JJMIE

Volume 17, Number 4, December. 2023
ISSN 1995-6665
Pages 509– 519
https://doi.org/10.59038/jjmie/170406
Editor-in-Chief: Prof. Ali M. Jawarneh

Jordan Journal of Mechanical and Industrial Engineering

Innovative Approaches for Automated Seat Belt Compliance Detection

Luan Mulaku[a], Fatmir Azemi[b]

[a]Faculty of Mechatronic Engineering, University for Business and Technology Pristina,10000, Kosovo
[b]Faculty of mechanical and computer engineering, Universityof Mitrovica “Isa Boletini”, 40000, Kosovo

Received 27 May 2023 Accepted 21 Oct 2023

Abstract

This research delves into the significance of seat belt utilization, particularly within public transportation, for both drivers and passengers. The article examines the issue of non-compliance with seat belt regulations, including the use of counterfeit manufacturer items to disable seat belt warnings and improper seat belt positioning. With a focus on advanced technology, the article proposes various technical approaches to enhance the automatic detection of seat belt usage. These suggested methods entail the integration of a camera and buzzer with a microcontroller of seat belt compliance detection and the development of a supervised machine learning model that achieved a 99% accuracy rate in identifying seat belt usage through image analysis. Furthermore, the research introduces an innovative approach to verifying individuals' specific health conditions that health authorities have granted limited exemptions from wearing seat belts. The ultimate objective of this study is to promote seat belt usage, thereby safeguarding both drivers and passengers. It is intended that the findings of this research be considered by the vehicle manufacturing industry.

Keywords: Seat belt, Pregnant, Image processing, Passenger, Microcontroller.

1. Introduction

In the fluctuations of fatal accident rates, the human factor typically has the greatest impact, where they also present the findings from this paper. Even though seat belt use for drivers and passengers is nearly universally required by law, statistics on accidents show that many people who suffer fatal or serious injuries are either not wearing their seat belts or are not wearing them properly, a 12.92% increase [1].

Previous research has delved into various methods and products intended to deceive alarm systems, and conventional seat belt use has also been observed. This section provides an overview of existing literature and products associated with seat belt alert and evasion, highlighting the need for effective countermeasures to ensure road safety.

The Section of the methodology employed in this study elucidates the components of seat belt detection and results, and it also provides valuable insights into the effectiveness of the system and the challenges posed by individuals who attempt to bypass seat alerts.

This article aims to enhance automatic detection while ensuring the integrity and security of the system, emphasizing the improvement of automatic detection while maintaining the system's reliability and preventing any attempts to deceive it. While objectives are to improve the accuracy of automated detection algorithms by implementing machine learning techniques and enhance system robustness against evasion attempts by implementing countermeasures.

The Raspberry Pi Pico is a microcontroller board that provides the processing power for the project. It is programmed to control the camera, run the machine learning model, and activate the piezo buzzer when necessary. The OV7670 is a low-cost CMOS camera that can capture images with a resolution of up to 640 x 480 pixels. The OV7670 camera is connected to the Raspberry Pi Pico using several wires. These wires provide power to the camera and enable communication between the camera and the microcontroller.

A piezo buzzer is a type of electronic sounder that produces a high-pitched tone when activated. It is used in the seatbelt detection system to sound an alarm when the machine learning model detects that the seatbelt is not fastened. The piezo buzzer is connected to the Raspberry Pi Pico using two wires. One wire connects to a GPIO pin on the microcontroller, while the other wire is connected to a ground pin.

Scikit-learn is a Python library for machine learning, it is used to train and run a machine-learning model that can detect whether the seatbelt is fastened or not. The machine learning model and resulting model are loaded in the Raspberry Pi Pico. The Raspberry Pi Pico runs the model and makes predictions based on the input from theOV7670 camera.

Starting by bonding a Raspberry Pi Pico to a machine before connecting it to a camera module and piezo buzzer. Connecting the Pico’s 3.3V and GND pins to the positive and negative rails to the breadboards. After SDA and SCL pins of the OV7670 camera module to the Pico’s GPIO pins using male-female jumper wires. The camera module VCC pin should be connected to the 3.3V rail and its GND pin to the

* Corresponding author e-mail: luan.mulaku@ubt-uni.net.

negative rail. Positive wire of the piezo buzzer to GPIO pin on the Pico, and negative to rail negative of the breadboard. Furthermore, certain specific 4.7k features between the GPIO pin utilized for camera data connection SDA and the bread value's 3.3V rail as in Fig. 1.

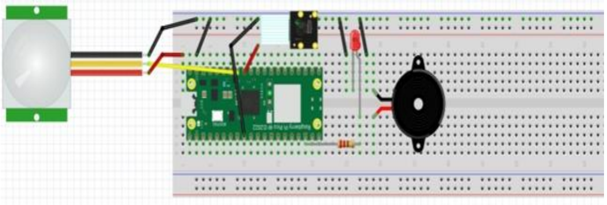

Figure 1. Circuit diagram

The Raspberry Pi Pico is physically connected to the OV7670 camera module and Piezo buzzer via breadboard from configuration Fig.1. Creating the foundation for the development programming and data gathering project. Must be verified that all connections are safe and the data of each component is precise to avoid troubles during execution as Fig.2.

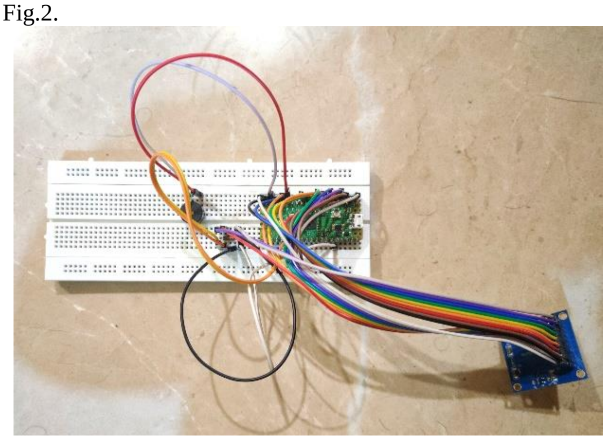

Figure 2. Complete device that is built to detect seat belt

1.1. Products intended for circumventing or deceiving a system

These goods are widely available, and even though some are marked "Do not use," those with symbolic costs were also curiously examined as part of this investigation. The device is unsafe and incapable of withstanding any force that could be produced accidentally. Yet, they are common and disable the seat belt alert in the majority of the tested autos.

Figure 3. Products that are also used as a continuation of seat belts, main purpose is to cancel the alarm

The item distinguishes itself from the previous one its simplicity and affordability, albeit lacking to options to attach it to a seat belt. While its mechanism is capable of withstanding greater force, its serves a singular function, canceling the beeper noise. Consequently, it's limited functionality renders it essentially useless for other purposes.

