EVOLUTION IN ELECTRICAL AND ELECTRONIC ENGINEERING
e-ISSN: 2756-8458

EEEE

Vol. 5 No. 1 (2024) 443-449
https://publisher.uthm.edu.my/periodicals/index.php/eeee

Smart Wireless Pedestrian Detection

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DOI: https://doi.org/10.30880/eeee.2024.05.01.056

Article Info

Received: 13 January 2024
Accepted: 15 March 2024
Available online: 30 April 2024

Keywords

Pedestrian, Haar Cascade, Raspberry Pi

Abstract

The World Health Organization aims to cut traffic-related accidents by 50% as part of its 2030 Agenda for Sustainable Development. It is possible to observe the movement of individuals across the pedestrian crossing by implementing the suggested localization method. Consequently, the smart city may establish a traffic flow that is both safe and effective. Ensuring that pedestrians have safe places to cross busy streets, like crosswalks and walkways that cross over occupied roads, along with various tactics, is very important. The world's major thoroughfares and pedestrian walkways are now busy places due to the constant advancement of technology and the need for more people to support it. As a result, using any type of roadway crossing place may make walking less safe and efficient. These days, one of the main features of street crossing zones is the button on each traffic light that doubles as a human detector, alerting the system to the presence of a pedestrian and prompting the system to request a "WALKING" signal as quickly as possible. Therefore, the goal of this study is to create a wireless, portable smart management system for pedestrian crossing areas that will automatically regulate traffic and enable pedestrians to cross the street securely and easily. To detect pedestrians, the system uses smart sensing, which automatically regulates the traffic lights at crosswalks. The sample images of pedestrians are taken from the Roboflow website. The detection of humans using Haar Cascade algorithm technique was done in Raspbian OS by using Python coding. From that, it will trigger the LED pedestrians traffic light to turn ON green light. Real-time object detection results yield a 78% accuracy rate for correct detections and a 22% rate for incorrect detections of 100 test images, with an average processing time of 0.3 milliseconds.

1. Introduction

Roadside pedestrian crossings are essential for both traffic flow and road safety [1]. The globe is in danger of running out of non-renewable resources because of the population's rapid growth [2]. This makes it possible for the city planner to comprehend the existing trend, anticipated demand, and required planning to guarantee that the citizens have a sustainable way of life [3].

Every year, up to 50 million non-fatal injuries and 1.35 million fatalities from traffic crashes occur, according to the World Health Organization [4]. In fact, pedestrian demand, manually operating pushbuttons, recognizing vehicular exposure, and pedestrian-vehicle communication are all more common in pedestrian fatalities than in other crosswalk locations [5]. In addition, due to their reliance on cameras, radar, and human interaction, most roadside pedestrian detection devices now in use have a high detection error rate and are expensive [6].

Pedestrian detection is to ascertain whether a person walks into the designated area. Several surveillance situations, such as those involving autonomous driving, railroad security, and private security, have a variety of uses for pedestrian identification. These scenarios are matched to the various target areas that need to be identified. Pedestrian detection must ascertain whether the observed pedestrian is in the target region in addition to knowing the position of the intruding object [7].

The Internet of Things (IoT) is fast transforming the way we live. Industry developments brought about by IoT are particularly apparent in the automotive sector [8]. The main objectives of the Smart City concept are data collection, sharing, and transfer between urban infrastructures, workflow cost reduction through process automation, and citizen-administration feedback on environmental improvements. In the end, these efforts should raise citizens' standards of living [9]. It might be difficult to ensure that traffic moves through a pedestrian crossing in a safe and efficient manner. People's speeds at a pedestrian crossing vary depending on their age and health [10].

The most vulnerable users of the road are pedestrians. Over half of all traffic fatalities are caused by collisions between vehicles and pedestrians, which can happen in a variety of circumstances, most notably when a person is attempting to cross the road. Collisions with pedestrians are a major source of death and serious injury in many nations.

Nowadays, the current road set up increases the risk of traffic accidents or injuries involving pedestrians, particularly during peak hours when both traffic volumes are relatively high. Due to this, pedestrians sometimes putting oneself in danger by making rash decisions when crossing the road, waiting for traffic to clear. This study analyzes all previous research and approaches to present a solution to detect pedestrians using the Haar Cascade technique.

