Zebra Line Detection and Speed Controller System Using Raspberry Pi Pico & ESP32

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***Abstract*-Now this scientific world getting better in technologies and have similar flaws in those technologies. Here we take a look at our transportation or driving. Because the technology of transportation starts to evolve from the stone age itself. The current world technology evolved in transportation more than before. Like, from diesel to petrol engines also electric vehicles with automatic driving options and the speed of the vehicles are getting increased from manufacturer to manufacturer. Also, from those technologies to ensure the safety of the driver or public some traffic rules, and traffic signals were made. For, Example traffic signals with zebra crossing, and speed limit areas.**

Many are not at all consider those traffic signs and rules because of a hurry. From that Overspeed or lack of concentration, accidents happen regularly. So, our motto is to ensure safe driving and people's safety in transportation. The objective of this project is to control accidents nearby zebra crossings and ensure the safety of the driver and the safety of the people who are crossing roads.

Here, in our project, we are using Raspberry Pi-Pico as a microcontroller with image processing technique with IoT implementation like using the ESP32 wi-fi module (which uses GSM) with a camera (taking image frequently 1s delay). The processor always compares the image with the trained image using the image processing technique. If the system detects the zebra crossing the function of the motor gets stopped till crossing the zebra line.

Tools Used-

Hardware requirement:

- ***Raspberry Pi- Pico***
- ***Esp32 Wi-fi Module***
- ***Power supply unit***
- ***Motor Unit***
- ***Camera***
- ***Relay unit***

Software Requirement:

- ***Python & Embedded C++ Language***
- ***PC***
- ***Web page***

I. INTRODUCTION

Now, in this present generation the things in transportation properties like heavy traffic, riding fast, and neglecting traffic signals are more common actions happening in the current day to day life. So, the safety concern and awareness about accidents and their impacts on everyone's life are important things to be remembered. The growing and rushing population is also a concern here. Because of the vast population, the usage of vehicles is increasing day by day. So, the possibility of occurring accident's is also increasing. It's all happened only because of the lack of concentration and indifferent behavior in following traffic signals. Also, most accidents happen only because of Overspeed.

Nowadays, the roads were very smooth to drive.so, many are riding fast. To control them the speed breakers are constructed near school areas, turnings, and some crowdy areas. Speed breakers also sometimes makes accidents. It's happened to the lack of concentration and awareness of the driver. The same kind of human error can happen in zebra crossing too. To avoid this kind of mistaken accident, we can implement our project by using the current evolving technology IoT. It's a thing that can connect a hardware system or access or operate a hardware system by using software programming by INTERNET. To detect the zebra crossing and speed breakers we can use the image processing technique. So, by using our technology we can detect speed breakers too. It's all about the embedded system. It's an operating system with the help of software programming.

The camera with the ESP32 Wi-Fi module takes a picture with a one-second delay. The image quality is a concern here. It's not at all a concern or problem here. Because, if we want to implement this technology in the future, we can use a better pixel resolution camera with the system. So, it will increase the accuracy and distance of detecting zones. Based on the image comparison by using the image processing technique from Raspberry Pi Pico the relay unit works based on the comparison results. The function of the motor gets stopped, based on the comparison results. It all happens by the connected units of the ESP32 Wi-Fi module and Raspberry Pi Pico. The implementation of checking zones is a continuous process, that works till the function gets shut down completely. The Raspberry Pi Pico and ESP32 wi-fi required a 5-volt supply to start its function. It's a Wi-Fi-based technology we can save the captured images too by using cloud storage or external memory cards.

II. RELATED WORKS

A recent survey states that the most numbers of accidents happen because of the high speed, lack of concentration and failure to follow traffic signals, and also the unaware obstacles on road. To avoid this kind of consequence the automotive manufacturers, traffic department authorities, and automotive research and development groups work continuously. Though still the accident rate is not getting reduced, it's getting increased day by day. It's all happened only because of a lack of awareness while driving, and indifferent behavior in following traffic rules.

