Design of Emergency Alarm System for Drowsiness Detection Using YOLO Method Based on Raspberry Pi

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***Abstract*—Drowsiness is one of the main factors causing traffic accidents that often lead to fatalities, as drowsy drivers lose concentration. Therefore, drowsiness detection in car drivers is very important to prevent accidents. In this research, an emergency alarm system for drowsiness detection using YOLO method based on Mini PC is designed. This drowsiness detection system uses a camera to take pictures of the driver's face and the YOLO algorithm to detect the eyes. If the driver's eyes are detected to be closed, the system will give a warning in the form of a buzzer, display on the LCD, and water spray to wake up the driver. Test results show that the system has an average accuracy rate of 88% under optimal lighting conditions and 66.8% under low lighting conditions. The system also records detection and response times for further analysis, demonstrating the ability to not only detect the driver's condition but also record the time of the event. The data results show that the system is capable of detecting "Awake", "Drowsy", and "Asleep" states with an accuracy rate of 80%, as well as providing effective warnings to the driver when it detects signs of drowsiness.**

Keywords—CNN, drowsiness, emergency alarm, YOLO

I. INTRODUCTION

Sleepiness is one of the factors causing traffic accidents that can cause fatalities. According to data from the Korlantas Polri, in 2022, as many as 24,000 traffic accidents in Indonesia were caused by drowsiness. The main factor causing accidents is fatigue or drowsiness [1]. Indications of fatigue in the driver can be characterized by blinking eyes followed by a nod of the head, eyes that often close while driving but mentioned yawning is the main indication of a driver starting to experience fatigue. From these problems, which can be said when the driver is tired and sleepy, a tool is needed that can help detect drowsiness in the driver so that preventive action can be taken immediately. Drowsiness detection alarm system for vehicle drivers is one way to prevent traffic accidents [2]. Drowsiness detection can be done in various ways, one of which is by using the YOLO method. An important step in detecting drowsiness is to do

face detection and expression detection. Research related to face detection to detect drowsiness in drivers has been carried out by several researchers [3].

The You Only Look Once (YOLO) method is a cutting-edge method of object detection with a high level of accuracy that can help realize products made by researchers [4]. YOLO is the development of the Convolutional Neural Network (CNN) method into a new algorithm and focuses on object detection by reusing classifier results to run detection features [5][6]. YOLO is a machine learning method used to detect objects in images or videos [7]. This method works by predicting the bounding box of the object in one iteration [8], [9]. The design of an emergency alarm system for drowsiness detection with the YOLO method based on Mini PC was built to be able to overcome these problems. This system uses a camera to take pictures of the vehicle driver's face [10]. Then, the image is processed using the YOLO algorithm to detect the face, eyes, and mouth [11]. If the driver's eyes are closed or head bowed, the system will give a warning to the driver. The warning is in the form of an indication in the alarm buzzer and a warning displayed on the LCD, as well as a water spray that is used to wake up drivers who have fallen asleep.

This research is important because it can provide solutions to prevent traffic accidents caused by drowsiness. The results of this research are expected to improve driving safety. The purpose of this research is to build a tool design and implementation of an emergency alarm system for drowsiness detection with the YOLO method that can detect signs of drowsiness in car drivers, design an emergency alarm system using a Mini PC which will include the selection of appropriate hardware and software, as well as an easy-to-use interface design, and evaluate the accuracy level of the emergency alarm system for drowsiness detection with the YOLO method based on Mini PC.

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II. METHODS

Hardware design consists of designing and mechanical form of the tool. Software design consists of applying the YOLO method algorithm, OpenCV, and image processing, object detection actions, and the components that make up the tool. Followed by hardware and software testing as well as data collection and continued with analysis and conclusions. System design aims to explain the design which includes electronic design, hardware design, software design, tool planning block diagram, and working principle of the tool based on the literature study that has been done. The design of hardware and controller devices is based on several mathematical calculations. While the software design is based on literature on the YOLO (You Only Look Once) method to identify drowsy facial conditions using a Mini PC. Furthermore, the basics of classifying datasets using the YOLO (You Only Look Once) method and algorithm are studied, as well as the basics of buzzer actuators, 16x2 LCD, and micro sd card module which are then made in order to identify drowsiness and emergency alarms in both mechanical and electronic systems. When the system has been successful, an analysis of the system response is carried out to compare the results with the design.

