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Raspberry Pi Image Processing Based Economical Automated Toll System

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Abstract - The highway toll system has already been developed and widely used in many developed countries. But most of them use Radio Frequency ID. In developing countries RFID for each car does not exist. And using RFID is still a costly solution. Some of the developing countries use image processing technique to detect license plate for auto toll system. But the problem is not solved yet due to high price of host device (e.g. computer) to run. Implementation of image processed toll systems are only limited in some places. Keeping these problems in mind we have developed this project where raspberry pi will be used as host. This minicomputer has the ability of image processing and control a complete toll system. A camera will be used to take picture of the vehicle's name plate to sort the toll charge according to vehicles category. Along with multiple automatic tolls taking booth there will be a manual booth with operator also who will handle those vehicles which experience issues with any of the automatic toll taking booth.

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GJRE-F Classification : *FOR Code: 080106, 290903*

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Raspberry Pi Image Processing Based Economical Automated Toll System

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I. Introduction

In developing countries likes Bangladesh the amount of vehicle is increasing rapidly. According to 3rd-EST-Forum Bangladesh Country Paper, annual growth of vehicle is more than 10% and most of them are motor vehicle [1]. So the manual toll system has become a real concern in Bangladesh. Being one of the leading developing countries, Bangladesh is not able to implement automated toll system due to its vast vehicle amount and high cost of implementation on a large scale. At present Bangladesh government has taken steps to digitalize all the vehicles license plate number. So, countries with digitalized license plate numbers can use this project to implement at a negligible cost for automated toll system. There are several countries like china has developed RFID based toll system [2]. There are some researches on developing image processing based toll system like Vehicle Number Recognition System For Automatic Toll Tax Collection by Shoaib Rehman [3] but it's based on computer dependent image processing system. In this system raspberry pi based image processing system depending automated toll system has been proposed. Raspberry Pi will take picture through Wifi camera and process the image of license plate. It will connect with database and subtract the toll from user account. When the toll is received the barrier will be moved automatically and after the car has passed the barrier will be placed again automatically.

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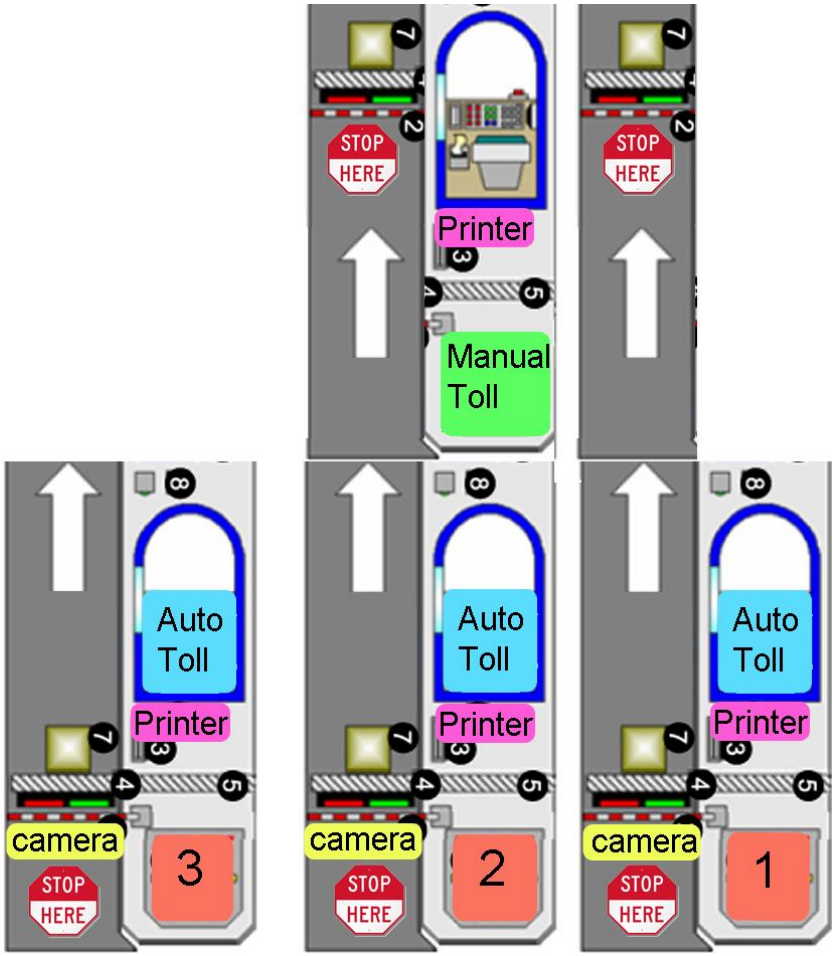