So, to reduce this automation technology is required. It should be run automatically and have to detect zones automatically and it should provide a clear intimation of obstacles (speed breakers) or pedestrians (zebra crossing). In our country, the population density is getting high. Also, it leads us as a large consumer of fuel. It's happened because every individual Indian owns their vehicle.

In India, the number of vehicles is almost 70% of the country's population ratio. Also, the roads in India are smooth to drive. It leads to fast driving and accidents. The major impactful accidents are happening in school and college areas, hospital areas, and crowdy areas. To control the accidents here we have to ensure a safe road crossing environment. To make it impactful we can implement a zebra line detection system using Raspberry Pi Pico and ESP-32 Wi-Fi module system in vehicles. This technological development has some related studies in it. The system using a Raspberry Pi microcontroller [1] is the best way to implement the system with IoT operation. Processing data using image processing in Raspberry is an effective and fast process of data. The Raspberry Pi Pico is a new technology we are using in this project. To detect a lane or zebra zone we are using image processing. It is the latest trending technology implementation used in detection. The image-to-image translation technique [2] is an initial process of image processing. The training of the zone detection in image processing using the black and white ratio in the image. The Zigbee technology implementation is an IOT-based or INTERNET-based technology [3] that helps to connect the system with the INTERNET. From this technology, we find that the INTERNET implementation has the GSM module. Breaches detection technique [4] using Haar cascade classifier is using image processing technique with to detect the lane of crossing vehicle from black and white percentage in the image. Hough transform for recognition of zebra crossing in natural scene images [5] can compare the images with the programmed image. The comparison results process of image processing is an easy technique implementation can be done the process effective and efficient.

The image comparison of accuracy fully depends on the quality or pixel resolution of the image. IoT-based smart garbage system [6] using Zigbee technology helps to connect the thing with INTERNET and make a hardware system to implement works based on the software programming. An IoT-based system using ESP-32 [7] is the latest technology that has the features of Zigbee technology with an additional attached camera system that will extend the wider features of the technology. The ESP-32 CAM will help to connect the system with a Wi-Fi module that has the local Wi-Fi hotspot technology to connect the system with the INTERNET. And another system that uses a relay as a switch by using a photo MOS relay [8] to implement the switching operation in system protection. It will protect the system by this switching operation from the relay switch operation. Investigation of digital protection relay for three-phase induction motor technology [9] using relay switch to protect the induction motor by switching operation. The relay system can control the function by changing the mode of operation relay like NORMALLY OPEN and NORMALLY CLOSED states. The knob gets changed when the switching operation is performed in the relay system. DC motors have the function of forwarding direction only because of the implementation of a single relay system. If we want to implement in both forward and reverse directions, we should include a double relay system function in our system. The Zigbee technology is having some threats like DDOS attack [10] (Distributed Denial of Service Attack). So, we have to choose an alternate new technology ESP-32. It was having a Zigbee implementation feature too. From the ESP-32 Wi-Fi module, we can implement Zigbee technology. So, this was an additional feature in ESP-32.

From the following information, we got some ideas about the latest technology and got that how to make our project work more effective and efficient. From the implementation of the image processing technique, we can maintain a high rate of success in our project. Also trending technology makes the system more unique and faster in performance. The ESP-32 is an energy-efficient system too. So, BY all the system components we can implement this project.

III. SYSTEM DESCRIPTION

In the following section, the hardware and system function with necessary components design is fixed. From those designs, the system diagram or block diagram of our project using Raspberry Pi Pico and ESP-32 CAM is shown in Figure 1.