This study embarks on the following objectives. Firstly, the design of LED pedestrian crossing system triggered when a full body is detected; second, the development of pedestrian detection system by using the Haar Cascade technique; and third the assessment of the overall performance of the developed system.

1.1 Background

Most of the research on crosswalk pedestrian recognition uses camera images. Furthermore, by extracting the crossing area from the path, utilizing surrounding object detection information to detect pedestrians around the crosswalk, and assessing whether a collision with the pedestrian occurred, it was also possible to drive in accordance with the circumstances. Only the crosswalk that crosses the global path of the autonomous vehicle is extracted when the crosswalk outline is extracted [11].

In paper [12], producing feature maps with semantic segmentation channels is a skill that the feature enrichment unit acquires. In comparison to the body network, the computational cost is not as high because the segmentation branch and the detection branch share most of their weights. Even after training the network for both the segmentation and detection tasks on several datasets, it still converges well and performs admirably in pedestrian identification. Fig. 1 shows the examples of detection results.

Fig. 1 *Examples of detection results*

From the top feature enrichment unit down the bottom, all features are conveyed in a backward fashion, producing ever-finer feature maps at ever-higher resolutions. High-resolution items are the primary target of the best feature enrichment units, while features of low-resolution objects will become weaker or even disappear. The bottom feature enrichment units will combine the high-resolution feature maps from the body network with the semantic features from the preceding feature enrichment unit to create high resolution feature maps that include both the localization information of low-resolution objects and strong semantic information. The body network will generate multi-scale enriched feature maps by constructing multi-scale feature enrichment units on various layers, increasing the network's resistance to multiscale objects. The concept of transmitting features backward with FPN is also shared by the feature enrichment unit. However, in order to enrich features, semantic segmentation feature learning is used. It transmits features in two primary streams: one for semantic segmentation and the other for FPN characteristics as shown in Fig. 2.

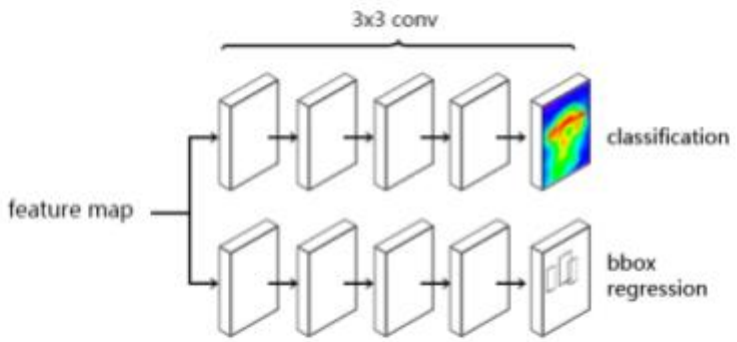


Fig. 2 *The two branches use separate weights, but the detector shares its weights across all the detection layers*

2. Material and Method

The implementation of the Smart Wireless Pedestrian Detection using the Haar Cascade technique involves key hardware components, including the Raspberry Pi 4 Model B, Raspberry Pi Camera, and a LED traffic light, each serving specific roles in real-time image analysis. Software components encompass Python for coding, and OpenCV for Haar Cascade algorithm implementation.

2.1 Block Diagram

Fig. 3 displays the overall block diagram for one roadside unit of the deployed testbed. First, open the Raspbian OS on the monitor. Second, the Raspberry Pi 4 board has a default application inside Raspbian OS to write and run the coding, it is called 'Thonny'. The system is programmed in such a way that, whenever the camera detects a pedestrian at the crosswalk, it will send the data to the Raspberry Pi 4 using Haar Cascade and display it in the monitor. After that, it will give a signal and trigger a LED traffic light. As a pedestrian crossing the road, the signal light retains possession of 'WALKING' in LED green light until no other pedestrians are crossing for the least time delays.

