Presence sensor for people detection and reduction of pedestrian waiting time in traffic light

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***Abstract*—With the increase in the fleet of vehicles, not only the drivers waste time waiting at traffic lights but also pedestrians who waste time waiting to close the vehicle traffic light in order to safely cross the street. In this way, this work presents a new alternative of a pedestrian detection system that can replace the button press system, which is currently used. The system presented in this work consists of infrared and piezoelectric presence sensors. In order to verify the influence of a pedestrian detection system in traffic, simulations were performed in one scenario in the software AnyLogic.**

***Index terms*—** pedestrians detection, infrared, piezoelectric.

I. Introduction

The development of cities and the urbanization of it have led to an increase in the number of automobiles in all countries, because people had looking for means to moving from one place to another. With the increase of the fleet it was necessary to increase also the number of intersections with the objective of providing greater security for the crossing of pedestrians and vehicles.

A divece used to authorize or prohibit the movement of vehicles and pedestrians on a road is the traffic lights. And there are two types of traffic lights, vehicular, to to authorize or prohibit the movement of vehicles and traffic lights for pedestrian to to authorize or prohibit the passage of persons [7].

Thinking of benefiting the pedestrians who waste time waiting to close the traffic of vehicles to be able to carry out the crossing of the street with safety, was installed the push button in strategic points in several cities of Brazil. These buttons are intended to inform the traffic controller of the presence of the pedestrian. However, these buttons are not always accessible to all people, especially those with special needs. According to [8], when used, the pushbuttons must be easily accessible and operable from a flat surface for wheelchair pedestrians and visually impaired persons. They should be conveniently placed in the area where pedestrians wait to cross the street. However, there is still a difficulty for the visually impaired to locate the button.

Recent works propose pedestrian detection via image processing, such as [4], [2], [1], [5]. But the use of image detection requires high processing, in addition to a database to be used in recognition. With this in mind, this work is aimed at specifying, analyzing and testing presence sensors (infrared and piezoelectric) to detect pedestrians to be installed at traffic lights in order to reduce the pedestrian waiting time, increasing the efficiency of both traffic vehicles such as pedestrians.

II. Basic concepts of traffic engineering

The capacity of a signaled approach is defined as the maximum number of vehicles capable of crossing intersection. Therefore, the capacity of a path interrupted by a traffic light is determined by the saturation flow [7]. Mathematically the capacity (c) is given by,

$$c = S\frac{g_{ef}}{C}, \tag{1}$$

where S is saturation flux, g_{ef} is the effective green time and C is the cycle time.

The saturation flow is defined as the flow that would be obtained if there were a row of vehicles on the approach and it was given 100% of green time of the crossing, i.e., an uninterrupted flow [7]. It is soon apparent that the available green time is not equal to the green time used. There is a loss at the beginning of time and a gain at the end with the time of yellow. As we have in Figure 1 Adapted from [7].

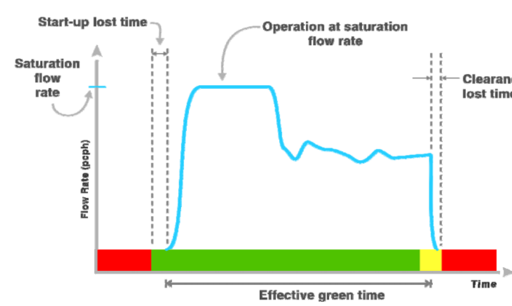


Fig. 1. Typical flow rates at a signalized movement.

The effective green time (g_{ef}) is given by

$$g_{ef} = G + Y + R - (l_1 + l_2), \tag{2}$$

where G is the normal green time, Y is the time of yellow, R is the time of red, and $l_1 - l_2$ is the time lost , which is given by the initial lost time (l_1), and the lost time of debugging (l_2).

The minimum green time for the pedestrian is given by,

$$g_p = pw + pc, \quad (3)$$

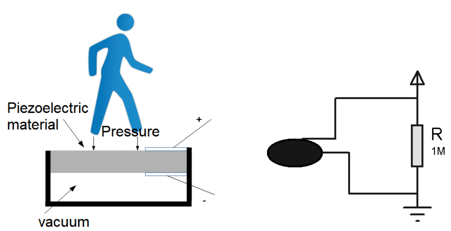
where pw is the duration of the walking interval and pc is the debug interval for the pedestrian.

