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Original Article

Development of a System to Detect Drowsiness in Drivers through Artificial Intelligence Techniques to Prevent Traffic Accidents

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Abstract *- Road accidents usually have many causes, but one that is very common around the world is driver drowsiness. The development of an artificial intelligence-based driver drowsiness detection system has been proposed as a means to prevent these incidents and protect the lives of drivers and other road users. The main objective of this project is to develop a driver drowsiness detection system using artificial intelligence techniques capable of detecting drowsiness in real time and alerting the driver in order to prevent traffic accidents. This system will make it possible to warn drivers and take preventative action before an accident occurs. It will use an approach based on artificial intelligence techniques, in particular machine learning. This AI-based driver drowsiness detection system has the potential to significantly reduce the number of road accidents caused by drowsiness, thereby improving road safety and protecting human life. In order to carry out the development of this project, the XP (Extreme Programming) methodology was used in order to have better management and communication development among the working team.*

Keywords *- Artificial intelligence, Machine learning, Road safety, Drowsiness, XP methodology.*

1. Introduction

Artificial intelligence is being used to detect drowsiness by analyzing patterns and signs of human behavior, such as posture and eye movements. For this reason [1], the University of Lima in Peru has developed a system that recognizes facial gestures using cameras to analyze customer satisfaction in restaurants, as they were unaware of customers' reactions after they had finished their meals. One of the most commonly used approaches is the search for facial landmarks, which are points on the skull that serve as reference points for certain parts of the face. This technique is used to identify facial expressions and detect lips. The most commonly used landmarks are the eye rims, mouth, nose, eyes, eyebrows, brain, and breastbone. Similarly, according to the author [2], using a data visualization technique, it can be seen that the proposed model has detected some biological markers related to sleepiness. In particular, these markers correspond to names such as Omega and Theta, among others. On the other hand, a system for detecting driver distraction and drowsiness has been carried out in Austria and Spain, where the author [3] points out that the eyes are the main indicator of drowsiness, and they use an algorithm to calculate eye closure, as it is the most appropriate visual indicator. For face detection, a powerful facial feature detector based on Deformable Part Models (DPM) was used. After processing and normalizing the facial region, a frame was used to normalize images under adverse lighting conditions. In short, systems based on artificial intelligence to detect driver drowsiness are currently being used around the world to prevent road accidents.This study set out to develop and evaluate an algorithm that could identify lane deviations brought on by tiredness.

Currently used algorithms struggle with issues including high false alarm rates and missing detections. The method makes use of steering wheel angle data, a random forest technique, and an ensemble definition of tiredness. To train and test the model, data was collected from 72 people who drove on the National Advanced Driving Simulator [4].

The random forest steering algorithm outperformed the widely utilized PERCLOS algorithm in terms of accuracy and performance in identifying cases of lane departure brought on by improper steering modulation as well as situations where drivers appropriately modified their steering behavior. This algorithm can be connected with mitigation systems and shows potential for identifying driver inattention.In the same way, a study was carried out to analyse the daily work of bus drivers on different routes from Arequipa to Peru, with route 4 being the one that showed the constant problem of drowsiness [5].

On Route 4, two drivers take turns at the wheel, one resting and the other driving, and it is known that drivers who rest do not sleep well. Studies have shown that this arrangement does not guarantee a safe journey for either the passenger or the driver.

Therefore, drowsiness while driving is one of the main causes of road accidents, which leads to very serious problems such as accident fines, legal consequences, loss of innocent lives and physical problems for the injured. Nowadays, many drivers, especially those who spend hours working on long road routes or those who work night shifts, are the main ones who experience drowsiness while driving, which leads to a high risk of causing a traffic accident. On the other hand, this study did not look at clinical conditions that may increase the fatality rate of AT. Obstructive Sleep Apnoea-Hypopnoea Syndrome (OSAHS), whose symptoms include snoring, apnoea, fatigue and excessive daytime sleepiness, is a fairly common and well-described condition. It is a serious public health problem because of the mortality associated with daytime sleepiness [6].

Despite some efforts made by road safety campaigns, the problem of drowsy driving remains a very significant challenge in terms of road safety. This project aims to propose a solution to prevent road accidents caused by drowsy drivers; the development of driver drowsiness detection is necessary because it must be effective in preventing accidents. For this reason, a webcam will be placed inside the vehicle to detect if the driver is drowsy. If it detects that the driver is drowsy, it will emit an audible alarm to alert the driver that he or she is drowsy and thus prevent an accident.

