dlib library 19.24.0 | The Dlib library is utilized for facial recognition and tracking, enhancing the system’s accuracy in detecting drowsiness indicators. Python serves as the backbone of the application, providing a platform to integrate all software components and program the system's logic. |
| PyTorch 2.1.0 | Framework PyTorch is employed to train and deploy YOLOv8, ensuring the system can manage real-time detection efficiently. Anaconda, an integrated development environment (IDE), will also be utilized in the development of the project for managing libraries and running experiments. |
| VS code IDE 1.86.0 | Visual Studio Code (VS Code) is a free, lightweight, and powerful code editor developed by Microsoft. It supports multiple programming languages and offers features like syntax highlighting, intelligent code completion, debugging tools, and built-in Git integration. Its extensibility allows developers to customize their environment using plugins and extensions, making it a versatile tool for software development across various platforms. |
| MongoDB | MongoDB is a NoSQL database that stores data in a flexible, document-based format similar to JSON, making it ideal for handling unstructured or semi-structured data. It is designed for scalability, high performance, and ease of use, making it popular for modern applications. |
| Roboflow | For dataset preprocessing, augmentation, and hosting. |

### Hardware

**Table 3-2** Hardware Utilization

|  |  |
| --- | --- |
| Name of Hardware | Hardware Description |
| Android smartphones | Necessary for deploying the system as a mobile application, these smartphones provide both the camera for capturing live video of the driver’s face and the speaker for delivering auditory alerts. This ensures smooth performance and ease of deployment. |
| Loptop/Desktop  Minimum specifications: 8 GB RAM (5.88 GB usable), 64-bit operating system, and x64-based processor. | Plays a critical role in the project's development lifecycle, serving as the primary platform for software utilization, system development, model training, and testing. The laptop should meet the following minimum specifications: AMD Ryzen 3 3250U processor (2.60 GHz), 8 GB RAM (5.88 GB usable), 64-bit operating system, and x64-based processor. While a touch display is not required, the system should support tasks like programming, debugging, and running simulations to ensure effective functionality prior to deployment. |

The hardware for the application includes a smartphone, which captures the driver’s face using its camera to detect drowsiness signs. It also processes the data and alerts the driver through the built-in speaker when drowsiness is detected. A laptop with specific system requirements (such as an AMD Ryzen 3 3250U processor and 8GB RAM) is used for developing and testing the software. This combination of smartphone and laptop ensures that the system runs smoothly and can be deployed efficiently on mobile devices.

### Data

## The data used for this system is critical to training YOLOv8 to detect drowsiness accurately. The dataset comprises a collection of 1,230 open-source and externally sourced images from roboflow of driver behaviors, including annotated images focusing on features like eye closure, yawning, and head tilting. To optimize the training process, 85.85% of the dataset is allocated for training, 8.37% for validation, and 5.77% for testing the model. The data preparation process, carried out in 2025, involved labeling these behaviors to enhance the model’s detection capabilities. By leveraging this comprehensive and well-distributed dataset, the system aims to achieve high accuracy in identifying signs of fatigue in real-world scenarios.

## Methods

This section presents the methodologies used in the study to guide the development and implementation of the driver drowsiness detection system. The methods are structured to ensure a systematic and efficient approach, integrating both research and development processes to achieve the project’s objectives.

### Research Design

The study adopts a developmental research method to design and implement a driver drowsiness detection system. This research design is appropriate as the project aims to develop a practical and functional application leveraging modern computer vision and machine learning techniques. The design integrates multiple stages, including data collection, algorithm training and testing, and system implementation, to ensure the proposed solution is accurate, reliable, and user-friendly. The focus is on applying deep learning models, particularly YOLOv8, for real-time drowsiness detection, with specific attention to detecting early signs like eye closure, yawning, and head tilting.

### Process Model

The system is developed using the Agile Methodology, which focuses on quick, continuous release cycles with small, incremental changes, allowing for frequent testing and iterations. This approach helps teams catch and fix issues early, rather than letting them pile up.