III. Sensors

The use of sensors is essential in the modern world. Whether it is to control industrial processes, monitor climatic and environmental conditions or simply facilitate everyday life procedures, we can find them in a variety of situations. In this topic we will discuss the presence sensors: piezoelectric and infrared.

A. Piezoelectric

Piezoelectric sensors are pressure sensors. According to [3] these sensors are commonly used on the floor under carpets to detect the presence of objects or people on a certain surface (Figure 2).



(a) Sensor with piezoelectric material detecting pressure.

(b) Circuit.

Fig. 2. Sensor piezoelectric.

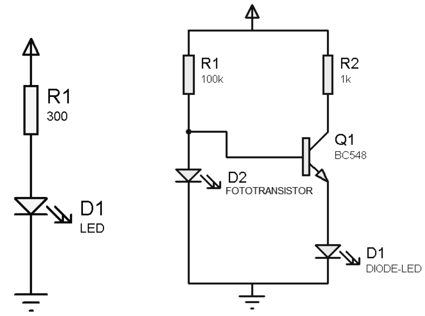
B. Infrared

Infrared sensors can be active or passive. The sensor used here is an active, because the passive sensor is more sensitive to sunlight. The active used here has two devices, one that emits (emitter) and another that receives (receiver) the infrared rays. The emitter and receiver form an infrared beam and when this beam is interrupted the sensor sends the detection signal to the controller (Figure 3).

Fig. 3. Infrared sensor detecting person.

The sensors consists internally of a switch (transistor) in which they alternate between two levels: high or low. The high state is a voltage of 5V and the low state is a voltage of 0V. This switch can be connected in two ways: with a pull-up resistor or pull-down resistor (Figure 4).

These sensors can be used in security applications such as alarms, perimeter protection, automatic lighting, garage doors and others [6]. Here it was used to detect people (Figure 3).



(a) (b)

Fig. 4. Circuit for the infra-red sensor: (a) emitter and (b) receiver.

IV. Proposed System

To perform pedestrian detection we will used the infrared and piezoelectric sensors in order to verify which one has a better response to the detection system. Figure 5 illustrates the two cases of detection, using infrared and piezoelectric. Unlike the push buttons in which the user needs to press them into this proposed system, the user is detected automatically, either by weight (under-floor pressure) or by interrupted infrared beam.

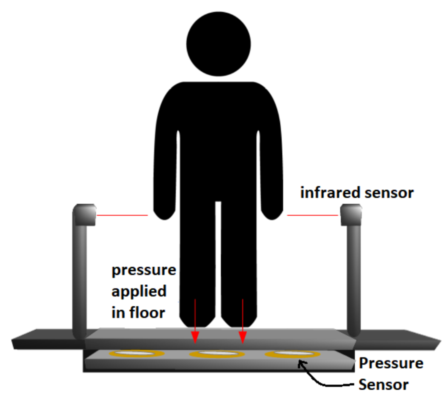


Fig. 5. Ilustration of the pedestrian detection system for the two cases.

In order to verified the final cost of materials for implementation of hardware of the detection system with infrared and piezoelectric sensor we presented the tables bellow. By the Table II we see that the system with the piezoelectric has a high cost compared to the system with infrared.

TABLE I
Cost of Material for Infrared System Detection

Item	Amount	Final cost ($)
Phototransistor Infrared TIL78	1	0,78
LED emitter IR TIL32	1	0,78
Resistors	3	0,78
Transistor BC548	1	0,30
Phenolite Board	2	2,61
PVC support	1	1,04
Wires	1	2,61
Encapsulation	2	10,45 (PVC)
TOTAL	-	19,33

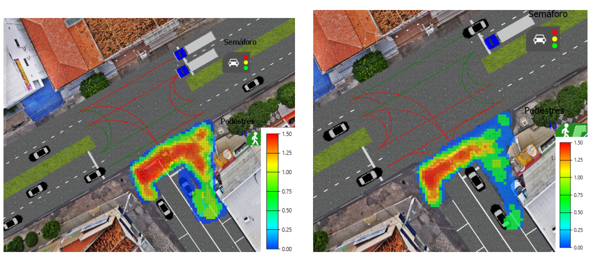
TABLE II
COST OF MATERIAL FOR PIEZOELECTRIC SYSTEM DETECTION.

