



AutoWake- AUTOSAR Based Automatic Drowsiness Detection System

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Abstract: Driver fatigue and drowsiness are the major safety concerns on the road these days. If someone is sleepy, then their reaction might slow down, they may blink more slowly, and their response times aren't what they should be. This project is all about tackling that with an immediate warning system that kicks in automatically. We're looking forward to create a real-time driver drowsiness detection system that adds to the automotive standard known as AUTOSAR (AUTomotive Open System ARchitecture). The system uses a camera to monitor the driver's face in real time, focusing particularly on their eyes. STM32, which are the processing unit takes care of the video camera feed. It eventually runs the AI algorithms and detection using computer vision tools such as OpenCV and MediaPipe. The AI checks for signs of drowsiness by examining facial features like face detection, how often the eye blinks (using the eye aspect ratio), and yawning detection (using landmarks around the mouth). Once, system spots a sign of drowsiness through the camera, it sends signal (for ex: `drowsy_status = TRUE`). This signal then travels from application layer to the BSW through RTE. BSW is nothing but a bridge between the two (AUTOSAR and RTE). BSW sends the signal (`drowsy_alert`) to the CAN (Controlled Area Network) and activates an Alert Module (preferably a buzzer). It communicates with the car dashboard this way. One advantage of using AUTOSAR is that it is compatible with multiple hardware and one code can be used for multiple micro controllers and this system is the foundation on the layered architecture of AUTOSAR. It smoothly integrates all these components in a dependable and reliable way.

Key Words: Driver Drowsiness Detection, AUTOSAR, Eye Aspect Ratio, Computer Vision, CAN Bus, ECU Alert System.

1. INTRODUCTION:

Road accidents caused by driver fatigue and drowsiness are a serious safety issue in modern transportation. Long hours of driving, stress, lack of sleep, and monotonous road conditions greatly impact a driver's alertness. A drowsy driver may have slower reaction times, less attention, frequent eye blinking, and may even experience involuntary eye closure. This may lead to fatal accidents if not addressed on time. Therefore, designing an intelligent system that can detect driver drowsiness will be able to reduce accident risks by providing timely alerts and improving overall road safety. Therefore, enabling vehicle communication to give warnings immediately will be essential to enhance road safety. Recent advances in computer vision and artificial intelligence have enabled the use of camera-based systems. in real-time driver behaviour monitoring. Analysing facial features of the driver such as blinking rate, closure duration of eyes, and yawning, respectively, have been effective in the same for fatigue detection. Other techniques include the calculation of Eye Aspect Ratio, Facial landmark detection can monitor in a continuous process without disturbing the driver, hence they benefit for everyday use in cars. Nonetheless, contemporary cars rely on standardized software designs in order to guarantee dependability, scalability, and hardware independence. AUTOSAR (AUTomotive Open System Architecture) is generally applied in the automotive to help the industry create standardized and reusable software components for various kinds of Electronic Control Units (ECUs).



The integration of AI-based driver monitoring systems into the AUTOSAR architecture makes this system even more modular. It also facilitates smooth communication between different software levels using the Runtime Environment (RTE) and Basic Software (BSW).

The present project proposes an AUTOSAR-based automatic driver drowsiness detection system that involves the use of artificial intelligence and ECU alert mechanisms. There is a constant capturing of the driver's facial details by the camera using computer vision techniques on an embedded platform like STM32. A warning signal will be sent to the driver if drowsiness is detected and then it is transmitted through CAN bus to trigger alarm signals such as buzzers or dashboard lights. The proposed system merges AI-driven analysis with a standardized automotive design, offering a reliable and flexible solution for improving driver safety.

2. LITERATURE REVIEW:

Driver drowsiness detection has remained an active research problem owing to the importance of the problem in terms of road safety. Various methods have been introduced to identify driver fatigue and drowsiness. Some of these methods include physiological measurements, car behaviour measurements, and vision measurement. Among all the measurement means introduced in driver drowsiness detection systems, camera-based driver drowsiness detection systems have achieved substantial popularity owing to the minimality of the impact of such measurements on driver behaviour. In camera-based detection systems, facial feature measurements are generally employed to determine the alertness level of the driver.

