An IoT Monitoring Design System of Road Overload Vehicles Based on Raspberry Pi

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Abstract – *The overload vehicles are the basic challenge of the road users because it caused many harms for roads and accidents in the roads. There are many who have been died everyday due to collapsing of roads. Automatic monitoring system became necessary and highly demanded to overcome this problem. This paper presents the design of wireless monitoring system based on Raspberry Pi model and using a camera for monitoring any case of breaking the law. The proposed design in this paper has a low cost and it has a simple structure. The system establishes a database to archive all the cases of infringing the allowed legal weight limit of the road. The camera captures an image when the vehicle's weight is out of allowed limit, the data is sent directly to the database which includes the date, time, weight and the path of the captured image. A webpage is used to provide an easy monitoring of the system. The system is experimentally tested several times and the obtained results show that the system has good performance and accurate results.*

Keywords: *Raspberry Pi, Sensor, IoT*

Article History
Received 18 January 2020
Received in revised 31 March 2020
Accepted 3 April 2020

I. Introduction

The increasing number of vehicles recently makes the management of every vehicle passing the road becomes more challenging. Therefore, the use of intelligent technology became necessary to replace the traditional system [1]-[2]. Despite of the load type, an appropriate loading of vehicle is important for safety travel because it helps to make the vehicle stable [3]. The overloading is a serious problem, involving not only the passengers but it also causes a damage to the road surfaces. A Canadian report shows that in many cases, the lifetime of the roads is decreasing due to the increased number of trucks that exceed the weight limits [4]. Drivers will have serious problem to steer the vehicle easily and it takes longer time to stop [5]. The overloading of car causes overheating in the tire which results to blow out the tire [6]. The overloading of vehicle put all the users of road at risks [7]. Indian Foundation of Transport Research and Training reported that 50% of the road accidents were occurred due to overload trucks, where based on this report over 92,500 people were killed each year in road accidents in India as a result of the wheels of the overloaded vehicles [8]. Unlike most of the published paper which often focused on monitoring the speed of the cars, this paper proposes an intelligent system of monitoring the violation of weight. The system uses Raspberry Pi technology which provides an easy mechanism for connecting a camera. The rest of the paper shows survey of the recent published works related to the field and explains the method and results of the paper.

II. Survey of Related Works

The risks of the overloaded vehicles to the economy and the increasing number of deaths associated make it an important issue discussed among researchers in many fields. The significance of this paper is in the use of modern control device and providing database which lists the cases of the law breakers. It also can be used for government future planning of maintenance. In Qingwu et al. [9], a design of monitoring vehicles in urban roads was shown, where the idea of the paper is based on using computer vision technology to recognize the license plate number of the vehicle by extracting it from the video. The system is designed only to be use for monitoring the road traffic without the ability of specifying the weight of

vehicles. Paul and Michael in [10] describe in their paper the implemented management system of monitoring the overload vehicles in South Africa. The paper evaluates the benefits of the system and it is not showing a real design. The paper concludes that the system has good performance in detecting the violation done by the transportation company. Paul A.et al. [11] presents an evaluation of the automatic overload monitoring system in France, where the system starts in 2007 and it provides the total vehicle length in addition to the gross vehicle weights. The system is not using the Raspberry Pi technology and it generally consists of camera, two piezoceramic sensors and two magnetic loops. The paper shows example of application to pavement and bridge assessment. The paper concludes that the check efficiency is improved by a factor 3. Yan Y. et al. [12] presents a monitoring design based on Polyvinylidene Fluoride (PVDF) traffic sensors, where the system consists of CPU unit, A/D converter and communication circuit, and it does not contain an internet connection and database system. The paper concludes that the system provides low cost and easy implementation, thus it can be used to solve the problem of overload vehicles.

III. Raspberry Pi Device

The Raspberry Pi is low cost single board computer which provides full functional of computer in tiny device [13][14]. The configuration of Raspberry Pi uses a USB ports where it allows simple connection between the Raspberry and any other USB compatible devices such as keyboards, camera and etc [15]. Raspberry Pi contains a network port which give it the ability to connect to any computer network through cable. Camera Serial Interface (CSI) enables the use of the designed Raspberry Pi camera module. The GPIO consists of 40 metal pins distributed by twenty pins in each side of the Raspberry. There are several models of Raspberry Pi released since the first version appeared in 2012. In June 2019, the latest released of Raspberry Pi 4 model 4 was released. Python language is the most common language that is used in programming the Raspberry Pi. It is a high level language which was created in 1980 by Guido van Rossum [16].