Item	Amount	Final cost ($)
Resistors	7	0,91
Piezoelectric Capsule 50mm	7	1,83
Phenolite Board	7	9,15
Flexible Floor	1	11,76 (50x50cm)
Wires	1	3,07 (6 m)
TOTAL	-	27,84

V. RESULTS AND ANALYSIS

A model of an intersection in the *software AnyLogic*[1] was implemented to analyze the impact of a pedestrian detection system in the vehicular flow through the avenues.

Figure 6 shows the density map of pedestrian trying to cross the crosswalk. Figure 6 (a) shows the density map without control of pedestrian crossing because of that there is a greater density of tumultuous people. Unlike the Figure 6 (b) in which a control for pedestrian crossing was used there is a lower concentration of people.

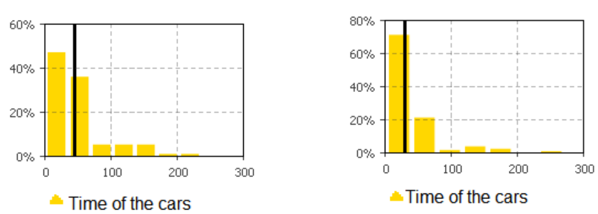


(a) (b)

Fig. 6. Simulation of intersection with density of pedestrian intending crosses the avenue: (a) No pedestrian detection; (b) With pedestrian detection.

In a way the use of time-out systems for pedestrians decreases the green time of vehicle traffic lights, since these need to be closed so pedestrians can cross the avenue. One way of not affecting vehicle traffic is by using a traffic light control based on the density of vehicles on the road, or in other words an intelligent traffic light.

Also using the same modeling of the intersection shown in Figure 6, we compared the scenario with transitional time of fixed and variable traffic lights time (Figure 7).



(a) (b)

Fig. 7. Time the cars remain on the scene: (a) Traffic light with fixed time; (b) Traffic light with variable time.

[1]AnyLogic is a multi-method simulation modeling tool developed by The AnyLogic Company https://www.anylogic.com/.

In Figure 7 (a) we have the mean time in seconds for the traffic light with a fixed time, in which an average time of $45.08s$ was obtained. In Figure 7 (b) we have the mean time in seconds for the traffic light based on traffic density, in which an average time of $31.65s$ was obtained. Therefore the value of the average reduced with a difference of 13.43, when a variable time is used. This evidences the advantage of using the pedestrian detection system with a traffic light with variable time based on the traffic density, allowing a greater fluidity in the traffic.

A. Pratical results

In order to perform the physical implementation, 11 LEDs were used to simulate the luminous indications of the four traffic lights, three of which were for vehicles and one for pedestrians. The controller used was an ATmega328 coupled in the educational platform Arduino UNO.

In Figure 8 shows the final prototype of the physical system, in which this prototype was designed so that the infrared sensor had a minimum height of 50cm so as to detect children as well. For the piezoelectric sensor, a flexible floor with dimensions of 40cm x 25cm was used in which the piezoelectric sensors were installed on the surface of the floor in order to detect any deformation in it.

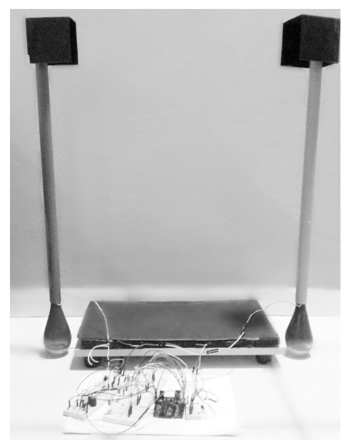
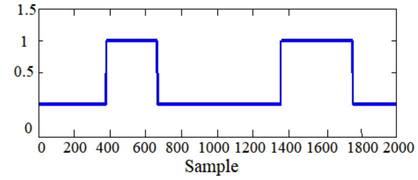


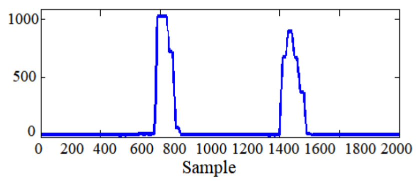
Fig. 8. Final prototype.