The drowsiness detection emergency alarm system using the Mini PC-based YOLO method designed based on the findings of literature research from previous studies can be seen in Figure 1. 5V 3A adapter power supply is used to power the Raspberry Pi while 12V 5A power supply functions as a driving force for the water pump and flash buzzer. In the input section, the push button functions as a reset control of the current state to the original state, the RTC functions as storing time when the device loses power and does not have access to a network connection after the device reboots, and the webcam functions to take object images. In the process section, the Raspberry Pi Mini PC is used to run the image processing program and perform the process of setting the water pump actuator and flash buzzer active actuator. In the output section, Relay & Flash Buzzer functions as an active alarm actuator that is activated by a relay by emitting sound and lights, Relay & Water pump functions as an actuator that acts by spraying water to wake up the subject, 16x2 LCD functions to display object detection indicators, and MicroSD Card Module functions as data logging the results of processing object detection data which is then stored on a MicroSC Card [12].

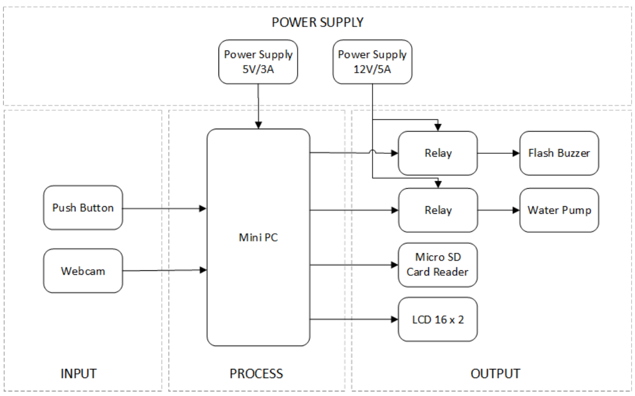

Fig. 1. System Block Diagram

Software design for emergency alarm system using YOLO method based on Raspberry Pi Mini PC. When the device is turned on, the webcam camera automatically turns on a few seconds after the Raspberry Pi boots. The camera then takes a picture, and the drowsiness detection system works based on a pre-trained dataset. The system distinguishes between awake and sleepy states, where sleepiness is indicated by eyes closed or head down for more than 3 seconds. If drowsiness is not detected, the system continues to take pictures, but if drowsiness is detected, the system saves a time log on the microSD card, turns on the buzzer, and displays a warning on the LCD screen. If after 6 seconds drowsiness is still detected and the push button has not been pressed, the water pump will turn on along with the buzzer until the button is pressed. There is also a protection system that detects if the push button is pressed for more than 15 seconds, to prevent misuse of the system. To reset the system and turn off the actuator output, the push button must be pressed, which also repeats the image capture by the camera. Once the reset process is complete, the system returns to normal functioning.

In the process of creating a YOLO dataset training dataset here using a website called Roboflow which can be accessed at the app.roboflow.com. The process starts with system initialization, followed by capturing face images using a webcam. A total of 650 face images were collected from 5 samples, each consisting of 130 images. This dataset is then used as the basis for model labeling and training. Once the images are collected, the next step is to label the images with bounding boxes. This labeling process involves labeling the image with a box frame, which marks the facial parts and expressions of sleepiness and wakefulness of the driver. The labeled images were then compiled into a training dataset to train the YOLO model to detect signs of drowsiness on the driver's face. Before the main training begins, the dataset goes through a pre-training stage, which includes processes such as data normalization and image augmentation, to ensure optimal data quality. Pre-training the dataset starts with system initialization, using the pre-labeled data as raw data. The dataset is then divided into three parts: Training Set at 70%, Validation Set at 20%, and Testing Set at 10%. Most of the dataset, 490 out of 650 images, is allocated to the Training Set which is used to train the model to recognize sleepiness-related patterns and features. Pre-Processing in the Training Set involves preparing the raw data, including resizing the images to 384x384 pixels. An augmentation process is performed to enrich the dataset with certain transformations, such as Grayscale, Brightness, and Exposure, which help the model become more robust and capable of better generalization. A total of 140 out of 700 images, or 20% of the total data, were allocated to the validation set. This set serves to test and validate the model during training, ensuring that the model does not suffer from overfitting and can perform well on data that has never been seen before. A total of 70 images, or 10% of the total data, were allocated to the testing set. This set is used to test the final performance of the model after training is complete. This testing data is completely separate and is not used during training or validation. After all processes were completed, the entire data set (training, validation, and testing) was generated into a new version with a total number of images reaching ≤1,680. These images are stored in the training database, which is then used to train and test the YOLO model. Once the training is complete, the trained model is stored in the dataset and can be exported in YOLOv5 format. The process ends when the

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trained model is successfully saved and ready to be used for drowsiness detection [13].