Existing research has proved the efficacy of the Eye Aspect Ratio (EAR) in the detection of closed or blinking eyes. The use of EAR has made it possible to ensure the continuous detection of drowsiness with minimal computational complexity. Additionally, the detection of yawns by considering the mouth landmarks has been included as a feature to enhance the accuracy of the yawning detection system. The use of computer vision libraries like OpenCV has also made the detection system more accurate and efficient.

Researchers have also investigated the use of drowsiness detection algorithm applications on embedded devices to support better real-time processing and to interact with vehicle systems. The embedded system controller and the single-board computer enable integration of the system with the Electronic Control Units (ECU) for better performance in terms of response time and system stability. Nevertheless, it is noted that current implementations and frameworks do not present a standardized software architecture for use in drowsiness detection systems.

Within the automotive system domain, AUTOSAR is recognized as a standard tool for designing modular, reusable, and platform-independent software components. Various research contributions have focused on safety systems designed through the AUTOSAR standard, indicating its benefits in terms of maintainability and interoperability. Similarly, various research contributions have recognized the benefits of CAN bus communication in sending safety-related information between ECUs. However, little research is reported on the development of AI-based driver drowsiness recognition using the AUTOSAR standard. Therefore, the need for a system arises, which includes the application of computer vision-based drowsiness detection using the AUTOSAR standard.

3. OBJECTIVES:

The main goal of this project is to develop and implement a driver drowsiness detection system that will increase road safety through its ability to detect signs of driver drowsiness and instantly notify the driver. The system will seek to monitor the driver's facial characteristics through the use of a camera and accurately detect signs of drowsiness via artificial intelligence and computer vision technologies.

Another important goal is to integrate the drowsiness detection mechanism within the AUTOSAR (AUTomotive Open System Architecture) framework to ensure modularity, scalability, and hardware independence. By using the layered architecture of the AUTOSAR, it is also an objective of the system to ensure that there is seamless communication between the application layer, Runtime Environment (RTE), and Basic Software (BSW) through reliable signal transmission.

The project also aims at establishing communication between the drowsiness detection system and vehicle ECUs through the use of the CAN bus systems, this helps ensure that the effective activation of alert components occurs, like buzzers and dashboard display lights. Besides, the system design ensures interoperability with a wider variety of embedded systems, therefore boosting its flexibility. The goal here is to come up with a dependable real-time driver monitoring solution relevant to the industry. That also means meeting the modern automotive safety standards.



4. RESEARCH METHOD :

The process begins with the continuous collection of the driver's video images through the in-vehicle camera system, which then facilitates by an embedded controller like STM32. The video frames are resized and denoised to ensure stable facial feature detection. Facial landmarks are obtained through OpenCV and MediaPipe tools to provide a basis for drowsiness detection by using eye-related traits.

Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR). When detected, a drowsy signal is sent to AUTOSAR RTE and BSW via the CAN bus to the ECU, enabling alerting mechanisms such as buzzers or dashboard warnings. The proposed methodology utilizes two facial landmark-based metrics for detecting driver drowsiness.

1. Eye Aspect Ratio (EAR)

The Eye Aspect Ratio (EAR) is defined as the measurement that measures the degree of opening or closing of an eye, based on the distances between certain points around the eye this distance is generally considered as a Euclidean distance between certain pair of points. Each eye is marked as 6 main points as in Fig. 1. The EAR for each eye is calculated using six facial landmarks: two horizontal points along the width of the eye and four vertical points along the eyelids. The Eye Aspect Ratio (EAR) is used to quantify eye closure and is calculated as:

$$EAR = \frac{\| P2 - P6 \| + \| P3 - P5 \|}{2 \times \| P1 - P4 \|}$$

where: -

P1, P2, ..., P6 are some points around the eye.

(P2- P6) and (P3- P5) are Euclidean distances between vertical pairs of points.