IV. Principle of Weight Sensors

The common structure of mechanical weight sensor often uses a steel spring. The operation mechanism of this weight sensor is based on Newton Law, where the weight can be given by the following formula:

$$mg = k(\Delta x) \quad (1)$$

where:

m : is the spring mass

k : is the spring stiffness

Δx: the displacement between the space mass position and the new position due to mass pressure on the string.

Load cell is the most common method that converts the pressure of the object in strain gauge to electronic output. The change on strain gauge produces a change in the resistor which play important role in specifying the output value. Piezoelectric materials sensors can produce electric field when an external force is applied on it. The principle of piezoelectric effect was discovered in 1980 [17]. Polyvinylidene Fluoride (PVDF) sensors is a type of piezoelectric film sensors which generate electric voltage when a mechanical stress is applied on it [18].

V. Methodology and Results

As shown in Fig.1, the simple model of the circuit configuration is consisting of camera, weight sensor and the Raspberry Pi.

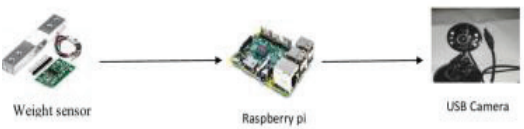

Fig. 1. Basic configuration of Raspberry Pi circuit

The mechanism of connecting the weight sensor to the Raspberry Pi is shown in Fig.2.

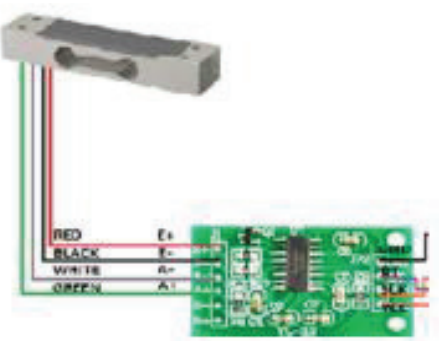

Fig. 2. Sensor connection to Raspberry Pi

Then the reader is connected to the other side with Raspberry Pi pins using four connecting wires to the ground pin, V_{CC} pin , SCK and DT pins. The configuration of the design also includes the camera, keyboard, mouse and a Wi-Fi in the USB slots of the Raspberry Pi, connected through HDMI connection for displaying. A power supply is connected to provide 5 volts which is needed to operate the circuit.

The Raspberry Pi controller is considered as the heart of the system where all the operations are processed through it, starting by reading the sensor values. The data is then analyzed weather they are within the normal load or overload. It also controlling the operation of the camera when it should capture a photo and sending the required data to the database. The normal load was specified less than or equal 40 gm for simulation purpose.

VI. Software Implementation

In the software section, firstly the website page is created in which our database is displayed as shown in Fig.3.

Fig. 3. Website page displaying the database

The software code is divided into two parts, the first one is for the sensor and the second one is for the camera. The result of the code is saved in a folder called load cell. In this code, we defined a variable called *w* to display the value of the weight which measured by the sensor. Here is the code of the sensor:

```
# / usr / bin /env python3
Import RPi . GPI0 as GPI0
From hx711 import HX711
GPI0 .setmode (GPI0.BCM)
hx = HX711(dout_pin=21 , pd_sck_pin=20)
while 1:
 # create / pin object
 hx = HX711(dout_pin=21 , pd_sck_pin=20)
 w=hx . get_raw_data_mean( )
 print (int(w/100) , "g")
```

In the next step a new window is opened and used to write the code of for the camera. In the first line, the code specifies to define the language of our code (bash language). Secondly, it calls up the load cell folder of the sensor to connect with camera code, execute the sensor code and save the value in load cell folder. Thirdly, it defines the variable called (DATE) to be the name of the captured image which consists of the date and the time with hours, minutes and seconds. Fourthly, it defines the path in which the image would be presented and saved. Fifthly, it defines a variable called value to present the image and print the value of the weight. Sixthly, it gives an order to open the webserver in the link and displays the image in a show window.

The design flow is shown in Fig. 4. When the overloaded car comes over the weight sensor which is installed in the monitored road, the sensor measures the car weight and send it to the Raspberry Pi. The Raspberry Pi the decides if the car has overload or not according to the standard weight reference which is stored in it previously. In the normal weight case nothing will happened , but for overweight case, the Raspberry Pi orders the camera to capture an image of the car, write several data (date, time, weight) related to the car and send the information to the database on the online website – via IoT. All information become available to all personnel online.

