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Development of a Driver Assistant and Vehicle Sensory System with Vehicle Fine Management

[1]Dulanjaya N.K.C., [2]Abeysiriwardena V.C., [3]Madushanka R.M.R.A., [4]Nimesh K.C., [5]Mrs. Hansika Mahadikara, [6]Ms. Suranjini Silva

[1,2,3,4,5,6]Faculty of Computing, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka

Authors E-mail: [1]it20228644@my.sliit.lk, [2]it20014568@my.sliit.lk, [3]it19147260@my.sliit.lk, [4]it20106638@my.sliit.lk, [5]hansika.m@sliit.lk, [6]suranjini.s@sliit.lk

***Abstract* - Innovative solutions targeted at improving traffic safety and driver wellbeing have been made possible by developments in computer vision and artificial intelligence. Through the creation of a driver warning and road sign recognition system as well as an enhanced eye health monitoring module, this study offers a holistic strategy to address important aspects of road safety. This project develops a coherent and efficient driver assistance system by integrating real-time image processing, neural networks, and driver behavior assessment using Python and OpenCV.**

Keywords: OpenCV, Neural Networks, Image Processing, real-world adoption, COLOV Neural Network.

I. INTRODUCTION

The incorporation of intelligent systems and cutting-edge sensors into cars has emerged as a crucial area of research and development in the quickly changing field of transportation technology. This research project focuses on the creation of a comprehensive Driver Assistant and Vehicle Sensory System (DAVSS) integrated with cutting-edge Vehicle Fine Management capabilities with the goal of enhancing road safety, optimizing vehicle performance, and improving the overall driving experience. Modern automobiles can detect their surroundings, communicate with one another, and even make autonomous decisions because of the proliferation of sensors, computers, and communication tools that are available to them [8].

The research study also explores the idea of "vehicle fine management," which entails integrating administrative and financial operations inside the DAVSS framework. By combining GPS data, electronic payment systems, and blockchain technology, this ground-breaking innovation enables the vehicle to dynamically manage toll payments, parking fees, and other road-related expenditures. Such integration not only simplifies the entire driving process but also paves the way for more intelligent, effective transportation systems. The design, implementation, and validation of the suggested DAVSS with Vehicle Fine Management are thoroughly examined in this thesis work. It combines knowledge from automotive engineering, AI/ML, sensor technologies, and blockchain in a multidisciplinary manner.

The project intends to demonstrate the applicability and efficacy of the system in real-world driving scenarios through the performance of rigorous experiments, simulations, and real-world testing. The technical specifics of sensor integration, AI algorithms, system architecture, and the underlying blockchain-based fine management system will be covered in detail in the parts that follow. This study contributes to the growing body of knowledge on intelligent transportation systems by a combination of theoretical analysis and empirical evaluation, and it lays the groundwork for vehicles that are safer, more effective, and more technologically advanced [9].

A) Detection of Road Sign Boards

The incorporation of intelligent technologies with automobiles has made considerable strides toward improving road safety and driver support in the current environment of automotive technology. The goal of this study is to create a revolutionary Camera-Based Road Sign Detection and Driver Alert System (CRSD-DAS), which combines cutting-edge image processing methods to identify road sign boards, extract relevant data, and give drivers real-time alerts and instructions. This system's main objective is to increase road safety by providing drivers with vital information about traffic conditions, potential dangers, and speed limits via an easy-to-use interface. Modern roads are decorated with a variety of sign boards that provide drivers with important information about rules, cautions, directions, and speed limits. In order to take pictures of these traffic signs, the CRSD-DAS makes use of a strategically located camera that is mounted on the car's dashboard. These photographs are used as the system's input, which sets off a complex series of image processing procedures to determine the nature, location, and content of each identified road sign. The extracted data is then used as

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the foundation for creating warnings and directions for the driver that are both timely and context sensitive [10].

B) Development of Driver Sleepinesss and Eye Health Monitoring System for Enhanced Road Safety

The protection of drivers on lengthy trips is of utmost importance in the dynamic world of transportation. The threats to road safety posed by fatigue-induced driver drowsiness and unidentified eye health concerns are severe. This study focuses on creating a cutting-edge mobile app called the Driver Sleepiness and Eye Health Monitoring System (DSEHMS), which uses real-time camera analysis to identify signs of driver inattentiveness, evaluate eye health indicators, and make prompt recommendations to reduce potential risks. This system promotes alert and safe driving habits in order to improve driver wellbeing and road safety by incorporating cutting-edge computer vision technology. Long periods of driving frequently result in driver weariness, which can impair alertness and reaction times and significantly raise the risk of accidents. By continuously examining visual clues recorded by a smartphone's camera, the DSEHMS seeks to address this problem. The device monitors crucial indicators of driver tiredness, including blink rate, pupil size fluctuations, and facial expressions [16].