Figure 4. A product which used to cancel alarm of seat belt

Connecting the seat belt in the manner indicated in "Fig. 4" below, which is understood to be behind the back while driving, is one method that no other product is used to turn off the alarm; this was not the subject of this work to acquire data, but it is a method that is widely used. A similar justification is offered when a seat belt is worn entirely behind the seat because it may make the driver or passenger uncomfortable by irritating their backs.

This approach is less common since, if they run into legal police, they have no choice but to rapidly put on the appropriate clothing, but the first scenario leaves that possibility open because it simply pulls it from back to front.

Figure 5. Method to cancel alarm of seat belt by placing behind back

As was highlighted, the use of these items works and mutes beeper noise, but doing so in this way does not change the law and falls short of providing the proper and required level of security in case of an accident. The low price of these products raises regarding its lack of testing and quality assurance. In a critical context, this lack of testing poses a potential risk, as it may compromise safety measures intended to protect against potentially life-threatening situation.

Figure 6. Implementation of a product for canceling seat belt alarms and the possibility of plugginggio it.

2. RELATED WORKS

Most literary studies have attempted to gather information and present statistics on physical and death injuries when a seat belt is not worn.

As is the situation [2] with studies on the prevalence of seatbelt use in relation to incidents involving public transit. These findings have been used in the work that will be presented to highlight the need for technical permissions in the form of stronger enforcement of seat belt use, particularly in public transit where accountability is higher.

The completion of this activity also benefits greatly from scientific studies, such as[3] campaigns to raise awareness of the importance of seat belt use and suggestions for seat belt adjustment. Users will receive a signal warning if they have not worn their seat belts in compliance with the rules, in contrast to the work that will be displayed.

Even during pregnancy, observed how the seat belt should be worn [4] in the early stages when the suggestion is to use a safety belt with three fixed points during the literature research. Three fixed points, including design and use, have been concluded; automatic implementation does not present a new issue in this work because plugs are manufactured at a single seat belt position.

Later in pregnancy, there are additional issues and injuries that could harm both the mother and the fetus. Table I illustrates the reasons behind the non-utilization of seatbelts among a group of women (n=175). A notable percentage, 89.1%, attributed their reluctance to seatbelt use to discomfort, while 45.1% expressed concerns about potential harm to a fetus. Approximately 12.6% indicated the unavailability of seatbelts on certain modes of public transportation as a factor. A smaller proportion, 5.1%, cited forgetfulness, laziness, or the absence of a habit of using seatbelts as the cause, while 4.6% found seatbelts on public transport to be inconvenient or unsuitable due to their short length and cleanliness concerns. Additionally, 5.1% mentioned that they primarily undertake short-distance travel by minibus. These insights underscore the diverse range of factors influencing seatbelt usage behavior among women and suggest the need for targeted interventions addressing these specific concerns to promote safety on the road.

Table 1. Reasons for not using seat belts [5]

Reason	**N$_o$ (%) of women (n=175)**	
Wearing seatbelts is not useful	22	12.6
Wearing seatbelts causes discomfort	156	89.1
Wearing seatbelts may harm the fetus	79	45.1
Not available on bus/minibus/MTR	22	12.6
Forgot, lazy, no habit to use seatbelts	9	5.1
Inconvenient; seatbelts on public transport are short and dirty/not user-friendly	8	4.6
Travel only short distances by minibus	9	5.1

If data from this research are analyzed, it may be necessary to redesign these circumstances, however, during this work, the design will not be altered, and the alternative will be left up to responsible medical centers with authorized access or authorized services to cancel based on a medical certificate warning for either the driver or passenger not wearing a seat belt.

Putting models into practice for damage reduction using actuators and sensors, where it's also required to design their codes so they can be activated in accident circumstances[6].If we look at evolution from one perspective, we can see that almost every generation has seen technological advancements in design, modeling, and application that have resulted in automation. All of this evolution has had the same primary objective, which is to reduce injuries sustained in accidents, which is understandable given that it is still a practice that should be permitted[7]. Although the use of technology raises concerns, if all potential outcomes are anticipated for an issue, then its solution is facilitated. In the case of seat belt use, this may also be taken advantage of through image processing by using various algorithms and filters, based on the information from HSV color, the monitoring of the entire scene through images, the positioning of the driver, and the identification of seat belt can be realized[8]. Monitoring is via additional components as sensors and A/D circuits[9] [10].

The qualities of these works can also facilitate the use of new techniques, as is the case with[11]. In this study, machine learning techniques are associated to three different forms of task-oriented educational data in various application scenarios.

The relative positions of these vehicle components are used in conjunction with the detection scores in a post-processing step to train a classification model using a support vector machine (SVM). Lastly, they use this classification model to execute a fine mapping and identification operation on the seat belt region. When used on a database of pictures gathered by traffic surveillance cameras, this technique worked successfully[12].

The YOLO neural network-based model is used for determining whether the driver's seat belt is fastened. The problem was solved in two steps using corner detection and main belt detection. These actions enable the system to detect the circumstance in which the seat belt is secured behind a person. The main portion of the belt was identified as the first item, and the belt corner was identified as the second object, using tiny YOLO. According to the model, it divides belt fastness into these three categories; the belt is not fastened, it is fastened correctly, and it is fastened behind the back, [13] or Neural Network as a prediction method [14] [15] (Bahaa Kazem, , Jasim Khawwaf , 2016).

The existing seatbelt reminder system, however, has a number of drawbacks, including the ability to be easily tricked by a "Seatbelt Warning Stopper" and the failure to recognize improper usage such as sitting in front of a tight seatbelt or wearing a seatbelt under the arm. Infrared (IR) cameras' lack of color information, wide Field of View (FoV) fisheye lenses' high distortion, the low contrast between the belt and its surroundings, hand or hair occlusions, and imprecise photography are just a few of the difficulties in recognizing seatbelt usage in general. To address the aforementioned issues, we present a revolutionary generic seatbelt detection and user identification approach in this research. A local predictor, a global assembler, and a shape modeling procedure make up the three parts of our method[17] or via image segmentation [18].

Tests reveal that, under the new legislation, it is not enough to manipulate Global Navigation Satellite System-GNSS information alone rather, an attacker must concurrently falsify data from the vehicle sensor and the GNSS receiver. The analysis performed, which only took a light-urban situation into consideration, is greatly expanded in this paper. The outcomes shown here complement those that were described in [19].Based on the information from HSV color, the monitoring of the entire scene through images, the positioning of the driver, and the identification of insurance can be realized.

Despite the fact that did not interact with the designs and their permission throughout this article, its frequent use is still challenging, as in the case of the research [20], independent of the current designs.