The main objective of this thesis project is to develop a driver drowsiness detection system using artificial intelligence techniques that is able to detect drowsiness in real-time and alert the driver to prevent traffic accidents; where this system will warn the driver and take preventative measures before an accident occurs.

2. Literature Review

Driving while drowsy is extremely dangerous as it increases the likelihood that drivers will miss traffic signs or junctions, drift into other lanes or even crash their vehicle, resulting in a minor or fatal accident [7]. One of the most important ways of analyzing driver behavior and detecting possible distractions is through the use of facial images [8]. For example, there is a technique called DriCare, which uses facial landmarks, or key points, to detect and track faces. The aim is to detect signs of drowsiness and also the driver's mood, such as sadness or tiredness. The technique consists of analyzing when the driver blinks, closes his eyes or yawns. Over time, this strategy has been improved by using two parallel convolutional neural networks (CNN VGG16) to detect the driver's facial expressions.

Two classifiers have been developed to detect drowsiness or fatigue through skin conductance, using a comparative study between the Multilayer Perceptron Neural Network (MLP NN) and the SVM. Thus, in addition to the analysis of eye and head movements, artificial intelligence also analyses skin conductance [9].

A system is proposed based on the use of a webcam to detect driver drowsiness from video recordings. Image processing and machine learning strategies have been used to make it cheaper and more portable. In addition, a methodology has been developed to know if the driver is drowsy using a behavioral approach. The aim is to provide an effective solution for detecting and preventing driver drowsiness [10].

UTA-RLDD is a dataset specifically created for the task of detecting drowsiness in multiple stages, unlike other datasets; this focuses not only on easy or extreme cases to identify but also on sensitive cases where micro-expressions are discriminative factors [11]. This makes it a suitable dataset to look for evidence of real drowsiness, which is the main aim of this work.

The driver is the main participant in various road accidents, which in turn are caused by various factors, one of which is drowsiness, which is evidenced by the driver's symptoms such as yawning, slow blinking, head tilted down, etc. For this reason, the development of a system to detect driver drowsiness in the vehicle is presented, consisting of a webcam as an input device, which allows the images of the driver's face to be processed. For this reason, the development of a system to detect driver drowsiness in the vehicle is presented. It will also consist of a webcam that will allow an input device to obtain images of the driver's face to be processed by an algorithm created in MATLAB, then detect their status and, depending on it, alert the driver [12].

As a result of the most important problem in Peru, road accidents, the idea was born to develop a system capable of detecting the symptoms of drowsiness in the drivers of the vehicles of the company Transports Costanera Sur E.I.R.L., as well as being able to be extended to all the transport companies in the city of Tacna, in order to avoid possible road accidents by transmitting warning sounds to the driver, allowing him to take preventive action [13].Technology developed by Ford to detect and prevent drowsy driving. Ford has used the following technologies to prevent drowsy driving. Ford's system collects biometric data via an infrared sensor in the dashboard, a heart rate sensor and a breath sensor in the safety perimeter. After examining the steering wheel and pedals, the system calculates the driver's ability to withstand an alert. Ford vehicles have a temperature sensor and a card frequency detection system [14]. However, the accuracy of detecting drowsy driving is not high due to these features alone.

The following circumstances make it likely that a traffic collision was caused by intoxication: the vehicle leaves the road unexpectedly or crosses into an oncoming lane, and finally, the driver does not indicate that he or she tried to avoid the accident. In this study, a prototype system was developed to regulate the driver's level of drowsiness. The system uses computer vision, machine vision, and pulse oximetry [15]. Drowsiness is characterized by an abnormal feeling of sleepiness or fatigue.

Driving requires complex psychomotor skills, and the risk of accidents and fatalities increases when drivers become drowsy. According to the National Highway Traffic Safety Administration (NHTSA), there were 91,000 motor vehicle crashes caused by drowsy driving in 2017, resulting in 17% of fatalities. The advent of IoT technology has opened up new possibilities for connecting humans and facilitating machine-to-machine communication.