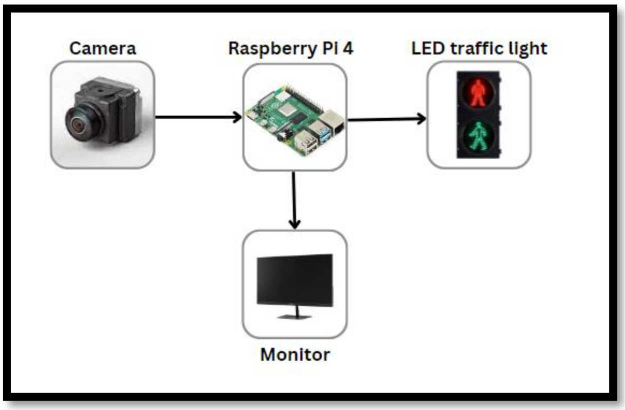


Fig. 3 *Portable LED Pedestrian Control System*

2.2 Pedestrian Detection System Flow

Fig. 4 shows the flowchart of the overall system where the camera captures the real time image of the road. The image captured processed by using Haar Cascade. If human is detected, the LED of the traffic light will turn green. The camera will check if the pedestrian had exited the zebra crossing. When all the pedestrians leave the zebra crossing, the LED light will change from green to red.

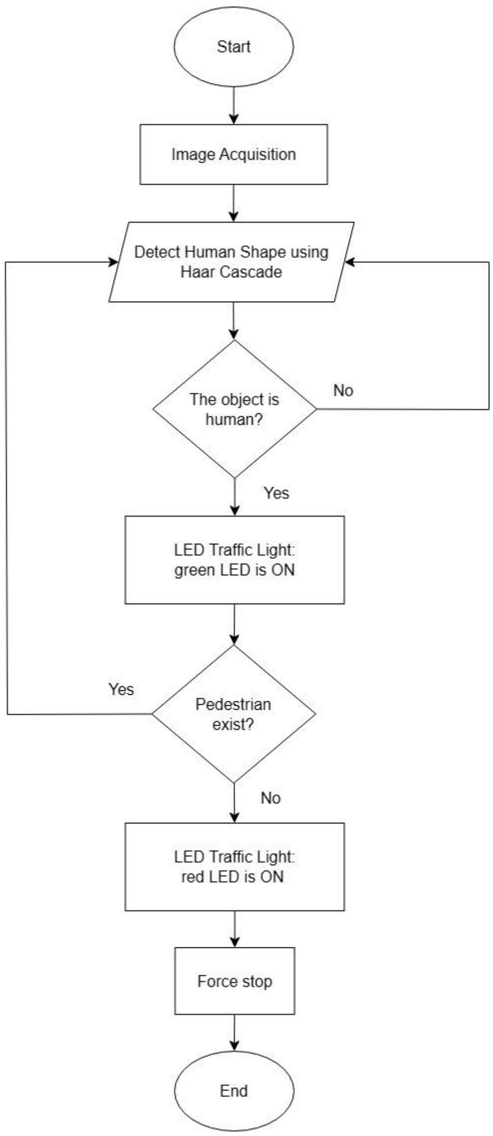


Fig. 4 *Flowchart of the pedestrian detection*

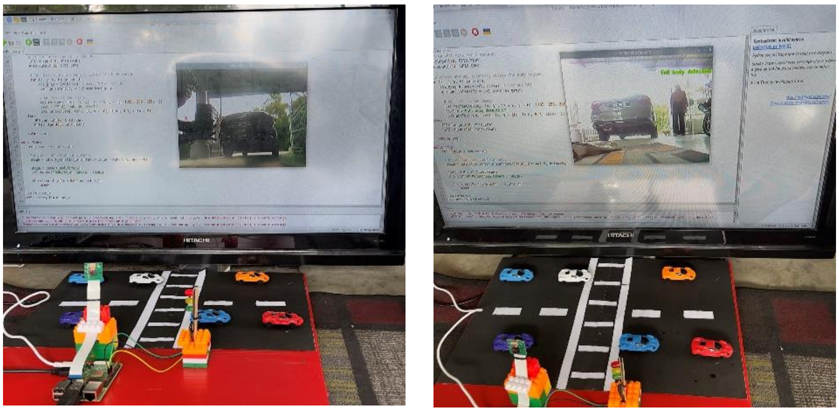
3. Result and Discussion

The results and discussion offer a thorough analysis of the data and its significance in relation to the research question and hypothesis, and it emphasizes the potential of image processing for pedestrians' detection. In this project, the pedestrians' images are obtained from Robolow website. The construction of an image database is the exclusive responsibility of the application system developer. The classifier's enhanced performance in the last stage of the detection system is due to the photo database. This dataset comprises 4000 sample images divide into two groups which are the train and valid models. There are 3603 train models and 397 valid models.