Arguably the most common source of injury is public transportation, which includes taxis, buses, and mini busses. Road damage is one of the most significant and well-known public health hazards. Each year, it causes 50 million injuries and 1.2 million fatalities, and the usage of a seatbelt significantly lowers cases by 60%. However, it is unclear how widely used seat belts are in Ethiopia or the contributing variables[2]. Very frequently, drivers reach the judgment that its use may not be sufficiently safe (when they link to very tenuous hypotheses that its use may be responsible for deadly accidents) and that it is lost until it is set, as in [21] the instance when 18% of them declared such reasons. Similar reasoning has been utilized by researchers[22], whose research on public transportation is based on surveys in which 77% of respondents said they use it regularly. They have determined that since one in five drivers do not wear it, law enforcement should exercise stricter supervision.

In order to reduce fatal accidents, the World Health Report on Road Safety urged for the use of seat belts in 2004; however, this does not rule out the possibility that its use could also result in injuries[23]. The reasoning for comparing the injuries inflicted by the crashes that have been given in the conclusion[24].

According to research conducted by a 35-year-old from[25], the issue known as "seat belt syndrome" has also recently become well-known. So far, wearing a seat belt correctly continues to have more negative effects than the syndrome itself. The results of a scientific study from the [26]on how much people trust and respect the laws affecting how seat belts should be fastened in the US, as well as a comparison of whether the same rule applies to both seats before and after the seat belt, suggest that efforts should be made to increase seat belt use among high-risk populations.

When the literature was examined, it became clear that these phenomena had been studied both from a design standpoint and for particular age groups and cases, such as the case of the most pregnant woman. Numerous statistics have been gathered in various locations for their use, as well as reports on the effects of their use and non-use. Although the non-usage of seat belts has not been seen, attention has been drawn to the ways that bogus items perform when it comes to using various approaches and methods to identify the use of seat belts. They behave as if they are not wearing seat belts. The scene of these products implies that the same statistics will be worth, possibly more in the case of use as a continuation by “Fig. 2”, that no measurement has been made or how much it could withstand.

It was noted in the vehicle's manual that some of the pregnant women do not correctly fasten their seatbelts, by using the cross-sectional method, the authors [27] discovered that 13.1% of the 1000 respondents don't always buckle their seatbelts. There is also a ton of study on topics like motorcycle riders who just don't wrap it up, various seat belt designs for pregnant mothers, and attempting to change in the early stages of pregnancy [28][29][30] [31] [32].

3. METHODOLOGY

The seatbelt detection project uses image processing and machine learning to detect whether the seatbelt in a car is fastened. The system consists of a Raspberry Pi Pico microcontroller, an OV7670 camera, a piezo buzzer, and the Scikit-learn machine-learning library. The OV7670 camera captures an image of the car seat, and the Raspberry Pi Pico processes the image using the machine learning model trained in Scikit-learn. If the model detects that the seatbelt is not fastened, it triggers the piezo buzzer to sound an alarm, alerting the driver to fasten their seatbelt. Overall, the components are connected using wires and a breadboard to create a complete circuit from “Fig. 1”

When the system was started, all potential outcomes were presented in a block diagram that was created after a comprehensive analysis of the problem.

As illustrated in “Fig6”, where the system will be triggered when a sensor detects movement, activation of the system will be controlled step by step. As the applicability of this work is believed to be in cars, that already have this technology installed, we have not looked at the movement. The detection will begin the moment there is movement; it will first check to see if the belt is placed; if not, the alarm will be activated; if it is placed, it will check to determine whether it's properly connected; if not, the alarm will be activated. The procedure will be repeated until all of the previous conditions are met, at which point the alarm will be deactivated.

The system will be compared using similar tools to see how it is responding and how much of the research's objective has been accomplished. Following several measurements in various scenarios, a statistical method study will be performed to determine how the system behaves, reacts, and divides accuracy in various contexts, providing them with explanations and even visual representations. In the end, summary data will be used to provide the accuracy average of all scenarios of this system.

The accuracy of 96 sample images for both scenarios, which will be taken every 0.1 seconds to detect and compare, is tested and examined using experimental methods.

As previously noted, "Fig. 7 and 8" is one of the 96 input images required for the datasets, on which programs will run to assess the results.

In this article, the following methods were used,

- Preprocessing images are analyzed and altered in terms of size, color, and other factors.
- Feature extraction - mainly examined in Object Identification
- Feature selection - used statistics and an algorithm in Machine Learning
- Interpretation presents results and accuracy data collected on the table.

In terms of the techniques, the machine learning model was trained using a method of supervised learning approach. A large number of annotated images with the labels "wearing a seat belt" or "not wearing a seat belt" were included in the dataset used to train the model.

Although the technology successfully detects seatbelts in a variety of situations, there are some limitations. Notably, because seatbelt identification relies on color contrast, the system may have problems when the driver is wearing a black shirt. Additionally, it could be difficult to spot drivers who are wearing white shirts with a black diagonal stripe that resembles a seatbelt. The system's reliance on color and visual cues is highlighted by these particular instances, and future improvements may be required to handle such complications.

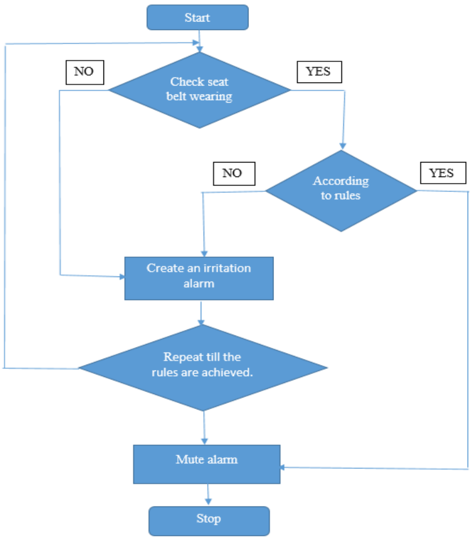

Figure 7. Flowchart to create code

Figure 8. Default as the input image for non-wear seat belt

Figure 9. Default as the input image for wearing a seat belt

4. DATA

The data collection process involves capturing a total of 192 images, with 96 images depicting scenarios with seatbelts and 96 images without seatbelts. The camera module captures an image every 0.1 seconds, and each captured image is stored in the camera image object. This data collection rate is chosen intentionally to allow for preliminary movement analysis before measurement begins, making it well-suited for the intended application."

In this context, a traditional cross-validation technique, such as k-fold cross-validation, has not been employed. Instead, given the availability of 96 images for each scenario, a simplified train-test split is used. The dataset of 192 images is divided into two distinct sets: a training set comprising 80% of the images (77 images from each scenario) and a testing set comprising the remaining 20% (19 images from each scenario). This approach ensures that both scenarios are represented in both the training and testing sets, allowing the model to be evaluated on a diverse set of data points. The 0.1-second image capture interval maintains a consistent and suitable flow of data for model training and testing, considering the need to analyze potential movements before measurement commences.

