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Traffic Signal Control for Emergency Vehicles Using IoT

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Abstract:
Day by day the traffic on roads is increasing and due to this we can see that there is a huge crowd on traffic signals. As traffic demand increases, vehicle speed slows down the traffic stream resulting in traffic congestion. Traffic congestion leads to delay in transportation and if there is any emergency vehicle like ambulance which needs to pass immediately, it gets delayed and can lead to huge loss. Due to this heavy traffic any emergency vehicle like ambulance or fire brigade gets delayed due to traffic on signals. To avoid this, we have made a device which works on IOT platform and can be used to control the traffic signal on spotting any emergency vehicle. First GPS module installed in the emergency vehicle will fetch the location to the nearest hospital and the route to the hospital will be set. Now when the vehicle approaches any of the traffic signals on the route, the GPS on the vehicle will transmit its location to the nearest signal on route. The nearest signal will turn green eventually when the emergency vehicle will come into a considerable range so that the traffic at that signal gets cleared before the emergency vehicle arrives. This will reduce the delay of the emergency vehicle due to traffic jams on traffic signals.

Keywords: Raspberry Pi, GPS module, LEDs, Resistors, Jumper wires, GPS module

I. INTRODUCTION

Day by day the traffic on roads is increasing and due to this we can see that there is a huge crowd on traffic signals. As traffic demand increases, vehicle speed slows down the traffic stream resulting in traffic congestion. Traffic congestion leads to delay in transportation and if there is any emergency vehicle like ambulance which needs to pass immediately, it gets delayed and can lead to huge loss. The Internet of Things (IoT) is a newly surfaced archetype which provides new opportunities in the field of communication and information technology. IOT can play a major role in cities becoming smart and fast.

The world's 1st stoplight was impermanent. It absolutely was an operated by hand gas-lit signal put in London in December 1868. It exploded but a month when it absolutely was enforced, injuring its police officer operator. Control began to appear necessary within the late Nineties and Earnest Sirrine from Chicago proprietary the primary machine-driven control system in 1910. It used the words "STOP"and "PROCEED", though neither word lit up. The inexperienced lightweight permits traffic to proceed within the direction denoted, if it's safe to try to therefore and there's space on the opposite faces of the intersection. The amber (yellow) lightweight warns that the signal is near to amendment to red. Actions needed by drivers on a traffic signal vary, with therefore me jurisdictions requiring drivers to prevent if it's safe to try to so, et al. permitting drivers to travel through the intersection if safe to try too therefore. A flashing amber indication may be a sign. A flashing amber lightweight is employed solely at pedestrian crossings, in situ of the combined red–amber signal, and indicates that drivers could pass if no pedestrian's area unit on the crossing. The red signal prohibits any traffic from continuing. A flashing red indication is treated as a stop sign. In some countries traffic signals can go in a flashing mode if the conflict monitor detects a tangle, like a fault that tries to show inexperienced lights to conflicting traffic. The signal could show flashing yellow to the most road and flashing red to the boulevard, or flashing red altogether directions. Flashing operation also can be used throughout times of day once traffic is lightweight, like late at the hours of darkness Due to this heavy traffic any emergency vehicle like ambulance or fire brigade gets delayed due to traffic on signals. To avoid this, we have made a device which works on IOT platform and can be used to control the traffic signal on spotting any emergency vehicle. As soon as the emergency vehicle is about to cross through a traffic signal, if there is red light in the signal, it will turn into green before a fixed interval of time. There is also a siren installed at the traffic signal to alert the other vehicles waiting at the signal that an emergency vehicle is approaching.