The complex image processing pipeline of the CRSD-DAS, which uses methods including image segmentation, feature extraction, pattern recognition, and machine learning algorithms, is the brain of the system. Even in difficult lighting and weather circumstances, the system can reliably identify road signs by using cutting-edge computer vision approaches. Additionally, including machine learning models ensures that the detection accuracy is continuously improved, allowing the system to adjust and enhance its performance over time. The creation of a user-friendly user interface that enables seamless communication between the system and the driver is a key component of this research. A combination of visual displays and audible signals are used to present real-time alerts to the driver, ensuring that important information is properly communicated without generating distraction. By balancing fast information delivery with preserving the driver's attention on the road, the CRSD-DAS hopes to make driving a safer experience overall [11].

Beyond the constraints of certain vehicles, the CRSD-DAS is significant. The system can help to lessen traffic infractions, accidents, and general traffic congestion by improving driver awareness and obedience to traffic signs. The study project also explores the difficulties of practical application, taking into account elements like computational effectiveness, robustness against environmental unpredictability, and the system's integration with current vehicle technology. The CRSD-DAS is thoroughly examined in this thesis paper, from its inception and design to its execution and evaluation. The project intends to demonstrate the applicability, efficacy, and possible influence of the proposed system on road safety through a mix of theoretical analysis, algorithm development, and empirical testing. This research helps to advance the field of intelligent transportation systems, paving the way for safer and more knowledgeable driving experiences [15].

C) Development of Air Quality Index (AQI)

The escalating global concern surrounding air pollution has led to a critical need for interventions that safeguard both public health and the environment. The increasing concentrations of air pollutants, primarily attributed to urbanization and vehicular emissions, have unequivocally been linked to a spectrum of health issues, encompassing respiratory diseases, cardiovascular disorders, and even cancer [1]. This alarming scenario is especially relevant for vehicle drivers who traverse densely populated urban areas, enduring prolonged exposure to harmful substances suspended in the air [2]. Considering this, the imperative to develop innovative systems capable of promptly and accurately assessing air quality becomes evident, thereby facilitating informed decisions to mitigate potential health risks. In direct response to this pressing challenge, this research endeavors to conceptualize and implement a sophisticated real-time air quality monitoring system specifically tailored for vehicle drivers. This envisioned system harnesses the capabilities of state-of-the-art technology, encompassing gas sensors, a Raspberry Pi-based computational platform, a GPS module, and a mobile application. By doing so, it empowers drivers with actionable insights into the air quality enveloping their vehicles. This system not only detects key pollutants but also evaluates their severity levels, thereby not only providing drivers with real-time information on the air quality index (AQI) but also issuing health alerts that illuminate potential health hazards, such as the elevated risk of developing conditions like asthma, lung cancer, and cardiovascular diseases [3].

D) Development of Fine Management System with Chatbot

The contemporary landscape of customer service and management systems has been significantly influenced by advancements in technology. In this context, this research paper embarks on a critical exploration of an innovative solution - the integration of a chatbot into the realm of customer support within the fine management domain. The central objective of this research is to propose and evaluate the potential benefits of employing a chatbot to handle customer inquiries pertaining to fine accuracy and related matters. As

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infractions and fines constitute integral components of maintaining law and order on roads, the efficiency and effectiveness of fine management systems are paramount.

II. LITERATURE REVIEW

Aiming to increase road safety by giving drivers real-time information about road conditions, potential hazards, and speed limits, the integration of camera-based road sign identification and driver alert systems has made great development in recent years. This overview of the literature explores significant developments in computer vision, image processing, and driver assistance technologies while noting existing research gaps and potential future study areas [12].

A possible way to increase road safety by addressing fatigue-related dangers and enhancing ocular health is to integrate mobile app-based driver sleepiness and eye health monitoring systems. This literature review highlights current research gaps and opportunities for further investigation while examining significant developments in the detection of driver sleepiness, eye health evaluation, and the design of user-friendly mobile applications [13].