By leveraging sensors and networking, IoT enables seamless information sharing and empowers the creation of systems with accurate data for making informed decisions. This article introduces a practical system designed to detect driver drowsiness, which can significantly contribute to reducing the fatality rate associated with traffic accidents [16]. Such IoT applications gather extensive data from sensors and utilize pattern recognition algorithms, often leveraging machine learning, a subfield of artificial intelligence. This paper presents the implementation of a system that detects a driver's drowsiness state.

The main objective of this dissertation is the study of sleep detection systems and their application.This research is based on the development of electronic devices for the prevention of traffic accidents. The main objective of this research is to use technology in the design and use of devices that help to maintain measurements, detection, and alerts of fatigue and drowsiness in drivers in the city of Loja.In order to analyze the information obtained, three research methodologies were applied: hermeneutic, phenomenological, and practical-projective. These methodologies were focused on carrying out an exhaustive analysis of the various bibliographical sources for the investigation of the topic and, as a result, making possible the implementation of the device with all the suggested measures through appropriate field tests where the functionality of the device was evaluated [17].

The results of the study are presented in the following section. To develop and apply a drowsiness detection criterion, a cube-by-cube analysis of the films in the dataset was performed. One of the most detrimental factors for driving is the occurrence of micro dreams as a result of not getting enough sleep. Based on this, a detection standard was established based on time with one eye closed [18]. In summary, the studies conducted by these researchers have been very successful.

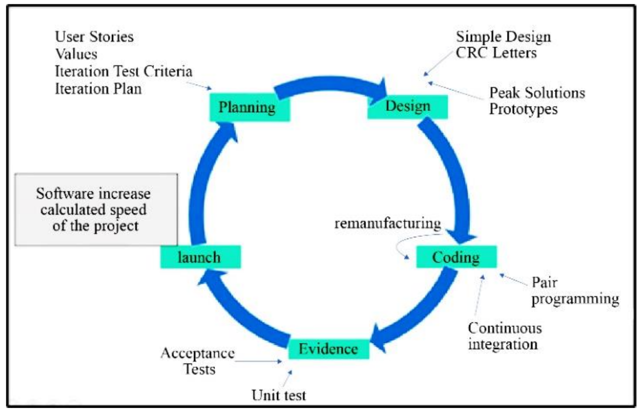

Fig. 1 XP Methodology

In summary, the studies conducted by these researchers focused on fundamental points in order to develop their drowsiness detection systems.

3. Materials and Methods

The XP methodology allows fast software deliveries since it is based on an agile methodology. It offers some ideas to speed up the software testing and delivery processes, as shown in Figure 1.

3.1. Extreme Programming (XP)

Extreme Programming (XP) methodology is one of the Agile frameworks used for artificial intelligence projects because it focuses on making software development fast, of high quality and responsive to changes as they occur [19]. The Extreme Programming (XP) methodology is one of the Agile frameworks used for artificial intelligence projects.

The methodology known as Extreme Programming (XP) was developed by Kent Beck in 1999 to address the problem of the difficulty of increasing requirements throughout the software development process. These changes are managed within the time and budget available [20]. The XP methodology sets a standard for the development of software.The XP methodology sets a standard for software development that is different from others for specific projects, with little time to complete and with a small group of stakeholders [21]. The XP methodology has been used for many years.

3.2. Planning

In this stage, fully specified problems are assessed with rigorous planning, predefined processes and regular documentation together with the customer. This is where the author analyses the business process. System requirements and functional characteristics to be used in the software system must be remembered. The result is that it is agreed that there are two actors on this website, namely the participants and the administrator. Due to the origin of the external BRI banks, no accounts are created, according to the trainers/lecturers.

Table 1. User stories

No.	User Stories
H-1	As a system administrator, I want you to use artificial intelligence techniques to analyse webcam images and identify drivers who show signs of drowsiness in order to prevent road accidents.
H-2	As an administrator, I want the system to use machine learning algorithms to recognize and distinguish facial features associated with drowsiness in real time.
H-3	As an administrator, I want the system to generate audible alerts if the driver shows signs of excessive drowsiness so that immediate corrective action can be taken.
H-4	As an administrator, I want the system to use the webcam to monitor the driver's eyes for signs of drowsiness.

The teacher will talk to the administrator if there is anything related to the training process. How to add self-learning materials to the participants' learning materials.