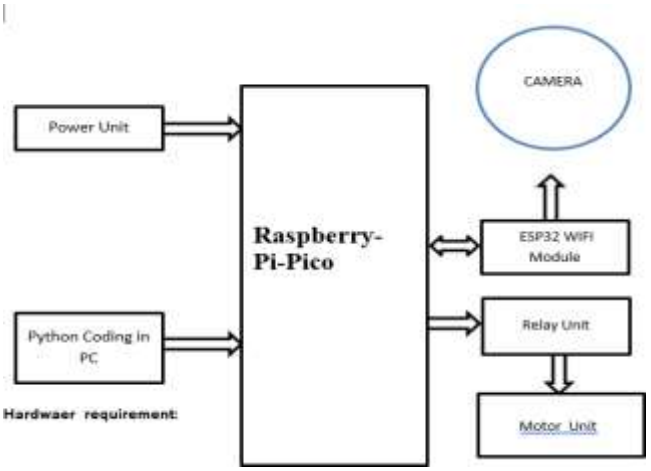

Fig. 1 Block Diagram

The Raspberry Pi Pico is a necessary component here, it is the brain of the system. The controller runs using python programming language to implement image processing techniques. The Raspberry Pi Pico is cheaper than Raspberry and has similar functionality to Raspberry. The image comparison and full control of the function system is depending on the controller only. The ESP-32 CAM Wi-Fi module connects the system through the INTERNET by implementing IoT technology. The cam takes images with a one-second delay and the process of comparison happens in the controller (Raspberry Pi Pico). The image comparison operation happens here through the process of image processing. The blur images may reduce the accuracy of detection. To avoid these consequences, we can implement this by using a better pixel resolution camera with it. The ESP-32 sharing images to a PC or laptop through Wi-Fi. If we want to store the captured images, we can do it by using an external memory chip or hard disk. The Raspberry Pi Pico compares the images from ESP-32 CAM and passes the control to the relay unit. It helps to control the

function of the motor unit. The power unit helps to run a system with the required power supply.

The function of the system operation has a flow of operations. Here, the initiative is running state only. Then system gets connected to Wi-Fi to capture the image. The ESP-32 CAM takes images and the Raspberry Pi Pico processes the captured image. If the image is matched to the trained or coded image then the control will move to the relay unit. The relay works as a switch here. By using this we can control our DC motor. It can run or stop the function based on the comparison result. If results not getting matched or different then the system is in on condition only. The function of the motor is running only. Here, the flow of the operation is kept on running like an infinite loop till the system is full and gets shut down. So, the function of the Zebra Line Detection Using Raspberry Pi Pico and ESP-32 functional flow chart is shown in Figure 2.

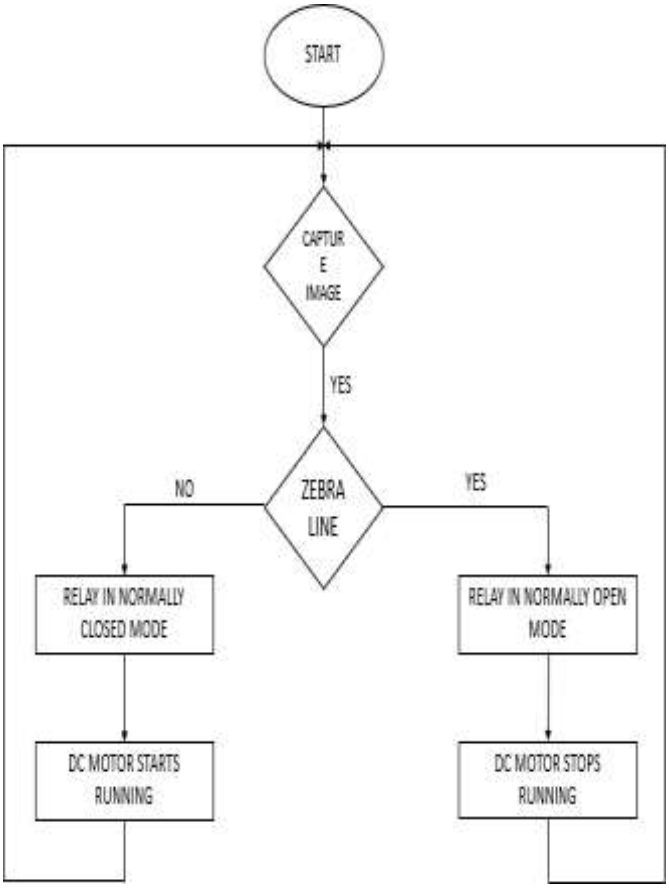

Fig. 2 Flow Chart

IV. SYSTEM HARDWARE AND SOFTWARE

A. The Raspberry Pi

The Raspberry Pi (Fig 3) is an SBC (small-board computer) which is having a wider operating system from windows to embedded RTLs. It was launched on 29 FEB 2012. This is a programmable chip which is works as a mini-CPU to perform projects, Robotics implementation like that. It has multiple input and output port supports to store data like Micro SDHC slot and USB. It also has various RAM capabilities and Graphics range. It all has different costs and quality depending on the features. The system required 5-volt power to run. We can use the USB charging option from the laptop and charger that can generate a 5-volt supply to run Raspberry Pi.