#### Agile Methodology



*Figure 3-1 Agile Methodology*

#### Requirement Analysis.

**Functional requirements**

Real time Drowsiness detection

* The user should be able to minimize/maximize audio of alert.
* Users should be able to start a video recording session.
* The system should monitor eye closure duration (blink rate and duration).
* The system should monitor yawning detection (via mouth opening).
* The system should monitor head nodding or tilting (based on head movement analysis).
* The algorithm should use machine learning or image processing techniques to analyze these indicators and detect drowsiness.

Alert Mechanism

* Once drowsiness is detected, the system should trigger an auditory alert to wake the user.
* The system should generate a report after each session detailing:

1. The total time of drowsiness detected.
2. The severity or intensity of the drowsiness.
3. Number of alerts triggered and user responses.

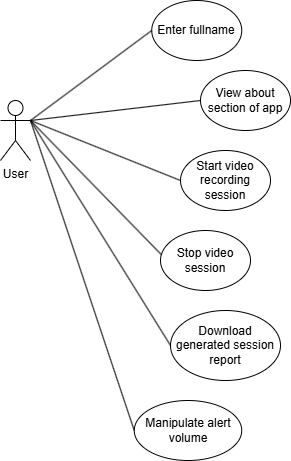
**Non-functional requirements**

* The system must process the video data with low latency, ensuring minimal delay between drowsiness detection and alert triggering.
* The system should be optimized to use minimal CPU, memory, and battery power (especially for mobile applications), while still maintaining real-time performance.

#### System Design

Formulate system UML diagrams and system architecture for the system. For the actual development of the mobile application the project will use React Native, a popular framework that allows us to create apps that work on both iOS and Android. With React Native, most of our code is written in JavaScript, making the development process faster and easier while still delivering good performance. The framework also lets us use native code (written in languages like Swift/Objective-C for iOS and Java/Kotlin for Android) to handle more complex tasks, such as running advanced machine learning models like YOLOv8.

The following figures display visual representation of the system including use-case diagram, and activity diagram.



*Figure 3-2 Use-Case Diagram*

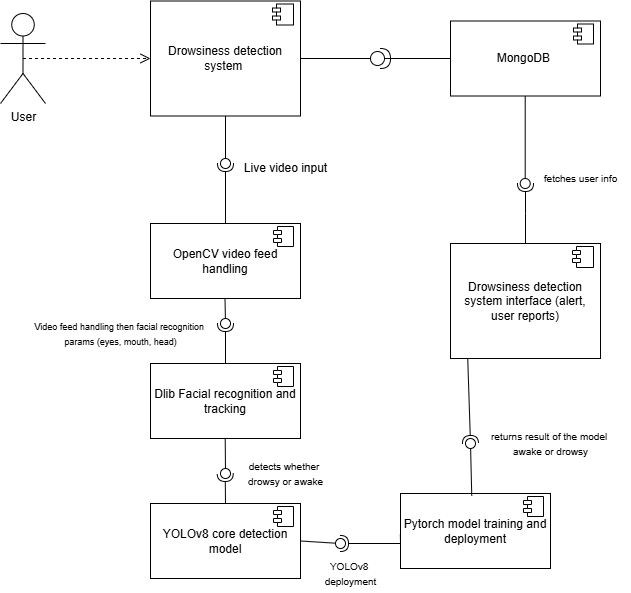
A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved.



*Figure 3-3 Activity Diagram*

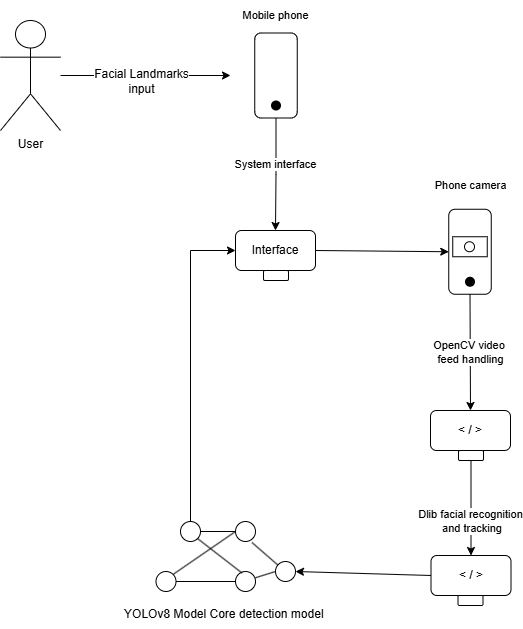
An activity diagram visually presents a series of actions or flow of control in a system. Activities modeled can be sequential and concurrent. In both cases an activity diagram will have a beginning (an initial state) and an end (a final state).