Akshata T and Divya V also built cost effective system to control the air pollution by calculating the levels of each pollution [9]. The air quality index for that area is calculated based on the observed readings, and the results are made available via a web page. However, this system's main drawback is that customers are not given a portable application to examine pollution levels right every time or a pictorial style for simple viewing. Zuber P, S C-Jalim outlined and system that identifies pollution hotspots, alerts authorities, and tracks available parking to minimize driving time and air pollution. But the main disadvantage of this system is that drivers are not provided with real time pollution levels outside the vehicle [10].

While literature on chatbots is abundant, their application to fine management and accuracy-related queries is limited. As the proposed research seeks to bridge this gap, it aligns with the broader trend of leveraging technology to optimize customer support processes. Additionally, studies exploring the impact of technological interventions on promoting responsible behavior, such as deterring careless driving, offer valuable insights that parallel the goals of this research. Overall, the existing literature on chatbots emphasizes their potential to revolutionize customer interactions and operational efficacy. However, the integration of chatbots specifically within fine management systems and their potential contribution to road safety remain underexplored areas. This research aims to contribute to this nascent area of study by examining the implications, benefits, and challenges associated with introducing a chatbot to address customer inquiries regarding fine accuracy and related concerns.

III. METHODOLOGY

This detailed technique describes the steps involved in creating a road sign detection and driver alert system that uses Python for eye health monitoring and OpenCV for sign detection. The system's goal is to use a camera to recognize traffic sign boards and give the driver the proper directions or alerts. Additionally, it uses Mediapipe for face feature analysis and OpenCV for camera access to track the health of the driver's eyes, looking for signs of dryness and tiredness. Using a camera mounted on a moving vehicle, a large number of photographs of various road signs must be taken in order to compile a diversified dataset of road sign images. The traffic sign identification and classification model is trained and tested using this dataset as its basis. A representative and thorough collection of road sign photographs that includes various sign kinds, lighting situations, perspectives, backgrounds, and environmental aspects frequently found on roadways is the aim [21].

To organize and manage the gathered collection of road sign photos, OS (Operating System) libraries must be used to make file folders for each class and store the images. OS libraries offer a mechanism to communicate with the operating system's file system and build a hierarchical directory structure for organizing and storing images according to their appropriate classes or categories [18].

OpenCV will be used to preprocess the dataset, including resizing, normalization, and noise reduction. Image segmentation techniques will be used to isolate road sign regions and relevant features will be extracted from the segmented regions. OpenCV's feature extraction and classification functions will be used to train a sign detection model, potentially utilizing Histogram of Oriented Gradients (HOG) descriptors and Support Vector Machines (SVMs). The COLOV pre-trained convolutional neural network (CNN) model will be integrated for classifying detected road sign images into specific types. Fine-tuning of the model using the collected road sign dataset.

OpenCV to access the camera feed and create a viewport to monitor the eye health of the driver. MediaPipe will be imported to define a facial mesh, with emphasis on eye regions. Eye detection will be implemented using the facial mesh to determine if the driver's eyes are open or closed. The blink rate will be calculated based on the time intervals between eye openings and closings. The thresholds for blink rate analysis will be defined as: dry eye (less than 5 blinks), wet eye (more than 20 constant blinks), and normal (between 10-30 blinks). Sleepiness of the driver will be detected if eyes

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remain closed for a duration between 10-30 seconds. The captured date and time will be used to analyze sleepiness patterns. A vibration kit will be integrated to provide alerts to the driver when sleepiness or eye dryness is detected. The vibration kit will be configured to generate vibrations when the defined conditions are met [21].

The process of selecting appropriate gas sensors involves a meticulous evaluation of various criteria. These criteria encompass factors such as accuracy, sensitivity, selectivity, response time, stability, and cost. The chosen sensors must effectively detect the primary pollutants of concern – carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO2), and particulate matter (PM) – while being compatible with the Raspberry Pi platform. Different sensor technologies, including electrochemical, metal oxide, and optical methods, are considered, each with its advantages and drawbacks. Calibration processes ensure alignment with reference standards, and cross-sensitivity is evaluated to prevent interference [14]. Sensor fusion might be employed to enhance accuracy. Additionally, factors such as environmental.

For this scenario we use MQ gas sensors which family of gas sensors are used to detect a wide variety of gases like alcohol, smoke, methane, LPG, hydrogen, NH3, Benzene, Propane etc. These sensors are made up of electrode which is coated with a sensing material, and it is heated to make it more reactive and sensitive. Under MQ gas sensor category we use MQ2 sensor, detecting methane, butane, LPG, hydrogen, and smoke for varied applications. Conversely, the MQ9 sensor homes in on carbon monoxide and flammable gases, vital for safety. Meanwhile, the MQ135 sensor captures gases from ammonia to VOCs, pivotal for comprehensive air quality assessment. There are the three gas sensors we used for this research.