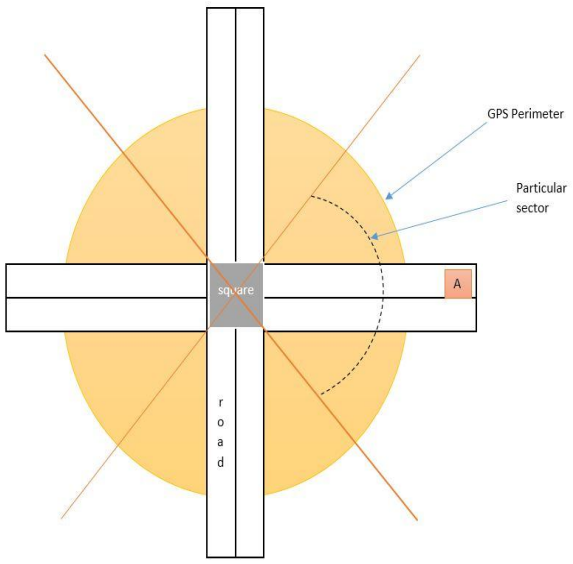

FIG. 1. DEPICTION OF HOW THE SYSTEM IS WORKING

First GPS module installed in the emergency vehicle will fetch the location to the nearest hospital and the route to the hospital will be set. Now when the vehicle approaches any of the traffic signals on the route, the GPS on the vehicle will transmit its location to the nearest signal on route. The nearest signal will turn green eventually when the emergency vehicle will come into a considerable range so that the traffic at that signal gets cleared before the emergency vehicle arrives. This will reduce the delay of the emergency vehicle due to traffic jams on traffic signals. The following procedure follows a set of algorithm and uses basic coordinate geometry for the following processes.

Distance Formula: Given the two points ($x1$, $y1$) and ($x2$, $y2$), the distance d between these points is given by the formula:

$$d= \sqrt{\{(x2 - x1)^2 + (y2 - y1)^2\}}$$

Now, using distance formula it is determined that the emergency vehicle is in range then the problem arises that to which plane the vehicle belongs. This can be determined by using the equation of a plane to which quadrant does it belong. Once quadrant is determined, the following traffic signals can be alerted sequentially. The horizontal axis in the coordinate plane is called the x-axis. The vertical axis is called the y-axis. The point at which the two axes intersect is called the origin. The origin is at 0 on the x-axis and 0 on the y axis. The intersecting x- and y-axes divide the coordinate plane into four sections. These four sections are called quadrants. Quadrants are named using the Roman numerals I, II, III, and IV beginning with the top right quadrant and moving counter clockwise. Locations on the coordinate plane are described as ordered pairs. An ordered pair tells you the location of a point by relating the point's location along the x-axis (the first value of the ordered pair) and along the y-axis (the second value of the ordered pair). In an ordered pair, such as (x, y), the first value is called the x-coordinate and the second value is the y-coordinate. Note that the x-coordinate is listed before the y-coordinate. Since the origin has an x-coordinate of 0 and a y-coordinate of 0, its ordered pair is written (0, 0).

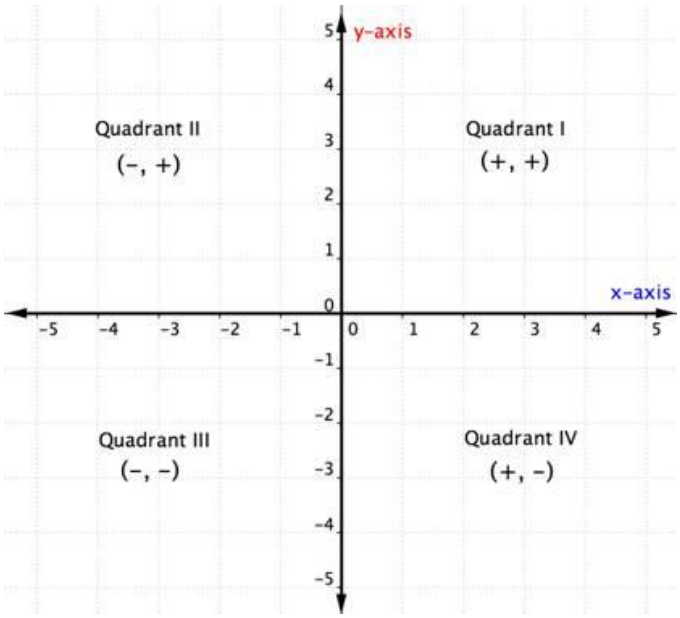

FIG. 2. DISTRIBUTION OF QUADRANTS IN A PLANE

Consider the point below.