DATABASE



*Figure 3-4 Component Diagram*

The component diagram of our drowsiness detection system provides a high-level overview of the key software and hardware components and how they interact to deliver real-time driver monitoring. It illustrates the modular architecture of the system, highlighting the various components such as the video feed processing, YOLOv8 model for drowsiness detection, alert mechanisms, user interface, and the underlying database management.



*Figure 3-5 System architecture*

In this system architecture indicates the overall flow or process of the project. Highlighting how the facial landmarks as input go through different software for accurate processing.

#### System Development

For the system development, the Backend will be built using Node.js with RESTful APIs to handle server-side logic, communication, and model integration. PyTorch will be used for training and deploying machine learning models, particularly for drowsiness detection. On the Frontend, the mobile application will be developed using React Native, allowing us to create a cross-platform app for both iOS and Android, providing a smooth user interface and seamless experience.

#### Testing

Testing is a critical phase to ensure that the system meets the requirements outlined and functions properly under all anticipated conditions.

Simulated Testing

* The system will undergo simulated testing in controlled environments with prerecorded video data to test its ability to detect drowsiness indicators (eye closure, yawning, and head tilting).
* Performance will be assessed for accuracy (correct detection of drowsiness) and speed (timely alert triggering with minimal delay).

Real-World Testing

* Real-world scenarios will be tested, where the system will be deployed on mobile devices or cameras in environments with varying lighting conditions and background noise.
* The application will be tested for robustness in different settings such as daylight, dim light, and low-resolution video feeds.
* Evaluate alert effectiveness: Ensure the auditory alerts are noticeable and loud enough to wake a drowsy user.

Usability Testing

* User feedback will be gathered from a group of testers to assess the ease of use of the interface (modifying settings, viewing reports, etc.) and the effectiveness of the alert system.
* Evaluate whether users find the alert duration, tones, and frequencies appropriate and non-intrusive.

### YOLOv8s algorithm

In this study, we use YOLOv8, a powerful neural network, to detect signs of driver drowsiness like eye closure, yawning, and head tilting. YOLOv8 is a type of deep learning model that can analyze images and videos in real-time, detecting and classifying objects quickly. We will train the model using predefined datasets of images showing signs of drowsiness. After training, the model will be tested for its ability to detect drowsiness reliably, with minimal errors. Finally, the model will be set up to process live video feeds, alerting drivers when drowsiness signs are detected, offering a non-intrusive way to improve driver safety.

We choose YOLOv8s for this work because it strikes an optimum balance between accuracy and efficiency, making it suitable for real-time driver drowsiness detection on mobile devices. Although smaller models, such as YOLOv8n, provide faster performance with minimal hardware demands, they sacrifice some accuracy, which is critical in the detection of subtle signs of drowsiness, such as eye closure, yawning, and head tilting. That would be from larger models: YOLOv8m, YOLOv8l, and YOLOv8x; these are considerably more computationally expensive. The sweet spot is clearly YOLOv8s, whereby reliable detections result without significant missed or false bounding boxes to ensure processing time remains conducive to real-time alerting at the level common in contemporary smartphones.

#### How does YOLO work462575653_1451915492472604_4999892052919635910_n

*Figure 3-4 Overview of how YOLO detects objects*

In YOLOv8, single-pass detection describes how the model recognizes and categorizes items in a picture or video frame in a single forward neural network pass. YOLO (You Only Look Once) models, such as YOLOv8, are characterized by this feature, which enhances their speed and effectiveness in real-time applications.