(P1- P4) is the Euclidean distance between the horizontal points along the width of the eye.

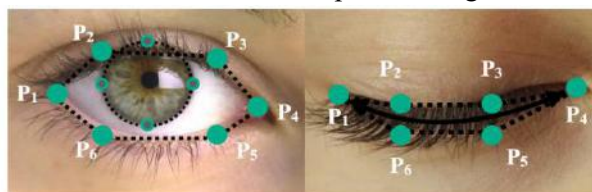


Fig. 1. The eyelid landmarks P_1 through P_6 are marked in filled green circles, whereas the iris landmarks are marked in unfilled green circles.

2. Mouth Aspect Ratio (MAR)

The Mouth Aspect Ratio computes the opening of the mouth. It is useful for detecting yawning as a possible sign of fatigue. MAR is calculated by computing distances between certain points on or around the mouth as in Fig. 2. Similarly, yawning is detected using the Mouth Aspect Ratio (MAR), defined as:

$$MAR = \frac{\| P2 - P8 \| + \| P3 - P7 \| + \| P4 - P6 \|}{2 \times \| P1 - P5 \|}$$

where: -

P1, P2, ..., P6 are some points near the mouth.

(P2- P8) and (P3- P7) and (P4- P6) are Euclidean distances between vertical pairs of points.

(P1- P5) is the Euclidean distance between the horizontal points along the width of the mouth.

The MAR increases when the mouth opens wide (for instance, during a yawn), and decreases as the mouth closes. Threshold-based evaluation of EAR and MAR values is used to determine the driver's drowsiness state

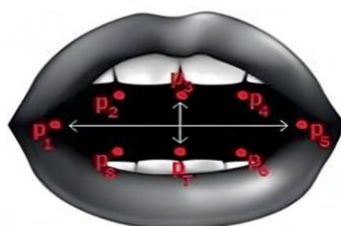


Fig. 2. Points distribution for calculating MAR



The overall integration of the drowsiness detection system within AUTOSAR framework is illustrated in Fig. 3.