After the implementation of the circuit, the waveforms of response were obtained. In the figure 9 has the response of the two sensors. The infrared sensor has its analogue and digital output, in this case only the digital output has been used because it is more precise. The piezoelectric sensor has only the analog output. It has a threshold of 30, when a person is detected its value approaches 1000. The piezoelectric sensor is more accurate because any variation in the floor, even if it is minimal, it detects. In the infrared, positioning is required in order to interrupt the infrared beam between the transmitter and receiver pair.

As shown in Figure 9 the two sensors detect the pedestrian satisfactorily. However when using the infrared in an environment exposed to the sunshine it is necessary to use an encapsulation to protect the sensor from the rays of the sun,



(a)



(b)

Fig. 9. Response of the sensors: (a) Infrared sensor detection response; (b) Piezoelectric detection response.

preventing the rays from interfering with the response of the sensor.

The main idea of this system of reducing pedestrian waiting time is that when the pedestrian is detected, an interrupt signal is generated for the controller and it is programmed for when this signal reaches the green light indication of the traffic light must go to (LOW) and the green phase of the pedestrian will be HIGH (Figure 10).

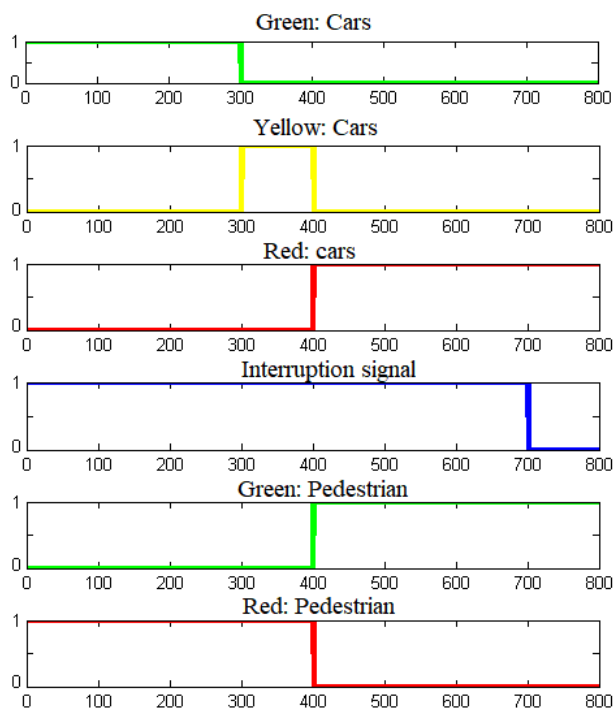


Fig. 10. Switching of traffic light phases and interruption signal.

Figure 10 shows the waveforms coming from the LEDs, for the vehicle traffic light associated with the pedestrian traffic light.

VI. Conclusion

The use of the traffic light in conjunction with a reduced waiting time system for pedestrians charity not only the driver but also all pedestrians, whether they are disabled or visual, elderly or children. This system would provide accessibility for people with special needs by crossing the pedestrian crosswalk safely, since pedestrians are detected automatically. It also enables the pedestrian traffic light to only activate when the pedestrian is detected in this way will be required to carry the passage only in place indicated.

In this work was implemented the prototype of the system which was shown efficiency in the detection of people. It has been seen that the piezoelectric sensor is more sensitive when compared to the infrared because any force applied to the floor it detects. Different from the infrared to which it is necessary to interrupt the beam of infrared light. One disadvantage of infrared is its sensitivity to the sunshine, to avoid them the sensor must be covered by a material that prevents the entrance of sunlight. However it has a lower material cost if compared with piezoelectric. By the way, this system could be adapted to use other types of sensors, for example ultrassonic or lidar, but tests need be done. This is an idea for futures works.

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