5. RESULTS AND DISCUSSIONS

This program is designed to operate on a microcontroller that is attached to a camera. The code's goal is to use a machine-learning model to determine whether someone is wearing a seatbelt. A line-by-line breakdown of the code is provided below.

From Table II, The aforementioned Python script imports a number of modules and libraries that are used to operate an OV7670 camera module, process images, and communicate with other hardware parts. The synopsis of each import statement is the time module is imported to make it possible to use time-related features like sleep, to enable the code to pause for a predetermined period of time, and the sleep function from the time module is imported, to make it simple to refer to pins on the microcontroller, the board module is imported, to enable communication with different hardware interfaces, such as I2C or SPI, basic busio module is imported, to enable the use of display-related features and graphics processing, the displayio module is loaded, to enable image processing, such as resizing or rotating images, the bitmaptools module is imported, to allow machine learning features like object identification or categorization, the svm min module is imported.

To enable the use of pulse-related functions, such as pulse width modulation, the pulseio module is imported (PWM), to enable the use of arrays in the code, the array module is imported, to enable control of the OV7670 camera module, a popular camera module used in microcontroller-based applications, the adafruit ov7670 module is imported, OV7670 SIZE DIV8 constant, which is a predefined constant that sets the size of the image taken by the camera module, is imported from the adafruit ov7670 module.

In order to manage the OV7670 camera module and carry out image processing and machine learning operations, different Python modules and libraries must be imported using the import statements in the code above.

Table 2. Pseudo code to import modules

Code: Imported modules from Library

```
import time
from time import sleep
import board
import busio
import displayio
import bitmaptools
import svm_min
import pulseio
import array
from adafruit_ov7670 import (
OV7670,
OV7670_SIZE_DIV8,
)
```

The function "beep" is defined in the code above, and it only accepts one argument, "buzzer". With a piezo buzzer or another comparable hardware element, this function can produce a beeping sound. A quick explanation of each line of code in the function is given below:

1. The "def" keyword before the function name "beep" and the argument "buzzer" in the function declaration.

2. A note describing the function's goal is added.
3. A list called "melody" is defined and it contains the sound's frequency value. In this instance, 1000000 divided by 1280 is used to calculate the frequency value.
4. The "array" module is used to construct an array from the "melody" list. This makes it possible for the list to be processed more quickly.
5. To iterate over the range 10 times, a for loop is needed. The buzzer will beep ten times as a result of this.
6. By setting the "buzzer.value" to True, the buzzer is activated.
7. The "time.sleep()" function is then used to pause the program for 0.1 seconds.
8. By setting the "buzzer.value" to False, the buzzer is switched off.

Generally, a buzzer object may be passed into the "beep" function described above to produce a beep sound. The beep sound is repeated a predetermined number of times using a for loop and an array to generate the frequency value. By adjusting the time value, the amount of time that passes between each beep can be changed; A function called sleep.

Table 3. Pseudo-code for the alarm

Code: Alarm alert

```
def beep(buzzer):
# Function to make a beep sound
melody = [int(1000000/1280)]*100
pulses = array.array("H", melody) # Convert the list to array
for x in range(10):
buzzer.value = True
time.sleep(0.1)
buzzer.value = False
```

The foregoing line of code creates a method called "rgb565 to 1bit" that only accepts the single argument "pixel val". The RGB565 SWAPPED pixel values are converted to grayscale values using this function. A quick explanation of each line of code in the function is given "def" keyword precedes the function name "rgb565 to 1bit," the argument "pixel val," and the function definition, a note describing the function's goal is added, the bytes of the 16-bit pixel value are first rearranged in the input "pixel val" using a values operation. "pixel val" is then updated with the resultant value, the red component of the pixel, which is found in the 5 most significant bits of the value, is then extracted from the 16-bit pixel value using masking. The shift operator ">> 11" and the bitmask "0xF800" are used to accomplish this, similarly, by applying the shift operator ">> 5" and the bitmask "0x7E0," Using the bitmask "0x1F," the blue portion of the pixel is removed.

The function then outputs the pixel's grayscale value, which is determined by adding the red, green, and blue parts together and dividing the result by 128.

Table 4. RGB convert

Code: RGB convert

```
def rgb565_to_1bit(pixel_val):
# Function to convert RGB565_SWAPPED to grayscale
pixel_val = ((pixel_val& 0x00FF) << 8) | ((25889 & 0xFF00) >> 8)
r = (pixel_val& 0xF800) >> 11
g = (pixel_val& 0x7E0) >> 5
b = pixel_val& 0x1F
return (r+g+b)/128
```

Overall, the OV7670 camera module and the AdafruitCircuitPython libraries are used in the code above to build up the image dimensions and object types required for image processing and machine learning. Both the machine learning images used for inference and the camera frames will be stored in the newly formed Bitmap objects. For use later in the code, the pulse output object "buzzer" is also initialized. Table V.

Table 5. Bitmap objects pseudo code

Code: Bitmap Objects

```
buzzer = pulseio.PulseOut(board.GP11)
cam_width = 80
cam_height = 60
cam_size = OV7670_SIZE_DIV8
ml_img_dim = 40 # machine learning image dimension
camera_image = displayio.Bitmap(cam_width, cam_height, 65536)
inference_image = displayio.Bitmap(ml_img_dim, ml_img_dim, 65536)
```

These lines set up the camera object by defining its connection interface (i.e., cam_bus) and various pins to connect the camera to the board, including data pins, clock pin, vsync pin, href pin, mclk pin, shutdown pin, and reset pin. Then it sets the size of the camera to cam_size, which is defined earlier as OV7670_SIZE_DIV8, meaning the camera resolution is 1/8 of its original size. The flip_y attribute is set to True, which indicates that the image will be flipped along the y-axis.

From Table VI.The OV7670 camera module in CircuitPython is used in the code above. The code creates an instance of the OV7670 class and sets its data and control pin configuration accordingly. The setup consists of a bus object used to communicate with the camera module called the cam bus, data pins, or pins used to connect the camera module to the microcontroller and convey picture data. There are eight data pins with the letters I through viii, a clock pin, which is used to time the entry and exit of data from the camera module, and the vertical sync signal is synchronized between the camera module and the microcontroller using the vsync pin, horizontal reference signal synchronization pin (href pin), which connects the camera module and the microcontroller, the mclk pin, which is where the camera module receives the master clock signal, shutdown pin, which controls whether the camera module is powered on or off, the reset pin, which is used to restart the camera module, is pin number eight.