In addition, the subject will be tested to see whether or not he/she understands what has been said [22]. In addition, the subject will be tested to see whether or not he/she understands what has been said to him/her.

After filling out the form and obtaining the necessary information from people who may have had close experience with drowsy driving accidents in the Lima district or elsewhere in Peru, the following user stories were collected, as shown in Table 1.

3.3. Design

The XP methodology is characterized by clear and simple designs for quick implementation as opposed to the more complex designs often used in other methodologies [23]. The XP methodology is characterized by clear and simple designs for quick implementation as opposed to the more complex designs commonly used in other methodologies.

This stage identifies problems during the process, such as constant changes of visual requirements by the client, design problems, and lack of coordination in the definition of a layout.

Iteration is responsible for the design of the interface, characterized by constant change as a result of changes made as a result of the decisions made by those involved in order to obtain an interface that adapts to the user's needs [24].

In the implementation design of the drowsiness detection system, the flow chart was determined and analyzed. Where found the processes and phases for the implementation and its future use, as shown in Figure 2.

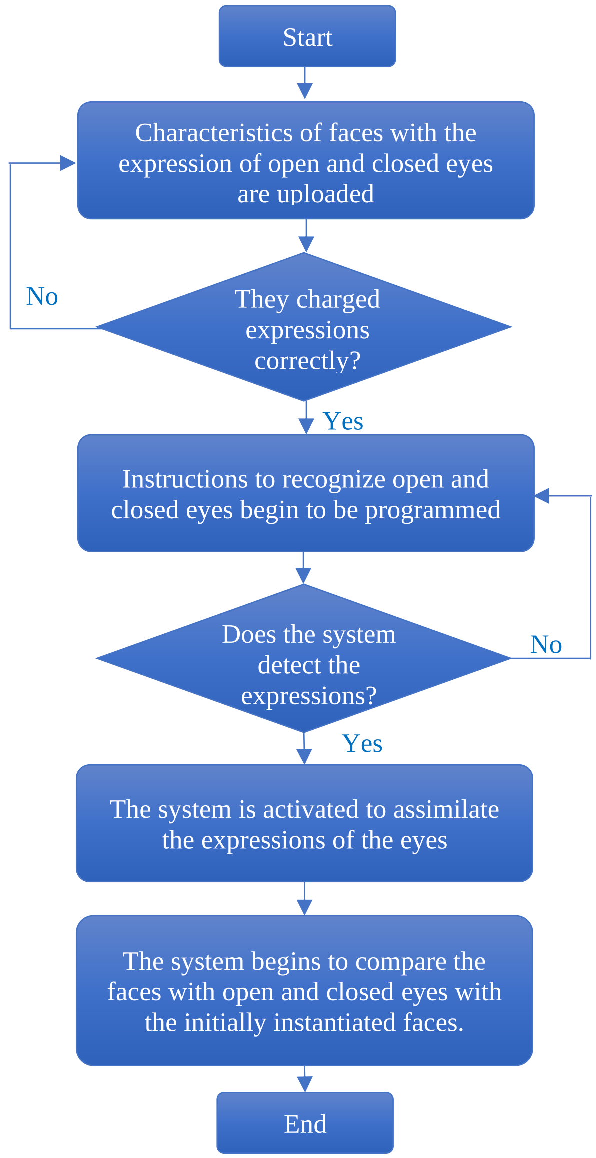

Fig. 2 Flow of the drowsiness detection system

3.4. Prototypes

Detection of a face with eyes open: In this section, the system will have already managed to identify the face, as well as to detect that the driver is present with his eyes open, that his state is correct, and that there is no danger present. In addition, the system will have managed to detect that there is no danger present, as it is mentioned that the driver is awake and that the counter is set to 0, which will not perform any function. As can be seen in Figure 3.

Detection of a driver with eyes closed: If there is a situation where the driver exhibits facial features incompatible with proper alertness, i.e. shows symptoms of drowsiness while driving, e.g. yawning or eyes closed, the system will issue an alert, warning the driver that it is detecting drowsiness so that he/she can normalize this potentially dangerous situation.

Fig. 3 Recognition eyes open (Awake)

This is indicated by the word sleepy, and when the counter exceeds 2 seconds, the alarm is automatically activated. This can be seen in Figure 4.