Figure 1 : Complete project outline of Automated toll system

II. Hardware Diagram

There are two types of unit in this system. One is automated toll unit and another is manually toll collecting unit. Both these units are connected internally through RF transceiver. If automated unit face any obstacles like unauthorized vehicle number, insufficient balance etc then the vehicle needs to pay toll through manual system.

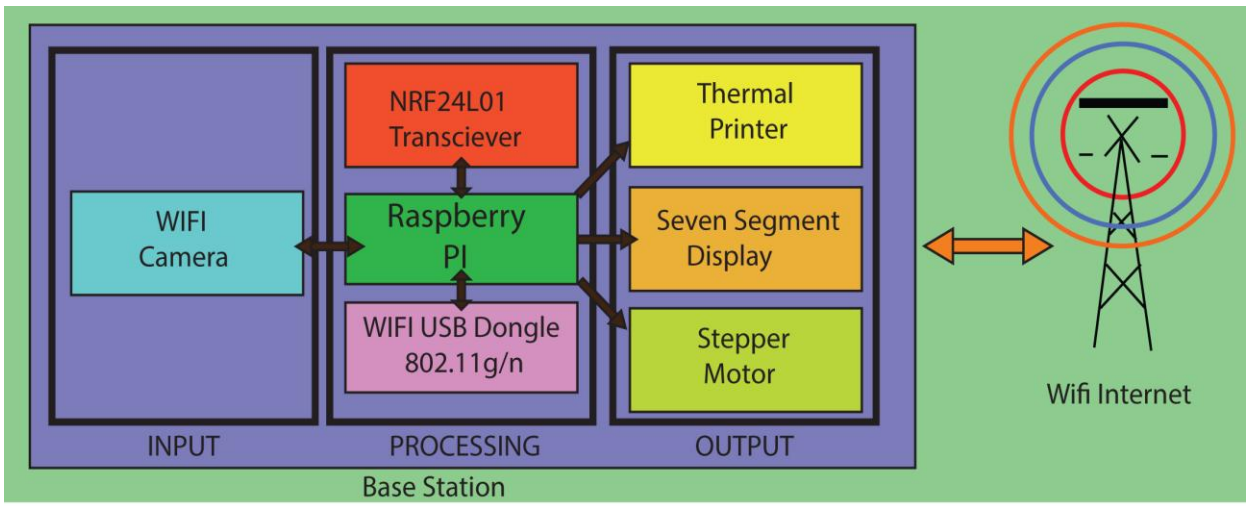

Figure 2 : Automated toll processing unit

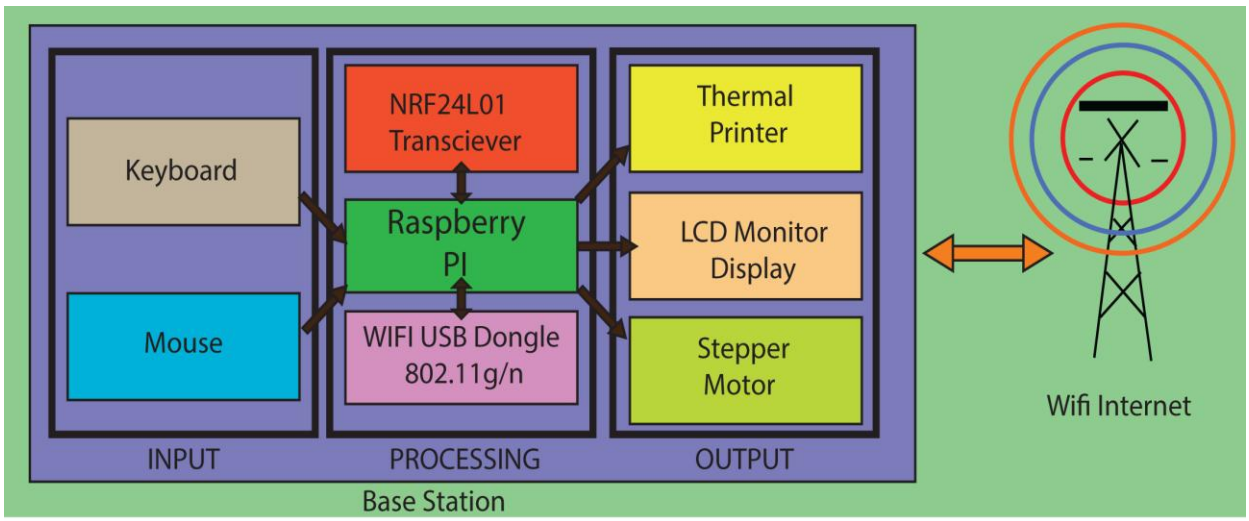

Figure 3 : Manually toll processing Unit

An automated toll processing unit consists of wifi camera to capture the license plate number. In processing there are Raspberry Pi, NRF24L01 transciever & Wifi USB dongle. In output section thermal printer, seven segment display & stepper motor is connected. Raspberry Pi receives the image from wifi camera through wifi network. And through optical character reading algorithm it identifies the license plate number. As the pi is connected with internet it transmits the number to server for matching and subtraction of toll from users account. When successful transaction occurs the stepper motor rotates 90degree clockwise and opens the barrier. Seven segment display starts back counting of 20seconds. Within 20seconds vehicle needs to pass the barrier and after 20s stepper motor again rotates 90degree anti clockwise and close the barrier. Thermal printer prints the toll token and the system is ready for the next vehicle.