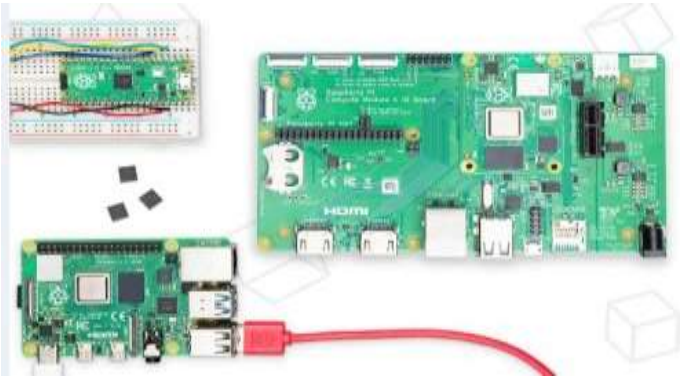

Fig 3 Raspberry Pi

B. The Raspberry Pi Pico

The Raspberry Pi Pico (Fig 4) is a new microcontroller device that is flexible to work, tiny in size, faster than Raspberry Pi, versatile board, and very economical. It was launched by RASPBERRY PI in 2020 and built using RP2040. This is a programmable chip. We can code this by using C and Micro Python. It also has a unique input port like a micro-USB port. It is constructed by a cortex-M0+ processor with 264KB internal RAM with a 16MB flash chip.

Fig 4 Raspberry Pi Pico

C. ESP-32 CAM

The ESP32-CAM (Fig 5) is a low-cost, low-power system of the chip of full-featured microcontrollers with an integrated camera, microSD card socket, Wi-Fi module, and Bluetooth feature. The ESP32-CAM is a wider using system in IoT-based technologies. It has Bluetooth standard 4.2 BR/EDR and BLE. It has Wi-Fi standard of 802.11 b/g/n/e/i. It has a frequency adjustment range of 80 MHZ to 240 MHZ. It has support interfaces UART, SPI, I2C, and PWM. It supports 4G technology and outputs images in JPEG. It has a various resolution of camera features in it. It has a minimum of 2 MP to 5 MP. It will function with an input power of 5-volt. Also has an on and off intimation LED and has nine input and output ports in it. Also, it is smaller in size and a portable device. We can use this technology in various IoT applications and projects.It is a versatile technology with Arduino and well support in Raspberry Pi too.

Fig 5 ESP-32 CAM

D. Relay

A relay is an electrically operating switch (Fig 6) that can open and close an electrical circuit. Which is used to control high voltage circuits by using low voltage circuits. It has two modes. One is Normally open and the second one is Normally closed mode. The initial position is Normally open which means no contact. When the system gets supply from the controller the mode changed to Normally closed which means with contact. The relay has a common terminal too. That makes the switching operation by the normal switch.

Fig 6 Relay

E. DC Motor

The DC Motor (Fig 7) is an electric device that converts electrical energy into mechanical energy. Which required a 12-volt supply to run the Motor. Also, it is having slow speed with help of a speed control mechanism which reduces the speed of the Motor. It is using DC (Direct Current) power supply. The motor has a control switch, which is a relay. The function of the motor can be both the direction. It depends on the positive and negative terminal of the Motor. We can make it by using a double relay in a system. The DC Motor is having processor control and Wi-Fi control also.