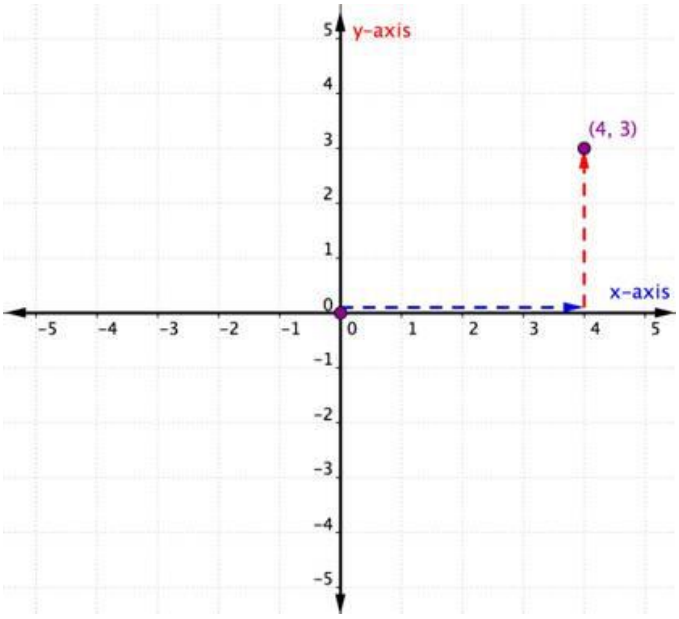

FIG. 3. FINDING LOCATION OF A SAMPLE POINT

To identify the location of this point, start at the origin (0, 0) and move right along the x-axis until you are under the point. Look at the label on the x-axis. The 4 indicates that, from the origin, you have travelled four units to the right along the x-axis. This is the x-coordinate, the first number in the ordered pair. From 4 on the x-axis move up to the point and notice the number with which it aligns on the y-axis. The 3 indicates that, after leaving the x-axis, you travelled 3 units up in the vertical direction, the direction of the y-axis. This number is the y-coordinate, the second number in the ordered pair. With an x-coordinate of 4 and a y-coordinate of 3, you have the ordered pair (4, 3). The area near the crossroad will be divided into four parts each having a particular set of coordinates, so the algorithm checks to which sector the vehicle is coming. Once the sector is identified, distance to the nearest signal can be calculated using coordinate geometry distance formula and thus the information is passed successfully to the nearest signal and the signal will turn green.

II. IMPLEMENTATION

Distance Measurement Techniques

At present, the popular distance measurement techniques include ultrasonic, infrared, laser, machine vision and radar measurements. The distance measurement based on machine vision obtains the value of the distance by the real-time processing of visual signals. There are different techniques to measure the distance between the vehicle and the camera. We perform the distance measurement by computing the Euclidian distance, Manhattan distance and Canberra distance. In the following we briefly discuss these distances:

Euclidean Distance

It is the geometric distance in the multidimensional space. One technique that may suit a wide variety of image analysis applications is the distance transform or a Euclidean distance map. In general, if a = (a1, a2, a3,…, am) and b =(b1, b2, b3,…, bm) are the two points in m-space, then the Euclidean distance (d_{ECD}) between points a and b or b and a is as follows:

$D_{ECD}(a,b)=(b1-a1)2+(b2-a2)2+.....+(bm-am)2=\sum i=1m(bi-ai)2$ (1)

Let the pixels within a two-dimensional frame (x, y) be divided into two classes: object pixels and background pixels. For2D points, a = (a1, a2) and b = (b1, b2) the Euclidean distance is:

$$dECD(a, b)= (b1-a1)^2 + (b2-a2)^2$$

Manhattan Distance

The Manhattan distance between two points is the absolute sum of the differences of their coordinates. In general, if a = (a1, a2, a3,…, am) and b =(b1, b2, b3,…, bm) are the two points in m-space, then the Manhattan distance (dMHD) between a and b is defined as follows:

$$dMHD(a,b)=\sum i=1m|ai-bi|$$

The Manhattan distance between points a = (a1, a2) and b = (b1, b2) is:

$$dMHD (a, b) = |a1 - b1| + |a2 - b2|$$

Canberra Distance

This distance is a weighted version of the Manhattan distance and is frequently used for data scattered around an origin. In general, if a = (a1, a2, a3,…, am) and b =(b1, b2, b3,…, bm) are the two points in m-dimensional real vector space, the Canberra distance (dCAD) between a and b is given as follows:

$$dCAD (a, b) =\sum i=1m|ai-bi||ai|+|bi|$$

The Canberra distance (dCAD) between two vectors a, b in 2D real vector space is given by:

$$D_{CAD} (a,b)=|a1-b1||a1|+|b1|+|a2-b2||a2|+| b2|$$

Since sensors' performance in distance calculation is highly dependent on the environmental conditions, vision systems are highly preferred for moving vehicle distance calculations. The accuracy of the distance measurement techniques is computed by comparing the simulation results with the true practically measured distance.

Vehicle Counting Method

An input video sequence of road traffic can be processed and analysed to get vehicle counts and speeds. The traffic management centre can utilize this information in a traffic signal control module, resulting in an efficient traffic management. The vehicle counting method includes the following steps:

i. Grayscale conversion.

ii. Foreground extraction.

iii. Defining Region of Interest (ROI).

iv. Thresholding.

v. Filling the holes.

vi. Morphological operations.

vii. Detect the vehicles entering the ROI.