The chosen gas sensors must be completely integrated with a Raspberry Pi microcontroller, which will serve as the system's main processing node, during the integration phase. The Analogue to Digital Converter (ADC), Raspberry Pi, and A9G GPS GSM GPRS development Modules are parts of the processing unit. Each sensor is attached to its individual Sensor Board (ISB), and those ISBs are connected to the General-Purpose Input Output (GPIO) ports on the ADC Fig. 1. The Raspberry Pi, an essential component, contains computational power and adaptability, enabling it to accurately coordinate real-time air quality monitoring based on ADC digital signal produced from GAS sensors. In addition to determining the precise geographical coordinates of each vehicle's current location, the GPS module also plays a crucial dual role by transmitting this vital spatial information to the core system every 10 seconds.

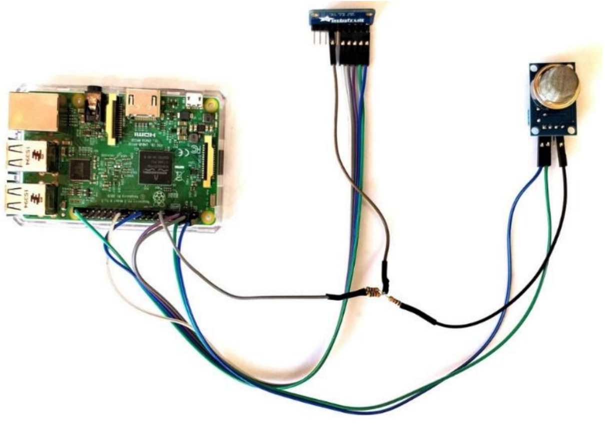

Figure 1: Connect the ADC module with gas sensors

To create an accurate representation of air quality, the system will continuously gather data from the gas sensors each 10sec. The collected data, including pollutant concentrations and GPS coordinates, will be stored for further analysis. The concentration of each pollutant is measured in micrograms per cubic meter (µg/m³). This concentration is then compared to specific concentration breakpoints associated with the AQI categories. Based on the calculated AQI values, the pollutants will be categorized into different air quality levels, such as 'Good,' 'Moderate,' 'Unhealthy for Sensitive Groups,' 'Unhealthy,' and so on. Each category will be associated with specific health risks, such as increased incidence of asthma, lung cancer, and cardiovascular disease.

AQI Color	Level of Concern	Index	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	O_3 (ppb)	CO (ppb)	NO_2 (ppb)	SO_2 (ppb)
Green	Good	0 - 50	0 - 25	0 - 50	0 - 50	0 - 2,250	0 - 65	0 - 15
Yellow	Moderate	50 -100	25 - 50	50 - 100	50 - 100	2,250 - 4,500	65 - 130	15 - 30
Orange	Slightly Unhealthy	100 - 150	50 - 75	100 - 150	100 - 200	4,500 - 9,000	130 - 350	30 - 80
Red	Unhealthy	150 - 200	75 - 150	150 - 275	200 - 300	9,000 - 15,000	350 - 650	80 - 250
Purple	Very Unhealthy	200 - 300	150 - 250	275 - 450	300 - 400	15,000 - 30,000	650 - 1,250	250 - 600
Maroon	Hazardous	300 - 500	250 - 400	450 - 650	400 - 600	30,000 - 50,000	1,250 - 2,000	600 - 1,000
Beyond AQI		>500	>400	>650	>600	>50,000	>2,000	>1,000

Figure 2: Each pollution breakpoints

Once the concentration is compared to the concentration breakpoints, an individual AQI value is assigned to each pollutant Fig. 2. This individual AQI value is calculated using a formula that varies for each pollutant. The general formula is shown in Fig. 3.

$$I_P = (C_P - BP_{Lo}) \times \frac{(I_{Hi} - I_{Lo})}{(BP_{Hi} - BP_{Lo})} + I_{Lo}$$

$$I = max\{I_P\}$$

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P = Pollutant
C = Concentration
I = Air Quality Index
BP = Breakpoint
Hi = High
Lo = Low
C_p = Concentration of the Pollutant P
I_p = Sub-Index of the Pollutant P
BP_{Hi} = Breakpoint concentration that is greater than C_p
BP_{Lo} = Breakpoint concentration that is less than or equal to C_p
I_{Hi} = Index value corresponding to BP_{Hi}
I_{Lo} = Index value corresponding to BP_{Lo}

Figure 3: AQI calculation formula

A mobile application will be developed to provide real-time air quality information and health alerts to the driver. This Android mobile application will be developed using Java and Android Studio, serving as a platform to deliver real-time air quality information and health alerts to drivers. Data will be wirelessly transmitted from a Raspberry Pi, with options including Bluetooth or Wi-Fi connectivity. The app's interface will display the current air quality level, AQI value, pollutant concentrations, and relevant health warnings. Also, the user selected destination will display AQI level of that location. Push notifications will be triggered when the AQI crosses certain thresholds, advising the driver on the appropriate actions to take.