In-vehicle driver simulation: Imagine a driver inside his car and a camera strategically placed in front of him that is part of a drowsiness detection system. The driver is sitting in his seat with his hands on the steering wheel and his eyes fixed on the road. When the camera detects that the driver is showing signs of drowsiness, audible alarms are triggered by artificial intelligence systems to warn drivers of potentially dangerous conditions. As shown in Figure 5.

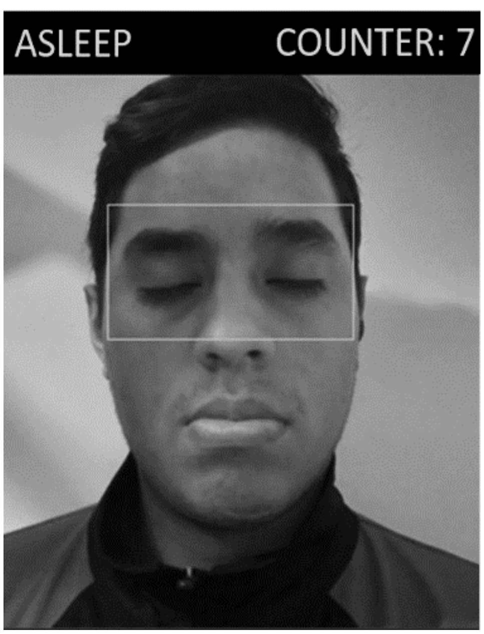

Fig. 4 Eyes closed recognition (asleep)

Fig. 5 In-vehicle driver simulation

3.5. Coding

Coding is produced in the form of pair programming, following agreed standards, unit tested, version controlled and continuously integrated. Because any one programmer is often prone to error, there must be another programmer involved in the development and to sign off on it. It is also important to involve the customer throughout the project, supporting the developers [25].It will import the necessary libraries, such as OpenCV (to capture video from a camera), Vic (customized for audio files), NumPy (works with matrices and vectors) and Keras load model (to load a machine learning model from a file). Then, several variables are initialized. Video capture (captures the video from the camera).

The cascade selectors eye Left and eye Right (detects the left and right eye in the image). Next is the NumPy array, which will be called "data" (stores processed image data). Then, load the Keras model from the file named "keras model.h5" using the load model function. Finally, start the additional variables for eye tracking and a counter as it will store the number of times my model thinks it is sleeping, and when it reaches a certain number, it will wake us up. This is shown in Figure 6.

```
# Importing Libraries
import cv2
import vic
import numpy as np
from keras.models import load_model

# Initializing Variables
video_capture = cv2.VideoCapture(1)
eyeLeft = cv2.CascadeClassifier('/Users/user/miniforge3/pkgs/l
eyeRight = cv2.CascadeClassifier("/Users/user/miniforge3/pkgs/l
data = np.ndarray(shape=(1, 224, 224, 3), dtype=np.float32)
model = load_model('keras model.h5')
p = vic.MediaPlayer("wakeup.mp3")
left_x, left_y, left_w, left_h = 0, 0, 0, 0
right_x, right_y, right_w, right_h = 0, 0, 0, 0
contador = 0
```

Fig. 6 Code importing library and initializing variables

```
#Running Video
while True:
    ret, frame = video_capture.read()
    height, width = frame.shape[:2]
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)

    # Showing Counter
    cv2.rectangle(frame, (0, 0), (width, int(height * 0.1)),
    (0, 0, 0), -1)
    cv2.putText(frame, 'Contador: ' + str(contador),
    (int(width * 0.65), int(height * 0.08)),
    cv2.FONT_HERSHEY_SIMPLEX, 2, (255, 255, 255))
```

Fig. 7 code running video

This code will run in a loop, exposing the counter at the top of the frame captured by the camera. As visualized in the code fragment in Figure 7.

```
# Identifying Right Eye
ojo_der = eyeRight.detectMultiScale(
    gray,
    scaleFactor=1.15,
    minNeighbors=3,
    minSize=(30, 30)
)
for (x, y, w, h) in ojo_der:
    cv2.rectangle(frame, (x, y), (x+w, y+h), (0, 255, 0), 2)
    right_x, right_y, right_w, right_h = x, y, w, h
    break

# Identifying the Left Eye
ojo_izq = eyeLeft.detectMultiScale(
    gray,
    scaleFactor=1.15,
    minNeighbors=3,
    minSize=(30, 30)
)
for (x, y, w, h) in ojo_izq:
    cv2.rectangle(frame, (x, y), (x+w, y+h), (0, 255, 0), 2)
    left_x, left_y, left_w, left_h = x, y, w, h
    break
```