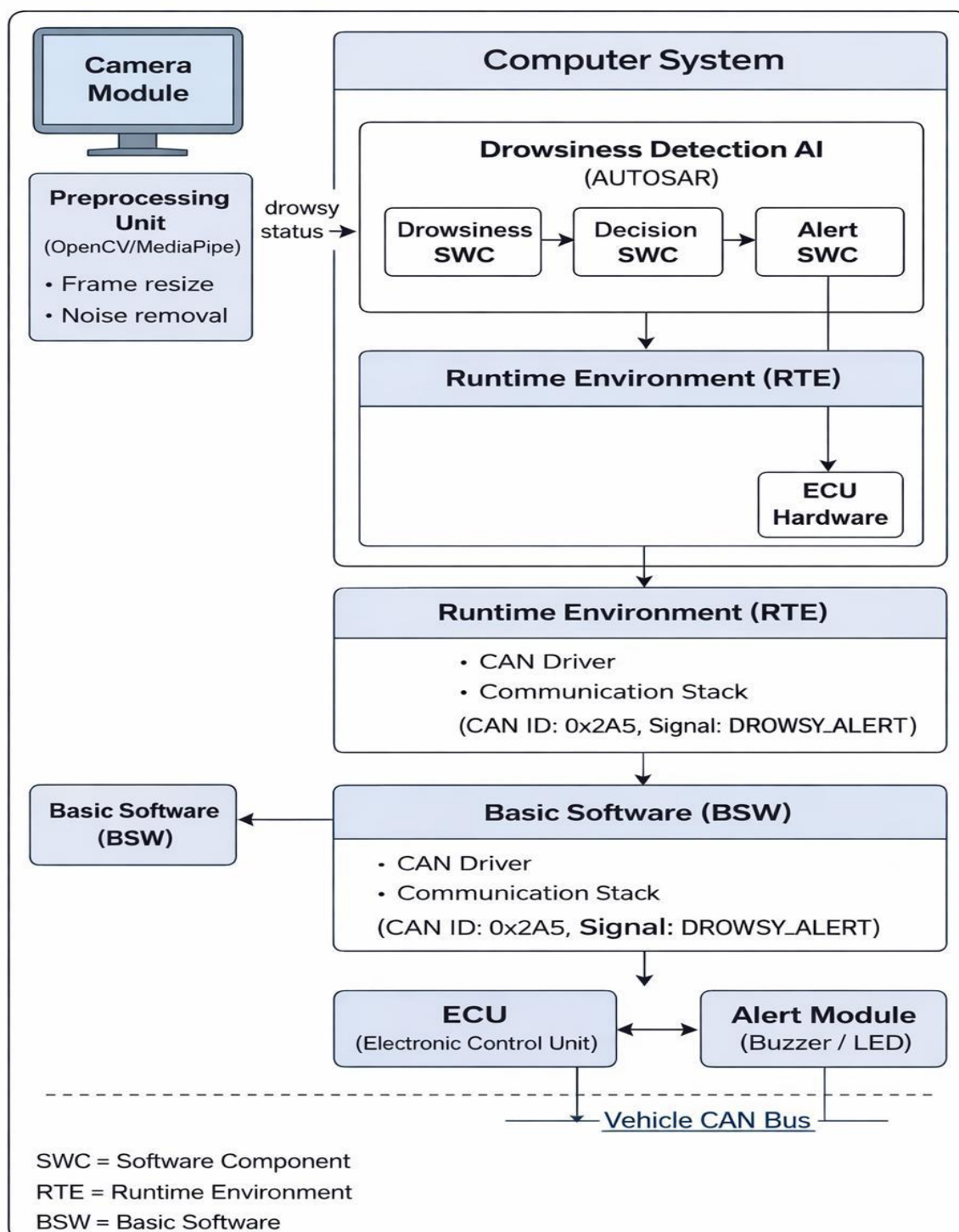


Fig. 3. Proposed system block diagram for driver drowsiness detection.



5. FINDINGS :

From the literature review, system design, and implementation of the AUTOSAR-based proposed system for driver drowsiness detection, the following important findings are observed:

- **Effective Real-Time Drowsiness Detection**

The system is capable of detecting drowsiness in a real-time manner by always tracking the faces of the drivers through a camera-based method. The use of vision-based methods makes it easier to detect drowsiness by identifying such behaviour as eye closure and yawning.

- **Reliable Performance on Embedded Platform**

Implementation on a small device such as an STM32 embedded controller shows that the proposed system can run efficiently even on devices with low computational power. Image preprocessing and detection of facial landmarks were performed successfully within a reasonable response time.

- **Accurate Detection Using EAR and MAR**

Also, by employing Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR), it has become possible to obtain certain reliable indicators that help detect drowsiness. The threshold-based evaluation of these parameters helps avoid false detection.

- **Seamless AUTOSAR Integration**

The ability to integrate with the AUTOSAR architecture allows structured communication between the application layer, the RTE, and the BSW. This improves its modularity and allows the signal transmission to occur reliably.

- **Efficient CAN-Based Alert Communication**

The CAN bus system is clear in transmitting the drowsiness alert signal sent by the BSW to the ECU. It helps promptly and effectively in implementing alert mechanisms like buzzers and dashboard warnings.

- **Improved Driver Safety Response**

The timely actuation of alert devices is useful for reducing the chances of accidents and enhancing driving safety from the early stages of drowsiness.

- **Scalability and Hardware Flexibility**

Because of such a layer-based AUTOSAR architecture and hardware abstraction, it will be easily adaptable, or rather, easily modifiable, so that it could be used for future automotive safety applications.

6. DISCUSSION :

The proposed AUTOSAR-based driver drowsiness detection system analysis is an indication that the integration of artificial intelligence with a standardized automotive software architecture significantly enhances vehicle safety systems. A majority of existing solutions for drowsiness detection have concentrated mainly on the detection algorithm, with very minimal considerations concerning implementation on in-vehicle communication frameworks, thereby limiting their practical applicability. The proposed system offers this limitation through the incorporation of the detection logic within the AUTOSAR framework, thereby guaranteeing structured communication between software layers.