Testing drowsiness detection using YOLO begins with setting up the hardware and software, including installing the YOLO model and connecting the camera to the system. After that, an initial configuration is performed to ensure the model can process images in real-time. A series of tests were then conducted to evaluate the system's ability to detect signs of drowsiness, such as closed eyes, with the detection results displayed as bounding boxes on the screen. In addition, drowsiness detection was also tested based on distance, using distance ranges of 60 cm, 70 cm, 80 cm, 90 cm, and 100 cm, which were chosen according to the typical distance between the driver's cabin and the driver's face in a vehicle. The results of these tests were then analyzed to ensure that the system functions according to the expected specifications.

Dataset testing for YOLO training begins after the model has been trained with a pre-prepared dataset. The results are analyzed through graphs that show metrics such as precision, recall, and confidence. Before that, it is necessary to explain the Confusion Matrix, which involves TP (True Positives), FP (False Positives), TN (True Negatives), and FN (False Negatives). TP is the number of events actually predicted as positive by the model, FP is the number of events incorrectly predicted as positive, TN is the number of events actually predicted as negative, and FN is the number of events incorrectly predicted as negative. Recall is the ratio between the number of correct positive predictions (True Positives) to the total true positive elements (True Positives + False Negatives). Precision is the ratio between the number of correct positive predictions (True Positives) to the total positive predictions made by the model (True Positives + False Positives). Confidence is a value that indicates how confident the model is in the predictions for an object. In the context of YOLO, the confidence score is the probability that the bounding box contains a particular object, which helps determine whether the object prediction is strong enough to be considered correct. This analysis aims to assess the training progress, detect possible overfitting or underfitting, and ensure the model achieves the desired performance. Based on the results of the analysis, a decision can be made whether further adjustments need to be made to the dataset or training parameters.

Overall system testing begins with setting up all the necessary hardware and software, such as the drowsiness detection module, buzzer, water pump, LCD, microSD card for data logging, and reset button. The system is then configured to ensure that each component is integrated and functioning properly. The testing process includes checking the functionality of each component: the drowsiness detection should trigger the buzzer and water pump if needed, the LCD should display the information accurately, the microSD card should log the data correctly, and the reset button should be able to restore the system to its initial state. In order to make the analysis results more accurate, the drowsiness detection test was conducted under low light conditions (low lux). This is important because low light intensity can affect drowsiness detection results, especially at lower confidence levels [14]. Analysis of the test results was conducted to ensure that all components were working according to the expected specifications.

III. RESULTS AND DISCUSSION

The testing process was carried out by block part and testing the drowsiness detection system using the Mini PC-based YOLO method. In testing the Raspberry Pi 5 showed a significant increase in CPU performance. The Single-threaded Sysbench test produced a value of 2,729 events per second, while the Multi-threaded Sysbench test recorded 10,912 events per second [15] The strong single-thread performance shows that the device is excellent for tasks that require the speed of a single-core processor. Meanwhile, the high multi-threaded performance signifies a good ability to handle parallel tasks, making it ideal for multi-threaded applications and workloads. This improvement is due to better CPU architecture and higher clock speeds compared to previous models. The memory performance of the Raspberry Pi 5 is also excellent, with the system being able to handle 10,912 read/write operations per second when using 4 threads. This represents an increase in memory bandwidth and efficiency, which is crucial for tasks involving big data processing and multitasking [16]. The increase in memory speed and capacity over previous models allows for better overall system responsiveness and performance. Disk performance also showed significant improvement, especially in read operations. A read speed of 101 MB/s and a write speed of 60 MB/s are good results for a device in this category, ensuring fast and efficient data access. Although the latency results for random read/write operations, especially the high latency for 4K random writes (138.80 ms), show some performance limitations, likely due to the nature of flash storage and system I/O capabilities, the high sequential read and write speeds (over 400 MB/s) show strong performance for tasks with continuous large data streams. This makes the Raspberry Pi 5 suitable for applications such as media servers or data logging systems.