The code sets the camera's size after configuration and flips the image vertically. These options are up to you and may vary depending on the particular application. Overall, the code above initializes, configures, and sets a few possible camera parameters for usage with CircuitPython's OV7670 camera module.

Table 6. Defining connection interface pseudo code

Code: Defining connection interface

```
cam = OV7670(
cam_bus,
data_pins=[
    i.    board.GP0,
    ii.   board.GP1,
    iii.  board.GP2,
    iv.   board.GP3,
    v.    board.GP4,
    vi.   board.GP5,
    vii.  board.GP6,
    viii. board.GP7,
],
clock=board.GP8,
vsync=board.GP13,
href=board.GP12,
mclk=board.GP9,
shutdown=board.GP15,
reset=board.GP14,)
cam.size = cam_size
cam.flip_y = True
```

The code then enters an infinite loop and captures an image from the camera every 0.1 seconds using the cam.capture(camera_image) method from "Table VII". The captured image is stored in the camera_image object. This time is also sufficient because there is tolerance where it is intended to be applied because the movement must first be analyzed before the measurement could begin.

Table 7. Infinity loop capture

Code: Infinity loop

```
while True:
# capture image in variable
cam.capture(camera_image)
sleep(0.1)
```

The captured image is then converted to a smaller size (ml_img_dim), which is defined earlier as 40 pixels. The image is first stored in a temporary bitmap object (temp_bmp), and then the bitmap tools.rotozoom() method is used to rescale and rotate the image, storing the result in the inference_image object. The original temp_bmp object is then deleted because we attempted not to load the system in this paper.

Table 8. Converting to a smaller size pseudo code

Code: Converting to a smaller size

```
temp_bmp = displayio.Bitmap(cam_height,
cam_height, 65536)
foriinrange(0, cam_height):
for j inrange(0, cam_height):
temp_bmp[i, j] = camera_image[i, j]
bitmaptools.rotozoom(inference_image, temp_bmp,
scale=ml_img_dim/cam_height, ox=0, oy=0, px=0,
py=0)
del (temp_bmp)
```

Next, the code iterates through each pixel in the inference_image object converts the RGB565 value to grayscale using the rgb565_to_1bit() function defined earlier and stores the resulting value in a list called input_data.

Table 9. Covert value to grayscale pseudocode

Code:Covert value to grayscale

```
input_data = []
for iin range(0, ml_img_dim):
for j inrange(0, ml_img_dim):
gray_pixel = 1 - rgb565_to_1bit(inference_image[i, j])
input_data.append(gray_pixel)
```

The camera_image object is then marked as dirty to indicate that it needs to be redrawn.

```
camera_image.dirty()
```

The svm_min.score() function is then called, passing inputdata as its argument. This function is part of a machine learning model that has been trained to detect the presence of a seatbelt in an image. The output of this function is stored in a variable called prediction.

```
prediction = svm_min.score(input_data)  # run ML model
```

This line checks if the prediction value (which was generated by running the ML model) is less than -50. If it is, then it assumes that a seatbelt is not being worn and triggers an alarm

```
if round(((prediction / 1) * 100)) < -50:
```

These lines check if the prediction value (which was generated by running the ML model) is less than -50. If it is, then it assumes that a seatbelt is not being worn and triggers an alarm.

There were only small changes made during the testing, and it is clear from the results above that the system always responded as it was intended and programmed to. From "Table XI," in row 3 on the left side, there will be one result that is greater than 100; this occurred because the driver was slightly curled and the belt was most likely not in a diagonal line.

All of the measures for both scenarios can be examined, and it is clear that the accuracy is very high. Furthermore, even if the driver or passenger's position is difficult, just a portion of their body is required to be identified, thus there was no need to examine any critical points where the system would not be able to respond.

Table 10. Prediction value by running ml pseudocode

Code:Prediction value by running ML

```
if round(((prediction / 1) * 100)) < -50:
print("seatbelt detected.")
beep(buzzer)  # make a beep sound
else:
print("no seatbelt")
sleep(3)
```

Table11. The result from testing for both situations

Weared seat belt score	Non-weared seat belt score
99.974	99.877
99.683	97.997
119.683	99.432
98.896	99.867
99.657	98.900
98.236	88.736
99.367	99.997
98.764	99.926
99.231	99.698
99.213	99.991
98.457	97.987
99.994	98.658
98.659	99.658
99.862	99.325
97.968	98.846

The machine learning model's average accuracy can be calculated by averaging the scores reported in each column. The average accuracy for the "Weared seat belt score" is 99.12%, and the average accuracy for the "Non-weared seat belt score" is 98.92%. In terms of methods, the machine learning model was most likely trained using a supervised learning approach. The dataset used to train the model would include a large number of labeled images, each labeled as "wearing a seat belt" or "not wearing a seat belt.".

According to "Fig. 11" and "Fig. 12," as part of Table XI even in this case where the seat belt is not fastened, the system has responded with an average accuracy of over 99%, activating the predicted warning in the process. In almost all of the cases where it has been tested, this model has responded accurately.

This work intends to avoid using fake products from "Fig. 2" and "Fig. 3," where it has not been examined whether sufficient hardware has been connected because we achieve in other ways since it is not necessary, as well as improper use from "Fig. 9" and "Fig. 10", where it has been observed whether or not the seatbelt is worn through the detection of the images.

Where regular usage of a seat belt is mandated by this mode. All of these findings have been examined using a driver's seat as an example, while the same analogy can be made for the passenger and the back seat utilizing cameras put in place such that the view confirms that there is sufficient space. It is acknowledged that each seat needs to be fixed by a camera since there are too many physical obstacles, both static and moving, for a single camera to handle.

The element that was not tested during this study was when the driver or passenger dressed in black, but believed it is sufficient because the seat belt creates a sufficient difference because it has the same width and thickness throughout. Technically, there are cameras with night vision or full color that have produced the same results today even if there was no lighting present during the capturing of the images, so even with this we can avoid fraud, where alternative methods and techniques, like NVD, can be applied as[33].These works can also be used in various analyses such as[34] through deep learning, which has discovered how many drivers have not worn their seat belts based on images, as well as some other analyses such as edge detection, the table of registration, plan the path, fuzzy logic, piezo sensors [35] [36] [37][38]. As a result, they concluded that using these forms can lead to more efficient and automatic monitoring. Because the results are satisfactory, researchers must have enough images for the datasets in order to increase the accuracy, and the use of resizing and some filters increases our belief in the outcomes.

Overall a separate testing dataset of labeled images would be used to test the model after it had been trained in order to assess its performance. The scores shown in Table XI indicate how well the model classified the test dataset.