Fig. 8 Left and right eye identification

This coding fragment allows you to recognize and see the rectangles around the right and left eyes in the frame captured by the camera. Where for the right eye, the is used eye Right as it is a cascade classifier to detect greyscale images also; for the left eye, the is used eye Left where in the same way, it will detect grey images as shown in Figure 8.

3.6. Test

After each iteration, tests are run before a new version of the software is released. On the other hand, tests must be planned before starting to create code. They are created based on the customer stories for each iteration. The user must describe several scenarios to prove that the story was executed correctly [26]. The user must describe several scenarios to prove that the story was executed correctly.

3.7. Launch

The release stage is the last phase of the XP methodology, and if you reach this stage, it means that all customer requirements have been met and that you have useful software that is ready for deployment [27]. For the release stage, there is a delivery plan through the defined user stories; for this plan, the priority and effort of each HU are taken into account; in this way, the defined requirements will be evidenced as fully developed and ready for release.

3.8. System Architecture

The process of the recognition system, taking into account firstly the storage of the photos for subsequent training, so that through artificial intelligence pseudo-codes, it can recognize the symptoms of drowsiness in a driver through a webcam and thus be able to issue an audible alert in case the symptoms of drowsiness are detected, as shown in Figure 9.

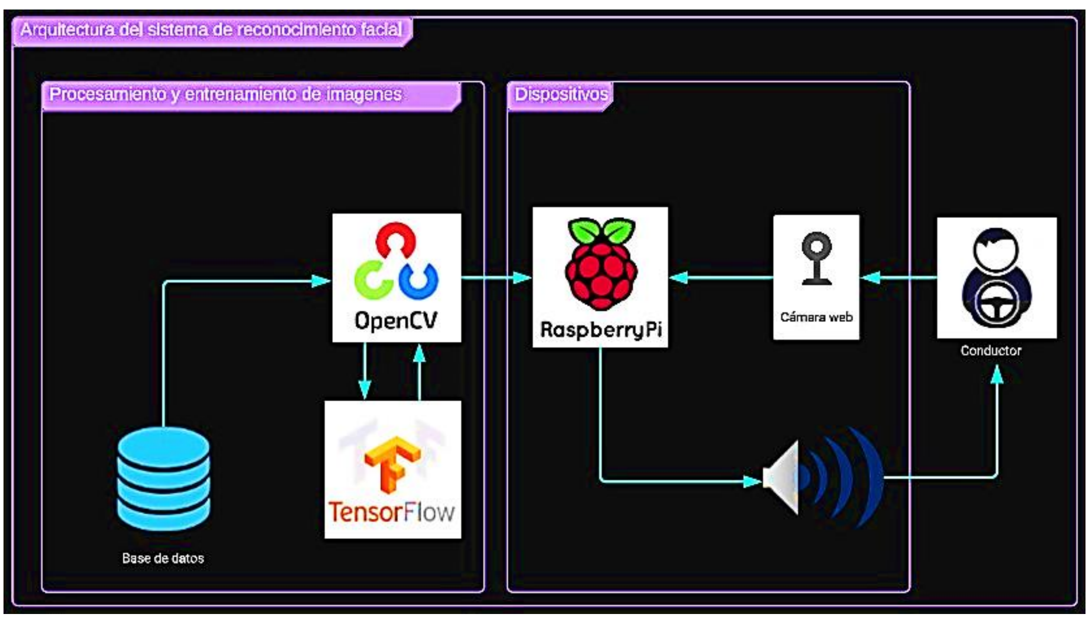

Fig. 9 System architecture

4. Results and Discussion

4.1. About the Survey

The survey asked 10 questions to the public consisting of road safety benefits, personal benefits, and effectiveness in accident prevention, as shown in Table 2.

Next, some questions were selected and analyzed with respect to their dimensions.