The LCD test results from the five trials showed that every time input text, the output displayed on the LCD screen matched the given input. This indicates that the LCD module works well, capable of displaying characters accurately and consistently according to the commands received. In addition, the brightness level setting function also works well. Testing the relay and water pump shows that in ten trials, the relay functions perfectly according to its function. When receiving logic 1, the output turns on, and when receiving logic 0, the relay turns off. The voltage released by the relay only has a difference of 2%-3% from the vcc used of 12.3VDC, with an average Vout of 12.4VDC. This shows that the relay is reliable to control the water pump with high consistency and accuracy. The water coming out of the water pump is also in accordance with its specifications, which is 2 liters per minute. Testing the relay and flash buzzer also showed similar results, with the relay functioning perfectly in ten tests. The relay output voltage shows the same consistency with a difference of 2%-3% from vcc, ensuring that the relay is reliable to control the flash buzzer. The webcam test results on the Raspberry Pi showed that in ten attempts, the webcam was able to capture images with good quality, i.e. 1920x1080 pixels resolution. This indicates that the webcam works well and is consistent in producing high quality images. Testing data logging using the microSD card module on the Raspberry Pi shows that in five trials using button input, the results are quite responsive with a latency of less than one second when the button is pressed, and the data is written to the microSD card in .txt format. This shows that the microSD card module works well in reading and writing

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data and provides a fast and consistent response. The push button test on the Raspberry Pi shows that in five trials, the push button is quite responsive with a latency of less than one second. This shows that the push button works well and provides a fast and consistent response, without experiencing physical problems, so the button is enough to press lightly to function.

Sleepiness detection testing using YOLO is divided into 2 aspects, namely based on distance and light intensity and based on noise treatment [17]. In this test, data collection is carried out using the aspect of the length of the detection distance between the webcam camera and the detection object, namely the face using a distance range of 60 cm, 70 cm, 80 cm, 90 cm, and 100 cm. In the test, there were 10 tests with 5 tests per detection between awake and sleepy when the room conditions were bright with the resulting light lux value averaging 210.4 lux. In testing and data collection when the condition of the awake face object gets an average confidence of 89.6% with the highest value at a distance of 80 cm and 100 cm with 91% confidence and the lowest confidence at a distance of 60 cm with 88% confidence. In testing when the room conditions are bright and the condition of the face object is sleepy, the average confidence is 89.6% with the highest value at a distance of 100 cm with 92% confidence and the lowest confidence at a distance of 70 cm with 86% confidence. In the test, there were 10 tests with 5 tests per detection between awake and sleepy when the room conditions were dim with the lux value of the light produced was an average of 27.4 lux. In testing and data collection when the face object is awake, the average confidence is 89.6% with the highest value at a distance of 80 cm with 91% confidence and the lowest confidence at a distance of 60 cm, 70cm, and 90 cm with 89% confidence. While in testing when the room conditions are dim and the condition of the face object is sleepy, the average confidence is 85.4% with the highest value at a distance of 100 cm with 90% confidence and the lowest confidence at a distance of 70 cm with 80% confidence. In tests conducted 15 times with 3 different people and noise treatment such as wearing accessories on the face and covering part of the face, the results of 15 tests 11 were correct in the detection test and 4 of them were wrong in detection. The 4 test samples that were wrong in drowsiness detection were all caused by covering the eyes either with hands or with sunglasses. But if only 1 eye is closed, the detection system can still detect correctly. While the other test data is correct because the variables used, namely the face, eyes, and mouth, are clearly visible in the video capture.

TABLE I. OVERALL TEST RESULTS FOR DROWSINESS DETECTION

Test to-	Lux	Detection Results
1	210	
2	24	
3	209	
4	22	
5	213	
6	26	
7	211	
8	27	
9	209	
10	24	

The overall testing of the device aims to evaluate the performance, reliability, and efficiency of the system as a whole. This process includes analyzing the function of each component, the integration between components, and the device's response under various operational conditions. The results of the drowsiness detection test in Table I show that out of a total of 10 tests conducted, 8 tests achieved correct confidence accuracy, while 2 were incorrect in detecting drowsiness. The 2 incorrect tests can be attributed to the detection object wearing sunglasses, which caused the eye variable used for detection to disappear, leading to inaccurate confidence levels. In certain conditions, such as in test number 9, it can also be considered that the detection object, particularly the eye, could still be detected despite wearing sunglasses, but the confidence level was very low, with a value of 42%. This could also be due to the low light intensity at the time, which was only 30 lux. Meanwhile, for other analyses, when the light intensity was high with a lux value above 200, the detection results achieved a high confidence accuracy, with an average value of 88%. However, when the light intensity was low, below 40 lux, the detection results achieved lower confidence accuracy, with an average value of 66.8%. In this case, it can be said that light intensity can influence the confidence accuracy level obtained.