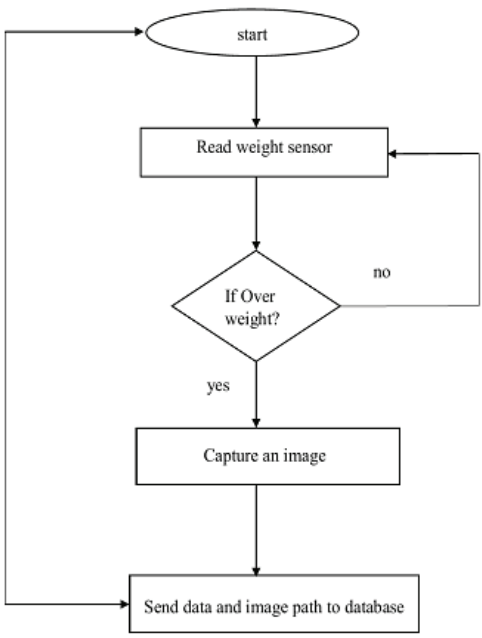

Fig. 4. Flow of System Algorithm

VII. Results and Discussions

The experiment execution are shown in two scenarios, the normal case in which there is no overload and the overload case where the weight is over the reference value that specified by the design operator.

A. Normal case (no overload)

In this case where the weight is less than 40 gm, the camera will not capture an image and the database will not receive any information because this considered a normal weight allowed for vehicles on roads. Therefore, the information was not required to be saved in database to avoid crowded of information.

B. Overload case

In this case where the weight exceeds 40gm, according to the reading of the sensor the Raspberry Pi writes the order for the camera to capture an image of the car and writes the data of the image (date, time, weight). The appearance of the execution window is as shown in Fig.5.

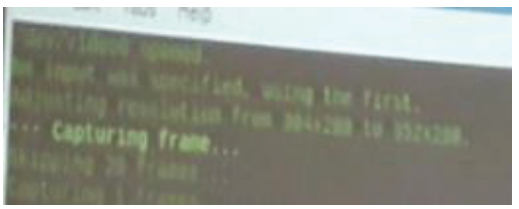

Fig. 5. Capturing image execution window

The experiment is repeated ten times to ensure that in each case the results of the system will be reported correctly in the database with the correct date and time as shown in Fig. 6.

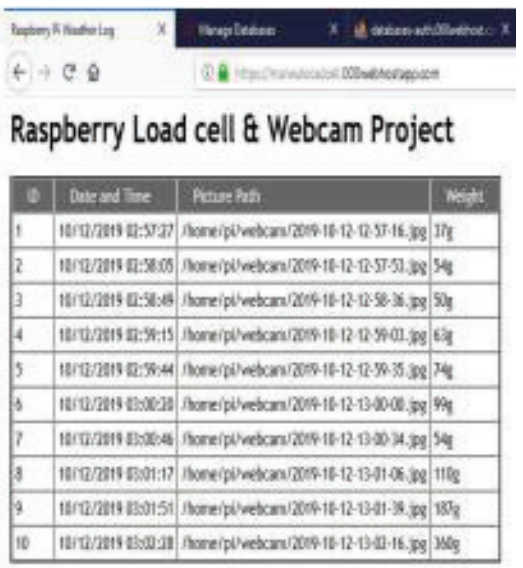

Fig. 6. Displayed Table of Database

In the database table the date and time of capturing the images are reported continuously as shown in Fig. 6. The information is helpful for future planning of the road required maintenance time. The results of the database show the path of the captured image of each overload car, which illustrates the car number, therefore it can be used to prove the infringement case. For example in the fifth test, the infringement occurred in the referred date and time and by tracking the path of the capturing image as shown in Fig. 7 and Fig. 8.

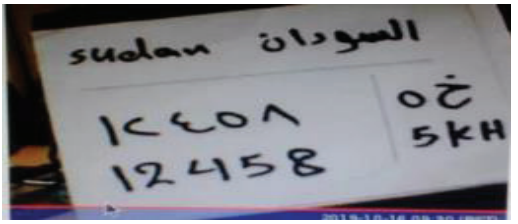

Fig. 7. Image rom the 5th test I

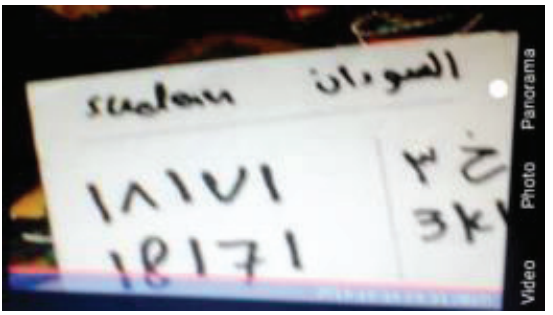

Fig. 8. Image from the 5th test II

VIII. Conclusion

Automatic monitoring overloads vehicles is required to reduce the human efforts and protecting the users of the roads from the problems that can occurred due to overloads vehicles. In this paper raspberry pi is used to monitor roads by using weight sensors in this roads, read weights , capture images for over weighted vehicles and saving the results in a web hosted online database to become available for government authorities.

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