Based on the descriptive statistics analysis results, are able to identify the following from Table XII:

- The average worn seat belt score is 100.57%, with a median of 99.37% and a mode of #N/A, indicating that the majority of the values are clustered around the mean and no clear peak value. The skewness of 3.77 and the standard deviation of 5.33% indicate that the data is somewhat spread out and skewed to the right.
- The non-worn seat belt score has a mean of 98.59%, a median of 99.43%, and a mode of 98.66, indicating that the majority of the values are clustered around the median with a clear peak value at 98.66. The skewness of and the standard deviation of 2.81% -3.48 indicates that the data is less distributed and skewed to the left.
- The difference in safety between wearing and not wearing seat belts is 1.99%, indicating that wearing seat belts has a slight advantage in terms of safety.
- Based on the minimum and maximum values, all values fall within the range of 100% to 119.68% for the worn seat belt score and 88.74% to 99.99% for the non-worn seat belt score.

According to the confidence levels, there is a 98% chance that the true mean of the worn seat belt score falls within the range of 96.96% to 104.19% and a 98% chance that the true mean of the non-worn seat belt score falls within the range of 96.68% to 100.5%.

Overall, the findings suggest that wearing seat belts may provide a slight advantage in terms of safety, with some variability in the worn seat belt score but greater consistency in the non-worn seat belt score. The descriptive statistics provide a useful summary of the data and can help inform safety decisions in public transportation and elsewhere. The outcomes of using digital technology to detect and control seat belt compliance are extremely significant. The ability to automatically analyze and recognize the difference between worn and non-worn seat belt scores enables the identification of potential flaws and the implementation of targeted improvements. The accuracy percentage results demonstrate the technology's dependability and precision, with a mean score of 100% for the worn seat belt column and 98.587% for the non-worn seat belt column. Furthermore, descriptive statistics such as the standard deviation, range, minimum, and maximum provide a thorough understanding of the data's distribution and variability. Overall, the impact of digital technology in enhancing safety in public transportation and beyond cannot be overstated, with its ability to automatically detect, control, and analyze differences leading to improved safety outcomes and potentially saving lives.

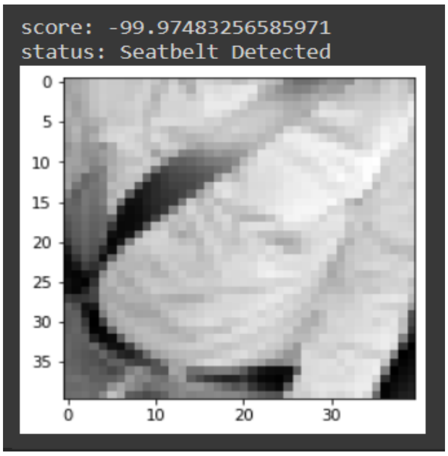

Figure 10. Obtained result after execution code where the seat belt is weared.

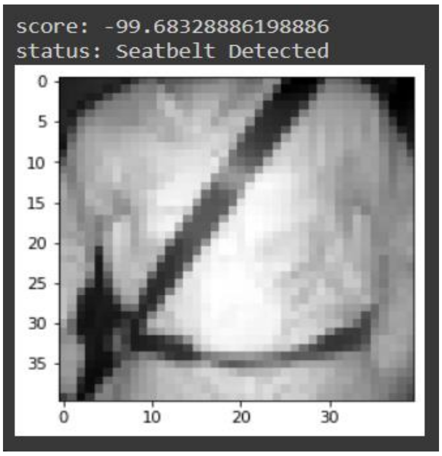

Figure 11. Obtained result after execution code where the seatbelt is weared

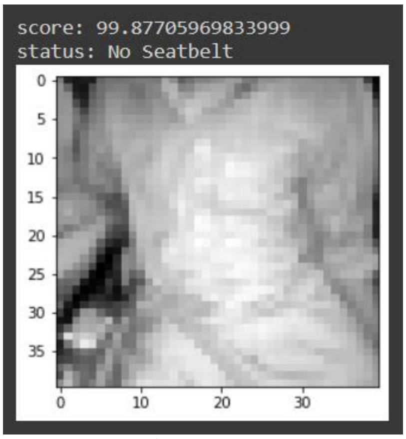

Figure 12. Obtained result after execution code where the seat belt is not weared

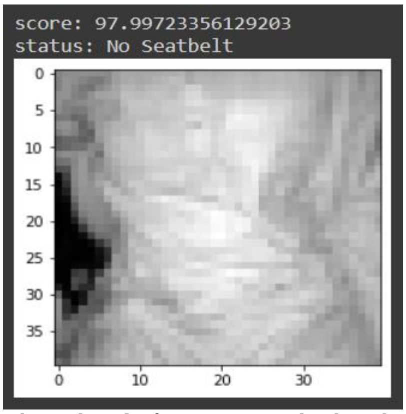

Figure 13. Obtained result after execution code where the seat belt is not worn.

Table 12. Applying descriptive statistics analysis from table. Xi

Accuracy/%		Weared seat belt score		Non-weared seat belt score	
Mean	100	Mean	100,5763	Mean	98,587
Standard Error	0	Standard Error	1,374916	Standard Error	0,726592
Median	100	Median	99,367	Median	99,432
Mode	100	Mode	#N/A	Mode	98,658
Standard Deviation	0	Standard Deviation	5,325028	Standard Deviation	2,814077
Sample Variance	0	Sample Variance	28,35592	Sample Variance	7,91903
Kurtosis	#DIV/0!	Kurtosis	14,46289	Kurtosis	12,7704
Skewness	#DIV/0!	Skewness	3,773748	Skewness	-3,47609
Range	0	Range	21,715	Range	11,261
Minimum	100	Minimum	97,968	Minimum	88,736
Maximum	100	Maximum	119,683	Maximum	99,997
Sum	1500	Sum	1508,644	Sum	1478,805
Count	15	Count	15	Count	15
Confidence Level(98,0%)	0	Confidence Level(98,0%)	3,60846	Confidence Level(98,0%)	1,906935

In terms of regulations, doctors occasionally give pregnant women permission to drive for a while without a seat belt, if you are a driver who is reversing or supervising a learner driver who is reversing in a vehicle used for police, fire, or rescue services, you are not required to wear a seat belt. driving a goods vehicle on deliveries that travel no more than 50 meters between stops a licensed taxi driver who is 'plying for hire or transporting passengers’ [39], but they frequently run into law enforcement checking the accuracy of the information. With the help of this GUI, it is easy to obtain a certificate from the appropriate medical facility for the time period required. Seat belt disputes sometimes result in lawsuits against corporations involved in accidents. With this, only authorized persons are permitted to stop the alarm and remove disagreements between police enforcement and insurance companies.

“Fig. 11” shows a Python program that generates a graphical user interface (GUI) for a seat belt detection app with an on/off beep feature for pregnant women. The Tkinteribrary is used for the GUI, and the pyserial library is used to communicate with a microcontroller to turn the beep on and off.