If any problem occurs the vehicle is indicated to go to manual terminal for manual toll payment. Manual system also consists of Raspberry Pi, as input here keyboard and mouse is used. Operator will enter the license plate number manually. The toll amount will be entered manually and printer will print the token.

All three auto terminal is connected with manual terminal through NRF24L01 transceiver. If any problem occur auto terminals indicate that to the manual terminal. All the terminals are connected to a tweeter account. They keep updating car number, amount of toll taken or any other issue it faces on tweeter through wifi.

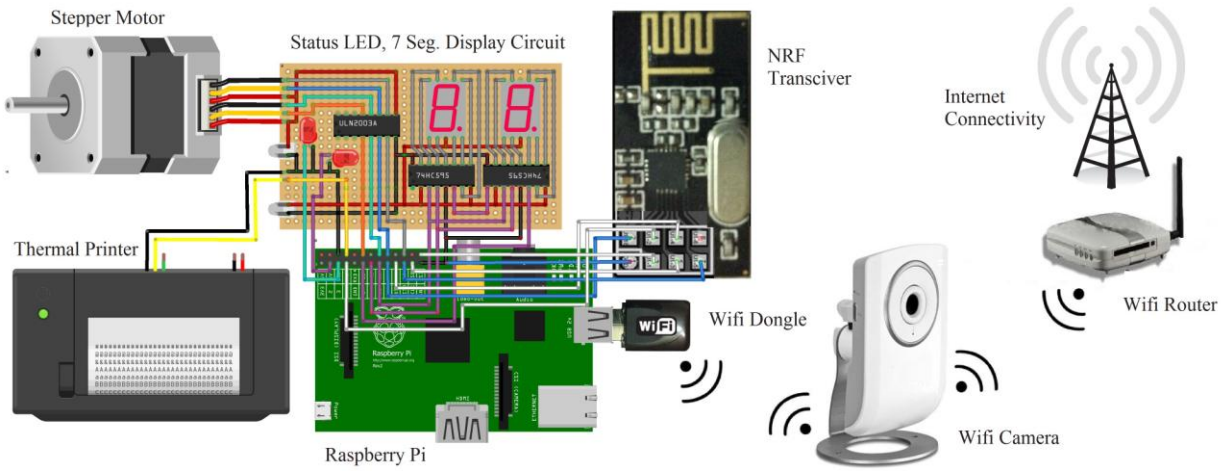

Figure 4 : Prototype Design of auto toll unit

III. Hardware Prototype

Raspberry Pi Model B has 512Mb RAM, 2 USB ports and an Ethernet port. It has a Broadcom BCM2835 system on a chip which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and an SD card. It has a fast 3D core accessed using the supplied OpenGL ES2.0 and OpenVG libraries. The chip specifically provides HDMI and there is no VGA support. The foundation provides Debian and Arch Linux ARM distributions and also Python as the main programming language, with the support for BBC BASIC, C and Perl.