In the first question posed to users, which was whether they would be willing to use an artificial intelligence system that monitors their driving patterns and issues alerts in case of drowsiness, 81.3% answered YES, which means that users do agree to use an artificial intelligence system to help them prevent possible accidents [14]. This can be visualised in Figure 10.

In the second question posed to the users, which was whether the development of a drowsiness detection system would help prevent traffic accidents, 68.8% answered YES, assuming that users accept such a system since there is currently a high rate of traffic accidents caused by drowsiness in drivers [16]. This can be seen in Figure 11.

Table 2. Survey questions

1. PERSONAL PREFERENCES
Would you be willing to use an artificial intelligence system that monitors your driving patterns and issues alerts if it detects drowsiness?
Would you be willing to invest in a vehicle equipped with a system that can detect drowsiness based on artificial intelligence to ensure your safety and the safety of other road users?
2. BENEFICIAL FOR ROAD SAFETY
Do you think that the implementation of a system that detects drowsiness in drivers using artificial intelligence techniques would help prevent traffic accidents?
Do you think that implementing such a system would be beneficial for road safety?
Would you be in favors of using technology that can alert drivers when they are drowsy to prevent accidents?
Do you think an artificial intelligence-based drowsiness detection system could reduce the number of accidents caused by driver fatigue?
Would you agree with the use of artificial intelligence technologies to prevent traffic accidents related to driver fatigue?
Do you think such a system could contribute to the reduction of road injuries and fatalities?
Do you consider that the implementation of this technology in vehicles would be an important advance for road safety in general?
3. EFFECTIVENESS IN ACCIDENT PREVENTION
Do you consider the development of a system that detects drowsiness in drivers to be an effective measure to prevent accidents caused by drowsiness?