Fig 7 DC Motor

V. RESULTS

The objective of the project is to develop a system that can detect the zebra line using Raspberry Pi Pico with an ESP-32 Cam Wi-Fi module. Which can operate the relay based on the comparison result's image by Raspberry Pi Pico and ESP-32. The function of the DC motor getting stopped or running is completely depending on the comparison results. So, the relay works as a one-way switch here. The function of a motor is only in the forwarding direction not in the reverse direction. Because the system will detect the zone before some distance of meters. So, there is no need for a second relay. If we want it in the reverse direction then we can use a second relay with the design circuit. The detection of the zebra line is an accurate one here by using the image processing technique. Here, the PCB design circuit is a combined circuit of Raspberry Pi Pico and ESP-32 Wi-Fi module. So, the space of the system gets reduced. Also, which can avoid the complexity of wiring here. The function of the vehicle gets started completely only if the system is connected to the INTERNET.

Once the ESP-32 gets connected with the PC based on the specified Wi-Fi hotspot, the ESP-32 Cam takes pictures continuously and the Raspberry Pi Pico runs the python code. Which performs an image comparison operation. Once the image is matched with the trained image, the function of the motor gets stopped till the vehicle crossed the Zebra zone. After that, if the image is mismatched with the trained image, then the function of the motor gets started by the relay function. The system will ensure the desirable results from our implementation. The final hardware result of our project system figure is shown in below Fig 8.

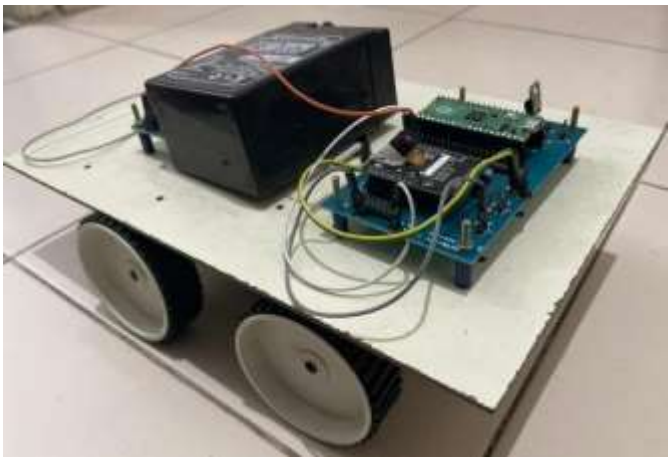

Fig 8

VI. CONCLUSION

The necessity or goal of our project is to avoid accidents in zebra lines and speed breakers and ensure the safety of the driver and the people who are crossing pedestrians. The camera is a necessary one here because the accuracy will increase only if the resolution of the camera is high. Also, the image processing technique is a key process here. The technology of software code with hardware components takes the process instant and effective. Also, the accident ratio will be reduced if it gets implemented in present vehicles.

The identification of the zone accuracy is all about the camera pixel resolution. The code used here is an effective programming language python. Which helps to run the process effectively and more reliable to code. From, these kinds of IoT implementation with accident reduction systems will be more effective in future enhancement of technology. The system works as a third eye for humans and creates a safe driving experience for the driver. From this technological implementation, the future of the world will be free from accidents near pedestrians. Also, it is an efficient technology to implement in our transport.

VII. ADVANTAGES AND APPLICATIONS

The system is a budget-friendly system. The Raspberry Pi Pico is a portable device and has similar functions to Raspberry

Pi. But the Raspberry Pi Pico price is comparatively lesser than Raspberry Pi. The accuracy of the pedestrian zone detection is high, because of the image processing technique. So, by using this system in real-time transportation we can reduce the occurrence of accidents ratio in pedestrians. Also, we can be riding safe near schools, colleges, hospitals, and some crowdy areas. The system is working as a full automation device. So, the working and occurrence of errors are minimal. By using this system in future vehicles, we can raise the market of vehicle selling. The accident reduction system will be upgradable based on future technology.

From this project technology, the accidents due to over-speed or lack of concentration will be surely reduced and will get better results in safe driving. Future technology like auto driving options and GPS systems are important and with that we can include our project to reduce the risk of driving. It is a great feature to control accidents and make peace-driving solutions. The rules of the traffic laws are gets keep by this automation system. So, the rules violation also gets reduced if we implement this technology. The goal of our project will achieve its full potential when it's getting to implement in our vehicles. The system will be an initial step for a smart vehicle system. We ensure here the safety of driving here.

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