Figure 5 : Raspberry Pi model B

Thermal printer is a serial printer which is used in several places like credit card machines, bus ticket counters etc. A printer has power, ground, RX & TX.

Figure 6 : Thermal Printer

IV. Circuit Analysis

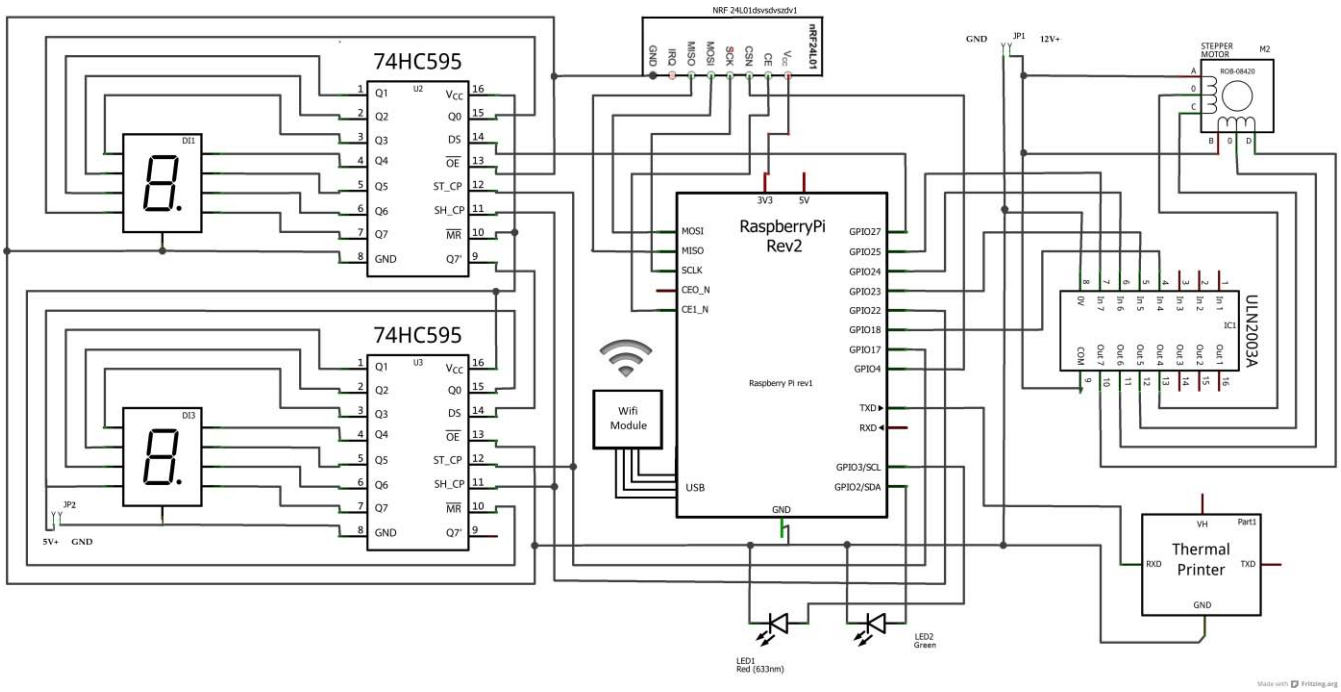

Figure 7 : Schematic diagram of auto toll section

Heart of this project is raspberry pi minicomputer. To interface with NRF24l01 raspberry pi has SPI. MISO, MOSI, SCK & SS pins of NRF transceiver is connected with MISO MOSI, SCK & SS pins of raspberry pi. Uart is used to communicate with thermal printer. Rx of raspberry pi is connected with Tx of thermal printer. The tx of thermal printer is not needed. Wifi dongle is connected through USB port. Other parts like seven segment display, stepper motor are controlled through GPIO pins. In manual entry section keyboard and mouse is connected in USB port of raspberry pi. As display 24' tv is used which is connected through a AV cable. The complete system is running on Linux ARC platform.