The experiment was conducted to test the functionality of the project. The build platform successfully achieved the project objectives. To ensure that every component is reliable and functional, the hardware will undergo multiple tests. The platform can detect the pedestrians correctly. The examination of the full body detection system, conducted through rigorous testing on a dataset of 100 images featuring the human body, provides valuable insights into its overall performance.

3.1 Analysis of Body Detection Using Haar Cascade

The experiment was conducted to test the functionality of the project. The build platform successfully achieved the project objectives. The platform can detect the presence of the human body and is able to process to detect the full body of human. Fig. 5 (a) shows the camera did not detect any human body so the pedestrians traffic light will turn on red light meanwhile Fig. 5 (b) shows that Person 2's body was detected, and the green light automatically turn on.



(a) **(b)**

Fig. 5 *Body detected using Haar Cascade (a) Red light turned ON when there is no human body; (b) Green light turned ON when it detects Person 2 body*

3.2 Time Taken to Detect Full Body using Haar Cascade and Yolov5

Haar cascade uses a simple and efficient feature extraction method, which allows for fast computation during the detection process. It is also known for its speed, especially on resource-constrained devices like Raspberry Pi. As for Yolov5, it can detect multiple objects in a single pass but may take more time to process images for a more complex model. This study has been tested in Haar Cascade and Yolov5 method in terms of their processing time. Table 1 shows the time taken using Haar Cascade meanwhile Table 2 shows the time taken using Yolov5.

Table 1 *The time taken using Haar Cascade*

Object Test	Time Taken to detect object (ms)
Test 1	0.1
Test 2	0.3
Test 3	0.3
Test 4	0.1
Test 5	0.1
Test 6	0.3
Test 7	0.3
Test 8	0.3
Test 9	0.3
Test 10	0.3
Average	0.3

Table 2 *The time taken using Yolov5*

Test	Item Detected	Time Taken to detect object (ms)
Test 1	2 persons 1 laptop 1 mouse	1800
Test 2	1 person 2 cars	1847
Test 3	1 person 2 cars 1 cellphone	1749
Test 4	1 person 1 car	1855
Test 5	1 person 1 car	1836
Test 6	1 person 1 car	1789
Test 7	1 person 1 laptop 1 car	1874
Test 8	2 persons 1 cat	2145
Test 9	1 person 1 car	1846
Test 10	1 person 1 car	1755
Average		16916

Based on Table 1, the average time taken to detect object using Haar Cascade is 0.3ms meanwhile in Table 2, the average time taken to detect object using Yolov5 is 16916ms. This is because it detected all the objects and made the camera lag. Haar Cascade are well-suited for real-time applications due to their speed and efficiency.

Table 3 *Object detection in real-time*

Output Images	Detect Body	Green LED Traffic Light ON
10	True	True
14	False	False
22	False	False
35	True	True
47	True	True
59	False	False
62	True	True
71	True	True
88	True	True
98	False	False

Table 3 shows the sample output images that have been tested after the full body being detected using Haar Cascade. Out of 100 test images, only 78 images were positive detected based on Haar conditions. Another 22 images were false because it was not accurate and detected another object as full body. Despite faults, the system attained 78% efficiency, demonstrating its relative efficiency.

4. Conclusion

In conclusion, this study aimed to develop an advanced LED pedestrian control system using the Haar Cascades method. A prototype of a pedestrian crossing system was meticulously designed and implemented. The major objective was to detect the existence of pedestrians. The detection of pedestrians was accomplished through the utilization of the Haar Cascade method, a robust technique for object detection in images.

For body detection, this system was able to detect the full body when a person walks by or is standing in front of the camera. The system's performance, precision, and accuracy were thoroughly evaluated through comprehensive testing and analysis. The results obtained from the evaluation process were then meticulously analyzed, providing valuable insights into the system's overall performance in enhancing pedestrian safety at crossings. Real-time object detection yields a 78% accuracy rate for correct detections and a 22% rate for incorrect detections of 100 test images, with an average processing time of 0.3 milliseconds.

Acknowledgement

This research is supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Tier 1 Grant Research (Q361).

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nur Zulaikha, Nik Shahidah;* ***data collection:*** *Nur Zulaikha;* ***analysis and interpretation of results:*** *Nur Zulaikha, Nik Shahidah, Suhaila;* ***draft manuscript preparation:*** *Nur Zulaikha, Nik Shahidah. All authors reviewed the results and approved the final version of the manuscript.*

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