Distance Based Emergency Vehicle Dispatching Algorithm

The sensor senses the presence of Emergency vehicles. The Emergency vehicles are ambulances, fire engines and police cars. Calculate the distance between the emergency vehicle and the intersection. The controller checks that the arriving emergency vehicles are at the same distance or not. If they are at the same distance, the controller randomly chooses the direction to set the green light. Else, he chooses the direction set in ascending order with the distance. Determine the green light duration based on the measured distance values and send these values to the traffic lights. Verify the passage of the emergency vehicle and measure the speed of the emergency vehicle and count the vehicles moving along with the emergency vehicle towards next intersection. The system sends the measured data to the next intersection. The controller checks for the presence of the emergency vehicle. If no vehicle, then it resumes normal operation. Else, it continues repeats from step 2 to step 6.

III. HARDWARE AND SOFTWARE DESIGN

In the proposed methodology we will provide solution to clearance of traffic to emergency vehicles like ambulance, fire-brigade, etc. This system works by continuously sending the location coordinates through google maps and a GPS module and these coordinates are received by a receiver/raspberry Pi and before 5 minutes(approximately) arriving to the signal, the traffic light will turn green to let pass the emergency vehicle.
The hardware components of the system are:

Raspberry pi

FIG. 4. RASPBERRY PI FOR COMMUNICATION AND PROCESSING

The Raspberry Pi is a series of small single-board computers. There are three generations of Raspberry Pi i.e. Raspberry Pi 1,2 and 3. In our proposed system, we are using Raspberry Pi 3. It contains the following components on it:

Four USB 2.0 ports (up to 480 megabits per second)
HDMI port
3.5mm 4-pole Composite Video and Audio jack
Micro USB Power Input
DSI Display Port
CSI Camera Port
MicroSD card Sold

40-pin GPIO (Male headers) On the proposed system, the single board computer (SBC) attributed with networking choice. We have selected raspberry Pi because it has the lowest cost among all SBCs. The operating system on raspberry Pi allows convenient software updates and installation like any other standard LINUX machine. It can also be configured as a web server. RPi provides a complete computing solution as provided by any desktop machine.

GPS (Global Positioning Module) Module

FIG. 5. GPS MODULE FOR SENDING LOCATION

GPS stands for international Positioning System by that anyone will invariably obtain the position data anyplace within the world. Firstly, the signal of your time is shipped from a GPS satellite at a given purpose. Later on, the time distinction between GPS time and therefore the purpose of your time clock that GPS receiver receives the signal are going to be calculated to come up with the space from the receiver to the satellite. An equivalent method are going to be finished 3 different on the market satellites. It's doable to calculate the position of the GPS receiver from distance from the GPS receiver to 3 satellites. However, the position generated by means that of this methodology isn't correct, for there's a mistake in calculated distance between satellites and a GPS receiver, that arises from a time error on the clock incorporated into a GPS receiver. For a satellite, associate degree timepiece is incorporated to come up with on-the-scene time data, however the time generated by clocks incorporated into GPS receivers isn't as precise because the time generated by atomic clocks on satellites. Here, the fourth satellite involves play its role: the space from the fourth satellite to the receiver are often wont to cipher the position in relations to the position knowledge generated by distance between 3 satellites and therefore the receiver, thus reducing the margin of error in position accuracy.

Registers
LEDs
Jumping wires
Breadboard

IV. CONCLUSION AND FUTURE WORK

This device will help in many deaths because of stuck of emergency vehicles in traffic at traffic signals. This device will help in faster movement of emergency vehicles even in heavy traffic cities without getting stuck in traffic jams. In the future, this device can be improved by making it more precise in determining the location of the emergency vehicles. There can also be some smart sensors which can detect the traffic density on the road and traffic signal which can be further analysed and the traffic light will change accordingly i.e. if the traffic density is more than as soon as the vehicle will enter the range of the traffic signal, the traffic light will change to green. And if the traffic density is less than the traffic light will change such that the traffic signal will change to green when the emergency vehicle will be nearer to the traffic signal thus avoiding traffic jam on the other side of the road. This project can also be linked with smart roads and smart traffic control system which will increase the efficiency of the device. In big cities with very heavy traffic, the range of the device installed in the emergency vehicle can be improved so that despite very heavy traffic, the emergency vehicle can pass through the traffic signal easily. There can also be an emergency siren installed at the traffic signal so that the traffic policeman and the public at that signal can be alerted that an emergency vehicle is approaching the signal so that emergency arrangements can be made at the traffic signal. There can also be an alert system installed in the hospitals so that the hospital, etc. can be alerted that an emergency vehicle is approaching so that they can make any necessary arrangements required according to the demand.

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