Two shift register (74HC595) is used to control seven segment displays. The shift register holds what can be thought of as eight memory locations, each of which can be a 1 or a 0.

To set each of these values on or off, we feed in the data using the 'Data' and 'Clock' pins of the chip. The clock pin needs to receive eight pulses, at the time of each pulse, if the data pin is high, then a 1 gets pushed into the shift register, otherwise a 0. When all eight pulses have been received, then enabling the 'Latch' pin copies those eight values to the latch register. This is necessary; otherwise the wrong LEDs would flicker as the data was being loaded into the shift register. The chip also has an OE (output enable) pin, this is used to enable or disable the outputs all at once.

The ULN2003 is a high voltage, high current darlington array containing seven open collector darlington pairs with common emitters. Each channel rated at 500 mA and can withstand peak currents of 600 mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout. 4 GPIO of raspberry pi is needed to drive the stepper motor.

V. Main Technology used

Image processing is the key factor of this project. In this project matlab is used to process the image [4]. In this project template matching algorithm is used. Here is the flow chart.

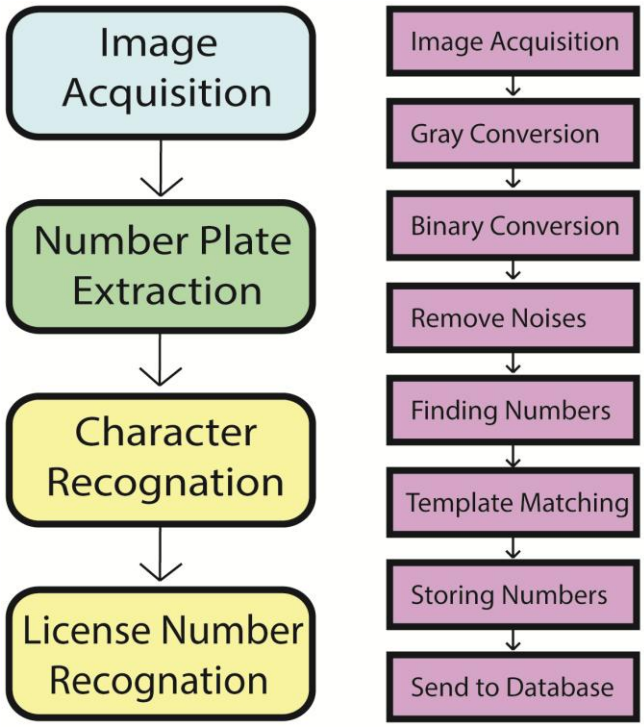

Figure 9 : Algorithm of optical character recognition

At first the front license plate number is captured through webcam and it crops an approximate area where the license plate could exist as the car stand stationary in front of the camera. Matlab code for these operations is

```
vid = videoinput('winvideo', 1, 'YUY2_640x480');
vid_src = getselectedsource(vid);
vid.ReturnedColorspace = 'rgb';
start(vid)
image=getsnapshot(vid);
imshow(image);
imagen= imcrop(image,[655 1153 560 85]);
```

Figure 10 : Cropped image of license plate

After converting it to grayscale & then binary image it looks almost same. Then the noise as the high pen is removed from the image.

Figure 11 : binary image removing noise

Through template matching in bangle the letters are saved in English in excel file. Here is the image of the output optical read digits.

	A	B	C
1	license number		
2	232813		
3			
4			

Figure 12 : License plate numbers stored in excel

Now this license plate number is sent to database for finding its toll amount and subtract the toll amount from users account.