The research commences with the collection of data from the "intents.json" file, containing patterns, tags, and responses for various intents. Each pattern within the intents is tokenized into words using the NLTK library's word tokenizer. Stemming is performed on the words to reduce them to their root forms, aiding in normalization and generalization. The words, labels, training data, and output data are prepared for model training.

A neural network model is constructed using the Keras framework, comprised of densely connected layers. The model architecture includes an input layer with the number of neurons equal to the length of the training data, two hidden layers with rectified linear unit (ReLU) activation, and an output layer with a softmax activation function. Stochastic Gradient Descent (SGD) optimizer is utilized to minimize the categorical cross-entropy loss function. The model is compiled, and if model weights are available, they are loaded. Otherwise, the model is trained on the prepared training and output data. Bag-of-Words Encoding: A function "bag_of_words" is defined to convert user input into a bag-of-words representation. User speech input is tokenized and stemmed, and the bag-of-words vector is constructed using the previously prepared words. Speech Input and Output: Two functions "speech_input" and "speech_output" facilitate speech recognition and synthesis. "Speech_input" records audio from the microphone, recognizes speech using the Google Web Speech API, and returns the recognized text. "Speech_output" converts synthesized text into speech using the pyttsx3 library. Chatbot Interaction: The "chat" function initiates a loop where the user can engage in a conversation with the chatbot. User input is obtained through speech_input, and if the user wants to quit, the loop terminates. The bag-of-words representation of the input is fed into the trained model to predict the user's intent tag. The corresponding intent's response is randomly selected and displayed to the user via speech_output.

The research paper's methodology is executed by running the code, enabling users to interact with the chatbot through spoken language. User queries are recognized and processed using the model's predictions, providing relevant responses from the dataset.

IV. RESULTS AND DISCUSSION

The introduction of the OpenCV and Python-based road sign detection and driver warning system, combined with the eye health monitoring module, has produced encouraging results in terms of improving traffic safety and driver wellbeing. An overview of the results that were attained is provided in this section, together with discussion of the findings' implications and a list of possible topics for further development.

A) Results

Using the trained model based on OpenCV and the COLOV neural network, the built system recognizes different types of road sign boards successfully. Real-time recognition of traffic signs from camera feeds showed accuracy in classifying several sign types, including warning, regulation, and informational signals. Based on the sorts of identified signs, appropriate instructions and notifications were created, giving the driver timely directions.

The real-time analysis of the driver's eye behavior by the eye health monitoring module was successful in identifying elements including blink rate, dry eyes, and tiredness. Successful analysis of driver eye behavior patterns revealed appropriate blink rates, symptoms of dry eyes, and signals of tiredness. The vibration package produced signals to combat driver drowsiness, assuring driver focus and averting hazardous collisions.

B) Discussion

The basis for better driver awareness and adherence to traffic laws is the precise detection and classification of road signs. The system's capacity to categorize road signs is

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improved by the smooth integration of COLOV neural network, adding to the development of a complete driver aid solution. Additional optimizations might concentrate on speeding up processing and improving robustness in the face of changing environmental factors like weather and lighting.

V. CONCLUSION

The creation of a thorough road sign detection and driver alert system in conjunction with a cutting-edge eye health monitoring module has produced encouraging results in the quest to improve road safety and driver wellbeing. This study has shown how technology may be used to reduce the dangers related to distracted driving, driver tiredness, and ocular pain. It does this by integrating OpenCV, Python, and outside neural networks. The real-time, accurate recognition of several road sign categories by the road sign detection and driver alert system was demonstrated, along with appropriate instructions and notifications to direct drivers' actions.

In conclusion, a comprehensive and efficient approach to road safety and driver wellbeing has been made possible by the combination of computer vision, neural networks, and real-time analysis of driver behavior. This study advances the development of intelligent transportation systems, which use technology to make roadways safer and provide better driving experiences.

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