TABLE II. TEST RESULTS FOR FLASH BUZZER, WATER PUMP, LCD, AND MICROSD CARD DATA LOGGING

Test to-	**Condition**		**Buzzer and Water Pump**	**LCD**	**Data Logging Micro SD Card**
	Detection	***Push Button***			
1	Detected Awake	Release	Flash Buzzer OFF Water Pump OFF	“Status: You Are Awake”	-
2		Release	Flash Buzzer OFF Water Pump OFF	“Status: You Are Awake”	-
3		Press >15 second	Flash Buzzer ON Water Pump OFF	“Alert Warning”	Warning Pressing in 2024-08-04 15:06:19
4		Press >15 second	Flash Buzzer ON Water Pump OFF	“Alert Warning”	Warning Pressing in 2024-08-04 15:07:11
5	Drowsiness Detected >2 second	Release	Flash Buzzer ON Water Pump OFF	“Status: You Are Drowsy”	You are Drowsy in 2024-08-04 15:09:24
6		Release	Flash Buzzer ON Water Pump OFF	“Status: You Are Drowsy”	You are Drowsy in 2024-08-04 15:10:05
7		Press	Flash Buzzer OFF Water Pump OFF	“Status: You Are Awake”	-
8		Press	Flash Buzzer OFF Water Pump OFF	“Status: You Are Awake”	-
9	Drowsiness Detected >5 second	Release	Flash Buzzer ON Water Pump ON	“Status You Are Asleep”	You are asleep in 2024-08-04 15:11:04
10		Release	Flash Buzzer ON Water Pump ON	“Status: You Are Asleep”	You are asleep in 2024-08-04 15:11:54
11		Press	Flash Buzzer OFF Water Pump OFF	“Status: You Are Awake”	-
12		Press	Flash Buzzer OFF Water Pump OFF	“Status: You Are Awake”	-

Based on Table II, out of a total of 12 tests, three main conditions were detected: "Awake," "Drowsy," and "Asleep." The "Awake" condition was detected in tests 1, 2, 3, 4, 7, 8, 11, and 12. In this condition, the system displayed the message "Status: You Are Awake" on the LCD, and there was no activity on the flash buzzer or water pump except in tests 3 and 4, where the buzzer turned ON as a warning because the push button was pressed for more than 15 seconds. The "Drowsy" condition was detected in tests 5 and 6, with the system displaying the message "Status: You Are Drowsy" on the LCD. In tests 5 and 6, there was no further action from the water pump. However, in tests 7 and 8, the push button was pressed, causing a reset of the current state, which made the system detect the "Awake" condition again. In tests 9 and 10, the "Asleep" condition was detected, the flash buzzer and water pump were activated because the system did not receive a response from the push button for more than 5 seconds, with the system displaying the message "Status: You Are Asleep" on the LCD. This indicates that the system responds more strongly when drowsiness detection continues for more than 5 seconds. Tests 3, 4, 5, 6, 9 and 10 also recorded data logging, showing the exact time of detection and system response. For example, in test 3, the warning to press the button was logged at 2024-08-04 15:06:19, and in test 10, sleep detection was logged at 2024-08-04 15:11:04. This demonstrates the system's ability not only to detect the user's condition but also to record the time of events for further analysis. Overall, the test table shows that the system can effectively detect various levels of drowsiness and provide appropriate responses through outputs controlled by the flash buzzer, water pump, and LCD, while also logging events for further analysis.

IV. CONCLUSION

The drowsiness detection system using the YOLO method successfully detected signs of drowsiness in car drivers with an overall accuracy rate of 80%. The system was able to distinguish between the conditions of "Awake," "Drowsy," and "Asleep," and provided appropriate responses through outputs such as a flash buzzer, water pump, and LCD. The emergency alarm system was successfully designed using a Mini PC, with proper selection of hardware and software. A user-friendly interface was also developed, ensuring that users could easily operate the system. The system is also equipped with a logging feature that records detection times and responses for further analysis. Testing showed that the system's accuracy in detecting driver drowsiness varied depending on light intensity. In high light conditions, accuracy reached 88%, while in low light conditions, accuracy dropped to 66.8%. Factors such as wearing sunglasses also affected accuracy. This system has proven effective in detecting various levels of drowsiness and triggering emergency alarms as needed.

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