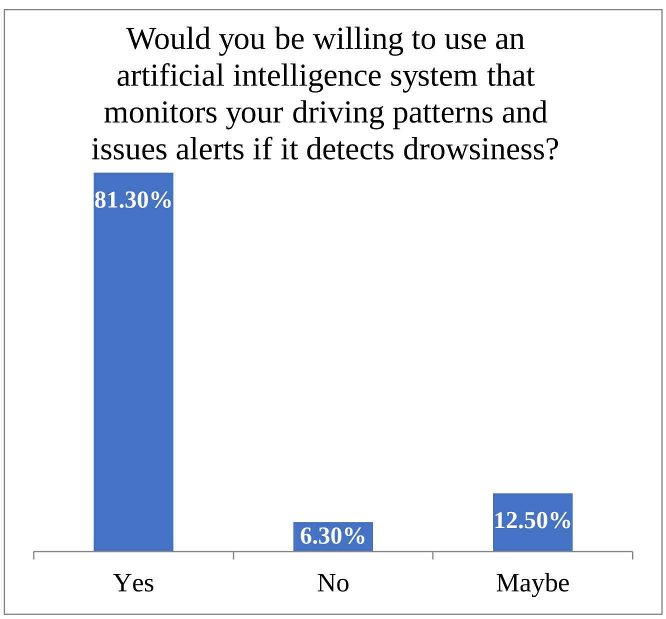

Fig. 10 Personal preference

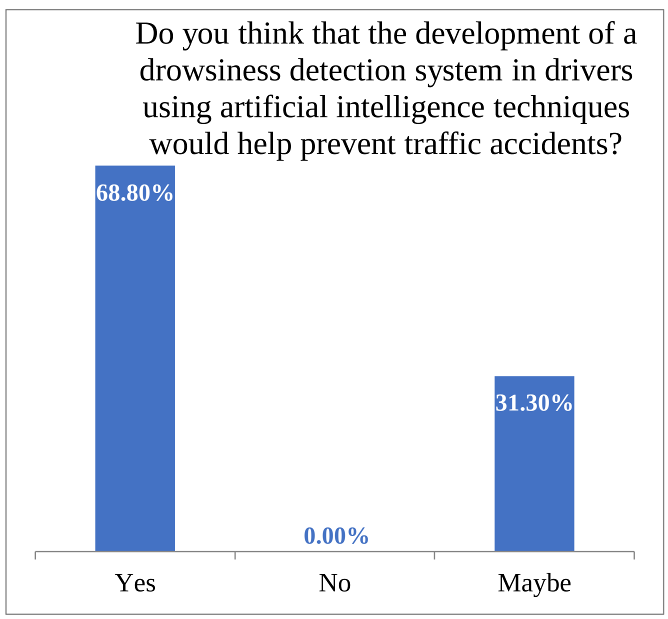

Fig. 11 Benefits of the drowsiness detection system

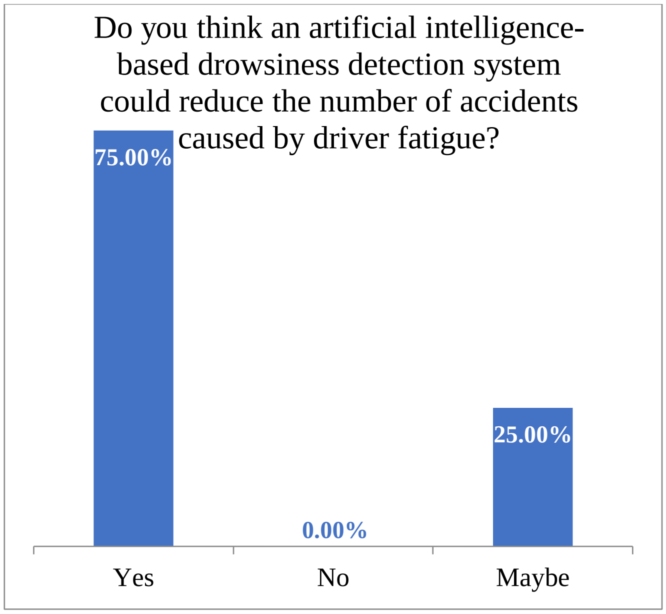

Fig. 12 Reducing drowsiness accidents with artificial intelligence.

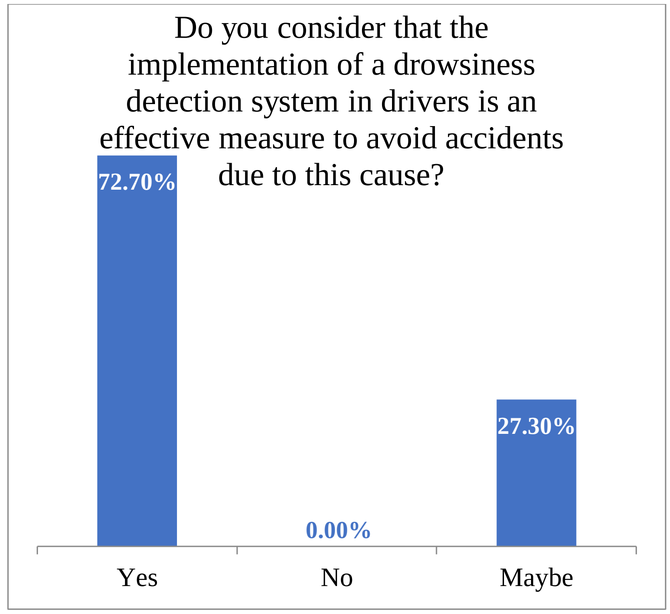

Fig. 13 Avoiding accidents with AI due to drowsiness.

In response to the third question chosen for the results, which asked whether people believed that an artificial intelligence-based drowsiness detection system could reduce the number of accidents caused by driver fatigue [18], 75% of respondents said yes, which can be interpreted to mean that users do believe that such a system with intelligence would help reduce the number of accidents caused by fatigue as can be seen in Figure 12.

In response to the fourth question chosen for the results, which asked whether people believed that the implementation of a drowsiness detection system in drivers is an effective measure to avoid accidents due to drowsiness, 72.7% of the respondents said yes, which can be interpreted as users agreeing that this could prevent some possible accidents with artificial intelligence as can be seen in Figure 13.

5. Conclusion

In conclusion, it will be a good solution to use an artificial intelligence system to detect drowsiness. According to the survey conducted, users are willing to use it, and this will help prevent accidents caused by driver fatigue. If implemented, it would be a major improvement in road safety, safeguarding people and avoiding tragedies on the roads. In short, this system has the capacity to make a difference and save lives.

It can also be mentioned how the XP (Extreme Programming) methodology could help this implementation succeed and increase the effectiveness of the system in detecting driver fatigue. At first, it was difficult to understand how the functionality of the system would work, but with the research that took place over the weeks, we were able to come to an understanding.

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