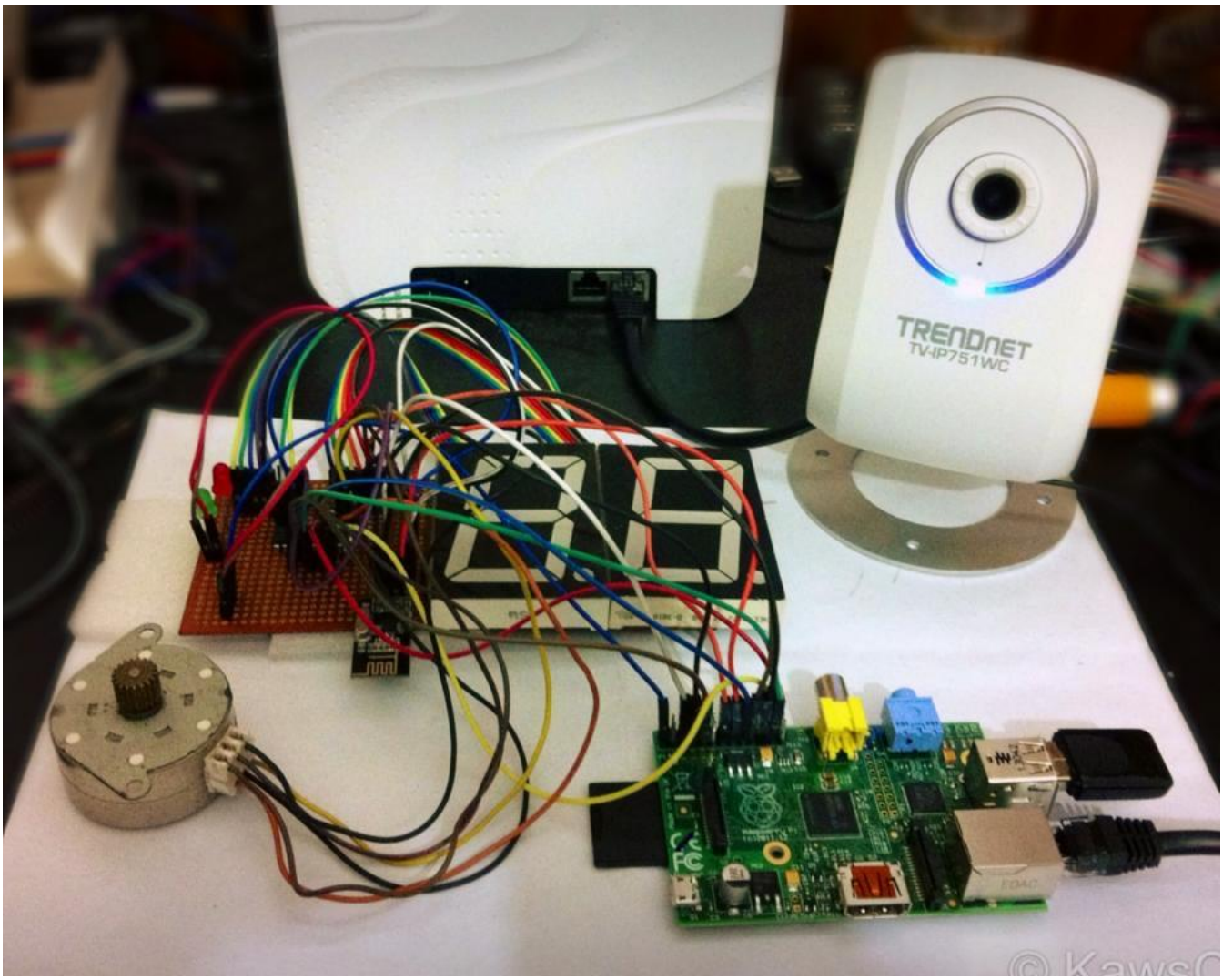

Figure 13 : Hardware implementation of complete toll system.

VI. Outputs & Update of Status

The complete system is connected with internet. Each toll both transmits an update to tweeter. All the errors or users information is stored in data base also. But for repair, hardware faults or user fault each booth sends a tweet to main toll head office tweet account.

First we need to install some required packages, open up a terminal on the Raspberry Pi, install the Python development headers and the ip package manager:

sudo apt-get install python-pip python2.7-dev.

Whenever a vehicle passes the system update its information on tweeter. Image of tweets are shown bellow:-

Figure 14 : Confirmation of payment from Tweeter

VII. Further Application

- Automated train ticket system.
- Automated bus ticket system.
- Unauthorized vehicle detection system.
- Traffic signal breaking detection system.
- Parking lot automation.

VIII. Conclusion

Raspberry pi based image processing is an new and advance technology which can open an era of computer vision. Other gestures and different types of image processing systems can be implemented in raspberry pi which will dramatically reduce the price of the system. But still there are some drawbacks like it has very limited memory which makes it difficult to store data and process database into it [6]. If these obstacles are overcome then it will become a great standalone embedded platform for different solutions.

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