In addition, the camera-based approach used in the system provides a good adequacy for real-time driver's behaviour monitoring. The advantage of vision-based methods allows the continuous detection of fatigue indicators, such as eye closure and yawning, under natural conditions without physical contact with the driver. This promotes users' comfort and allows the system to be suitable for real driving conditions. The use of EAR and MAR as parameters of detection is a good compromise between precision and computational lightness, and guarantees the feasibility of the system with respect to embedded platforms. From the implementation perspective, it can be noted that the system was executed over an embedded system like STM32, it is able to demonstrate the viability of "real-time" operation even in a system that is resource-poor.

Moreover, the step-wise AUTOSAR standard increases modularity of the system, which helps in enhancing its ease of maintainability. The application of a CAN bus for enhanced alert message transmission to the ECU proves helpful for timely activation of the necessary warning system.

The proposed system, when compared to traditional standalone, non-standardized approaches, promises better hardware flexibility and scalability. Although this system is developing as a prototype, from a performance point of view, it clearly demonstrates potential to be used in production vehicles in future. The above-mentioned discussion concludes that the proposed system, which uses AI-based perception, AUTOSAR, and CAN, improves the reliability and usability of the system.



7. CONCLUSION:

This paper has offered an automatic driver drowsiness detection system through AUTOSAR technology integrated with artificial intelligence and ECU alert mechanisms. It is observed that the system is efficient in monitoring driver facial features through computer vision technology and detects driver drowsiness in real time. The system also utilizes the layered advantage of AUTOSAR technology and CAN devices for signal transmission and finally offers scalability and flexibility in hardware, portraying its suitability for the field of embedded systems.

8. LIMITATIONS:

Even though the proposed AUTOSAR-based driver drowsiness detection system offers several advantages, certain limitations exist in the current design and implementation.

- **Limited Testing in the Real World**
Testing has so far been mainly carried out in controlled conditions. Extensive real-world testing in different driving conditions, lighting variations, and driver behaviours has not been fully conducted.
- **Sensitivity to Lighting Conditions**
Poor lighting conditions, possible shadows, and night driving may work against proper detection, since the system is dependent on camera-based facial analysis. This might necessitate additional illumination or infrared-based solutions.
- **Camera Position and Quality Dependence**
Incorrect placement of the camera or low-resolution cameras lower the reliability of face landmark detection, hence affecting the accuracy of drowsiness classification.
- **Threshold-Based Detection Constraints**
Applying fixed thresholds of EAR and MAR cannot depict the actual characteristics of every driver, as there is a lot of variation in the structure of eyes and individual blinking patterns.
- **Limited Hardware Resource Availability**
Embedded platforms, in particular the STM32 range, have limited processing and memory resources. Advanced AI models may require hardware of higher performance or additional optimization to operate on these devices.

9. RECOMMENDATIONS:

On the basis of the findings and limitations of this research study, some recommendations are proposed that can help to improve the proposed driver's drowsiness detection system using the proposed AUTOSAR-based approach.

- **Extensive Real-World**
The system has to be tested on a larger scale, and real driving conditions should also be considered, covering various lighting conditions, types of roads, and driving behaviour.
- **Adaptive and Personalized Detection Models**
The future version of this system could incorporate adaptive algorithms that use machine learning to determine the EAR and MAR thresholds for individual driver characteristics.
- **Integration of Advanced AI Techniques**
It is possible that more advanced deep learning models can be incorporated to improve detection effectiveness, especially when operating within difficult conditions such as low light or face occlusion.
- **Hardware Optimization and Acceleration**
However, using devices such as automotive-grade ECUs or hardware accelerators can improve the processing speed. This may allow more complex AI models to be employed.
- **Integration with Advanced Driver Assistance Systems (ADAS)**
The system may also be integrated with other active driving assistance system (ADAS) features, such as lane departure warning or adaptive cruise control, with the aim of attaining an integrated vehicle safety system.

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