When YOLO processes an image, it detects all objects within the frame and predicts a bounding box for each object. These bounding boxes indicate the location and dimensions of the detected objects. Each box is defined by four key parameters: the X and Y coordinates (representing the center of the box) and the width and height (representing its size). In addition to determining the location, YOLOv8 identifies the class of each object, such as "eyes closed" or "yawning," enabling it to recognize specific behaviors critical for drowsiness detection.

Additionally, the confidence score in YOLOv8 is like the model's level of certainty about its detection and classification of an object. It's a number between 0 and 1 that tells you how sure the model is that it has correctly identified and located an object within a bounding box. A higher confidence score means the model is more certain about the object being detected, while a lower score means the model is less sure.

### Evaluation

The evaluation phase assesses the overall effectiveness of the system, both in terms of its technical performance and user satisfaction.

#### **System User Feedback**

### The evaluation of the drowsiness detection system uses internationally recognized ISO standards to ensure thorough and reliable assessment. These questions are designed to measure key aspects such as the system’s functional accuracy (ISO 25010: Functional Suitability), response time (ISO 25012: Data Quality - Timeliness), and usability effectiveness (ISO 9241-11). This process checks how well the system detects drowsiness, evaluates its user interface and alerts, and gathers insights to improve its performance and enhance road safety.

### *Technical Performance*

* On a scale of 1 to 5, how accurate do you find the system in detecting drowsiness (e.g., eye closure, yawning, head tilting)? (ISO 9241-11: Usability Effectiveness)
* How often did the system correctly identify your drowsy state during use? (ISO 25010: Functional Suitability)
* Was the response time for triggering alerts fast enough to take preventive action? (ISO 25012: Data Quality - Timeliness)

### *Usability and User Experience*

* How easy was it to understand and operate the system?  
  (ISO 9241-11: Usability Efficiency)
* Did you find the alert mechanism (e.g., sound, vibration) effective in grabbing your attention?  
  (ISO 9241-112: User Interface)
* Was the interface visually clear and intuitive to use?  
  (ISO 9241-171: Accessibility)
* Were the instructions for setting up and using the system clear and sufficient?  
  (ISO 9241-11: Usability Learnability)

### *User Satisfaction*

* How satisfied are you with the overall performance of the drowsiness detection system?  
  (ISO 9241-11: Usability Satisfaction)
* Would you recommend this system to others who frequently drive? Why or why not?  
  (ISO 9241-11: Usability)
* Did the system's alerts or interventions reduce your risk of drowsiness-related incidents while driving?  
  (ISO 25010: Dependability - Safety)

### *Suggestions for Improvement*

* What features of the system would you like to see improved?  
  (ISO 9241-11: Usability)
* Were there any situations where the system failed to detect drowsiness accurately? If yes, please describe.  
  (ISO 25010: Functional Suitability - Accuracy)
* Do you think additional feedback mechanisms (e.g., mobile notifications or real-time dashboard insights) would enhance the system’s usability?

#### **YOLOv8 Performance evaluation**

When evaluating the performance of YOLOv8 in object detection tasks, several key metrics are used to assess the accuracy and reliability of the model. The evaluation of algorithm includes:

1. *Intersection over union (IoU)*

measures the overlap between predicted and ground truth bounding boxes, serving as a cornerstone for evaluating object localization.

1. *Average Precision (AP) and Mean Average Precision (mAP)*

AP and mAP provide a comprehensive assessment of precision and recall, with AP focusing on a single class and mAP extending this to multiple classes for a holistic evaluation.

1. *Precision and recall*

Precision measures how many of the positive predictions made by the model are actually correct. It shows how well the model avoids making mistakes by predicting things that aren't true positives. Recall measures how many of the actual positive cases the model correctly identifies. It shows how good the model is at finding all the true positives.

1. *F1 Score*

The F1 Score combines precision and recall into one number, giving a balanced view of how well the model performs by taking both false positives and false negatives into account.

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Use APA formatting for all references (in the body and in the listing here).

Use Mendeley software for easy referencing (mandatory).

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