A title, description, password field, date picker field, message label, and two buttons comprise the GUI. The buttons allow the user to turn the on or off the beep. The toggleBeep() method accepts a boolean argument toggle, which determines whether the beep is turned on or off. The method makes use of the serial library to connect to a microcontroller via a serial port. If the connection fails, the message label displays an error message. If the connection is successful, the microcontroller receives a command to turn the beep on or off. The method then waits for the microcontroller to respond before closing the connection. If there is a response, the method returns True; otherwise, it returns False.

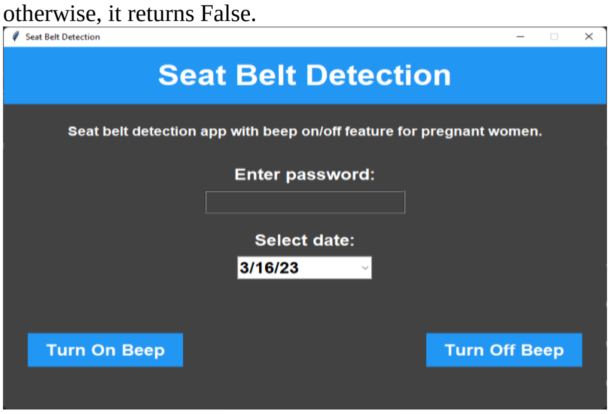

Figure 14. GUI to modify pregnancy rules

ACKNOWLEDGMENT

Neither any funding body from the public, private, or nonprofit sectors provided a specific grant for this research.

CONCLUSION

Findings from this and comparable articles should be obtained in a way that covers all user options, preventing the use of insufficient backup methods for seat belt use.

Since failure to wear a seat belt at all or improper use is one of the factors that increase the rate of injuries during accidents, it should be implemented by automakers and other producers of similar products on the basis that the value of human life is significantly greater than material values and benefits.

In the long term, it is better to enforce seat belt use to create a habit than to plan education efforts.

Due to disagreements over seat belt laws, insurance firms frequently face litigation situations for reimbursement, and the adoption of such works would end these contexts.

Future work

To keep track of whether a driver is wearing their seat belt the entire journey, a system similar to a tachograph can be used. However, since it would have to continuously collect data about the driver's seat belt status while in use, such a device would probably be more complicated than a conventional tachograph. The use of sensors in the car seats to determine whether the seat belt is fastened or not is one potential method for putting such a system into practice. The seat belt status might then be recorded periodically throughout the trip by connecting these sensors to a data recording system. Another strategy would be to examine the driver's images or videos using computer vision techniques.

Convolutional neural networks and real-time object tracking are advanced machine learning techniques that could be integrated to increase accuracy, while user feedback mechanisms and data augmentation with a variety of clothing patterns and seatbelt positions can further improve the model's generalization. More advanced and accurate seatbelt detection may also be achieved by incorporating thermal or infrared imaging, as well as working with the fashion industry to create apparel that is less likely to be mistaken for a seatbelt.

It is suggested that in the future, the service representatives of car manufacturers obtain licenses in each city where, according to the certificate from pregnancy from the requirement to wear a belt, only they have access to modify them, due to this, alternatives for password and time are also included into the GUI.

REFERENCE

[1] J.D.Febres, S. G.Herrero, S. Herrero, J.M. Gutierres, J.R.L Garcia, M.A.Mariscal, "Influence of seat-belt use on the severity of injury in traffic accidents," *European Transport Research Review,* vol. 12, no. 1,2020 p. 9.

[2] M. K. Woldegebriel,B. G. Aregawi, H. T. Gebru, "Assessment of seat belt use and its associated factors among public transport drivers in North Gondar, Ethiopia: a cross-sectional study," *BMC Research Notes,* vol. 12, no. 1, 2019, p. 98.

[3] L. Buckley,L.H. M. Jones, S. M. Ebert, M. P. Reed, J. J. Hallman, "Evaluating an intervention to improve belt fit for adult occupants: Promoting positive beliefs,," *Safety Research,* vol. 64,2018, pp. 105-111.

[4] . Hanahara, M. Hitosugi, Y. Tateoka "Education for appropriate seatbelt use required for early-phase pregnant women drivers," *Scientific Reports,* vol. 10, no. 1, 2020, p. 17609.

[5] W. C. Lam, W. K. To, E. S.K Ma, "Seatbelt use by pregnant women: a survey of knowledge and practice in Hong Kong," *Hong Kong medical journal = Xianggang yi xue za zhi,* vol. 225,2016, pp. 420-427.

[6] E.P Laan,van der "Seat belt control : from modeling to experiment"," *Technische Universiteit Eindhoven, Phd Thesis,* vol. 2009, no. 1, p. 183p, 2009.

[7] G. Agarwal, N. Kidambi, R.Lange, "Seat Belts: A Review of Technological Milestones, Regulatory Advancements, and Anticipated Future Trajectories," in *SAE Technical Paper 2021-01-5097,* United States, 2021.

[8] G. Huiwen, L. Hui, Z. Shaohua, L. Shutao, "Image-based seat belt detection," in *Proceedings of 2011 IEEE International Conference on Vehicular Electronics and Safety*, Beijing, China, 2011.

[9] Y. Tang, "Monitoring Algorithm for Speed Information of Autonomous Vehicles Based on Magnetoresistive Sensor," *Jordan Journal of Mechanical and Industrial Engineering,* vol. 14, no. 1, 2020, pp. 43-52.

[10] J.Tao, .Jia, Y. Gao, "Intelligent Remote Monitoring System for Minor Faults of Intelligent Unmanned Vehicle," *Jordan Journal of Mechanical and Industrial Engineering,* vol. 14, no. 1,2020, pp. 61-70.

[11] Y. Chen, L. Zhai, "A comparative study on student performance prediction using machine learning," *Education and Information Technologies,Vol. 28,*2023, pp. 12039-12057.

[12] Y. Chen, G. Tao, H. Ren, X. Lin, LZhang, "Accurate seat belt detection in road surveillance images based on CNN and SVM," *Neurocomputing,* vol. 274, 2018, pp. 80-87.

[13] *A. Kashevnik, A. Ali, I. Lashkov, N. Shilov, "Seat Belt Fastness Detection Based on Image Analysis from Vehicle In-abin Camera," in 26th Conference of Open Innovations Association (FRUCT), Yaroslavl, Russia, 2020.*

[14] F. B. Ismail, A. Al-Bazi, R. H. Al-Hadeethi, M. Vector, "A Machine Learning Approach for Fire-Fighting Detection in the Power Industry," *Jordan Journal of Mechanical and Industrial Engineering,* vol. 15, no. 5, 2021, pp. 475-482.

[15] J. Anithaa, R. Das, M.K. Pradhan, "Multi-Objective Optimization of Electrical Discharge Machining Processes Using Artificial Neural Network," *Jordan Journal of Mechanical and Industrial Engineering* , vol. 10, no. 1, 2016, pp. 11-18..

[16] B. Kazem,J. Khawwaf , "Estimation Bending Deflection in an Ionic Polymer Metal Composite (IPMC) Material using an Artificial Neural Network Model," *Jordan Journal of Mechanical and Industrial Engineering* , vol. 10, no. 2,2016, pp. 123-131.

[17] F. Hu, "Robust Seatbelt Detection and Usage Recognition for Driver Monitoring Systems" ArXiv, 2022.

[18] C. Peijiang, M. Yongjun, "Automobile Longitudinal Axis Detection Method Based on Image Segmentation and Preliminary Results," *Jordan Journal of Mechanical and Industrial Engineering* , vol. 8, no. 5, 2014, pp. 297-303.

[19] D. Borio, E. Cano, G. Baldini, "Motion Conflict Detection in the Smart Tachograph," in *European Navigation Conference (ENC),Gothenburg, Sweden* 2018,

[20] A.K. Abbas,A. F. Hefny, F. M. Abu-Zidan, "Seatbelts and road traffic collision injuries," *World Journal of Emergency Surgery,* vol. 6, no. 1, 2011, p. 18.

[21] A. M.Tapia, G.S.T. Riveors,J. C. Vargas,M.A.Incacoña, N.F. Valdez,O.V. Anahua, C.R. Mejia, "Use of seat belts among public transport drivers in Tacna, Peru: Prevalence and risk factors," *PLOS ONE,* vol. 16, 2021, pp. 1-13.

[22] N. F.Mbarga, N.Abubakari, L.N. Aminde, A. R. Morgan, "Seatbelt use and risk of major injuries sustained by vehicle occupants during motor-vehicle crashes: a systematic review and meta-analysis of cohort studies," *BMC Public Health,* vol. 18, no. 1,2018, p. 1413.

[23] A. Høye, "How would increasing seat belt use affect the number of killed or seriously injured light vehicle occupants?,," *Accident Analysis & Prevention,,* vol. 88,2016, pp. 175-186.

[24] Herath, Matheesha and Bautz, Peter and Parker, Dominic and Dobbins, Christopher, "he Importance Of Wearing A Seatbelt Correctly – A Case Report Of Blunt Trauma Causing Complete Shearing Transection Of The Gastroduodenal Junction," *nternational Journal of Surgery Case Reports,* vol. 20, 2020, pp. 17609.

[25] L. F Beck, M. J. Kresnow, G. Bergen, "Belief about seat belt use and seat belt wearing behavior among front and rear seat passengers in the United States.," *Journal of Safety Research,* vol. 68,2019, pp. 81-88..

[26] K. Hanahara, M. Hitosugi, Y. Tateoka, "Education for appropriate seatbelt use required for early-phase pregnant women drivers," *Scientific reports,* vol. 10, no. 1, 2020.

[27] M. Hitosugi, T. Koseki, Y. Kinugasa, T. Hariya, G. Maeda, Y. Motozawa,, "Seatbelt paths of the pregnant women sitting in the rear seat of a motor vehicle," *Chinese Journal of Traumatology,* vol. 20, no. 6, 2020, pp. 343-346..

[28] ,M. Schellenberg. N. S. Ruiz, V Cheng, P. Heindel, E. Q Roedel, D. H. Clark, K Inaba,D. Demetriades, "The Impact of Seat Belt Use in Pregnancy on Injuries and Outcomes After Motor Vehicle Collisions," *The Journal of surgical research,* vol. 254, 2020, pp. 96-101.

[29] K. L. Lee, M. C. Monuteaux, L. C. Burghardt, E. W. Fleegler, L. E. Nigrovic, W. P. Meehan, MD, S. A. Schutzman, R.Mannix, "Motor Vehicle Crash Fatalities in States With Primary Versus Secondary Seat Belt Laws," *Annals of Internal Medicine,* vol. 163, no. 3, 2015, pp. 184-190.

[30] N. Owattanapanich,M.R. Lewis, E.R. Benjamin, M.D. Wong, D. Demetriades, "Motor vehicle crashes in pregnancy: Maternal and fetal outcomes," *Journal of Trauma and Acute Care Surgery,* vol. 90, no. 5, 2021, pp. 861-865.

[31] R. Chibber, J. Al-Harmi, M. Fouda, E. El-Saleh, "Motor–vehicle injury in pregnancy and subsequent feto-maternal outcomes: of grave concern," *Journal of Maternal-Fetal & Neonatal Medicine,* vol. 28, no. 4, 2015, pp. 399-402.

[32] M. Durzaisamy, "Night Vision Technology," *International journal of science and research in technology,* vol. 3, 2017, pp. 411-415.

[33] B. Ren, G. Jiao, Y. Li, Z. Z. Jr., K. Qiao, Y. Yang, L. Yan, Y. Yuan, "Research progress of true color digital night vision technology," in Proceedings of the Seventh Symposium on Novel Photoelectronic Detection Technology and Applications, SPIE 11763, 117636C, Kunming, China, 2021.

[34] K.Rupal, K. Pimal, M. Rohan, G.Manish, "Image-based Seat Belt Fastness Detection using Deep Learning," *Scalable Computing: Practice and Experience,* vol. 23, 2022, pp. 441-455.

[35] Y. Ren, J. Liu, "Automatic Obstacle Avoidance Path Planning Method for Unmanned Ground Vehicle Based on Improved Bee Colony Algorithm," *Jordan Journal of Mechanical and Industrial Engineering,* vol. 16, no. 1, 2022, pp. 11-18.

[36] Y. Li, "Design of Path Tracking Control System for UAV Based on Adaptive Preview Method," *Jordan Journal of Mechanical and Industrial Engineering,* vol. 14, no. 1, 2020, pp. 101-108.

[37] S. Sahu, S.P. Jena, "Application of Hybrid Fuzzy Technique for

Damage Estimation in Structural Member," *Jordan Journal of Mechanical and Industrial Engineering* , vol. 17, no. 2, 2023 pp. 195-204, 2023.

[38] M. A. Bani-Hani, M. A. Al-Moghazy, W. A. Altabey, S.A. Kouritem, M. Hakam, "Detecting Technique of COVID-19 Via an Optimized Piezoelectric Sensor," *Jordan Journal of Mechanical and Industrial Engineering* , vol. 17, no. 2,2023, pp. 297-307.

[39] The UK. Goeverment, "https://www.gov.uk/seat-belts-law/when-you-dont-need-to-wear-a-seat-belt.," [Online]. Last retrieved: March, 2023