Smart Approach to Traffic Management using LabVIEW

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Abstract—This paper presents an intelligent traffic model which remedies some of the prevailing issues of traffic like over-speeding, corruption, casualties, fuel prices and crisis, traffic management. With various controllers along the roadside which are in continuous synchronization with on-road vehicles, some of the current road conditions are displayed on the screen inside the vehicle. The system raises the alerts in case of pedestrian crossing and over speeding along with the details of the fine imposed till date. The system is realized using LabVIEW graphical programming environment which confers its advantages. NI Vision Assistant and Vision Acquisition tools provides various image processing functional blocks which are helpful to calculate vehicle's speed.

Keywords—intelligent traffic system, wireless sensor networks, speed detection, LabVIEW based platform.

I. INTRODUCTION

According to the World Health Organization report, India records the highest number of road accidents deaths per year. About 5 lakh accidents take place on Indian roads killing about 1.3 lakh people and injuring about 5.2 lakh each year. These numbers translates one accident every minute and one death in road accidents every four minutes which is an alarmingly high number. Hence, the demand of the time is to design a system that makes the driver of the vehicle vigilent all the way about the current road conditions. Apart from it, the implementation of the proposed system is an effort to use the existing technology smartly in our day-to-day life and hence communicate the on-road traffic constraints dynamically to the driver.

In the past few years, many intelligent traffic systems have been proposed. One such example is of RFID based intelligent traffic management system [1], which aims at traffic regulation by calculating average speed and average traffic flow information that is sent to the server to find the shortest path. Other example includes Intelligent Traveler Information system (ITIS) [2]. It presents a vision of the next generation traveler information system, in which artificial intelligence techniques are drawn upon to create systems capable of providing travelers with more personalized planning assistance. However, all the past works done in this field lack that no model incorporates the features of traffic signal synchronization, speed detection, pedestrian alert system and at the same time smartly using the existing technology in our day-to-day life combined in single model. Moreover, no model establishes a mechanism that dynamically updates the driver about the present road conditions within the vehicle.

To incorporate this feature of dynamic on-road conditions synchronization, the model is designed in such a way that as soon as the client comes on the road (basically in the Wi-Fi range of the nearest master controller), it establishes a wireless connection with the master controller. The master controller communicates the information like the traffic signal status, signal timers, pedestrian alert and the speed limit of the road in the car, thus giving a full view of the road segment while the client is still far from the site. This helps the driver to manage his future drive accordingly, hence saving fuel and avoiding all sorts of road causalities to a great extent.

II. MODEL DESCRIPTION

The block diagram of the system is as shown in “Figure 1”,

![Figure 1. Block diagram of the proposed system](image)

The system is an assimilation of following two main sections:
- On-Road master controller along the road
- In-Vehicle navigation alert

The On-Road master controller along the road comprise of a controller for traffic light signals along with an over-speed detector system and a pedestrian switch (on the poles; where there is no traffic signal) while the In-Vehicle navigation alert is a Graphical User Interface (GUI) installed in the vehicle which displays traffic light model, signal timer, pedestrian alert, over speeding alert along with the total fine imposed. Additionally, the master controller is also connected with the databases at the central traffic control center.
control center. The data exchange between the master controller and In-Vehicle end is implemented using TCP/IP protocol. Being a connection oriented protocol, it poses less chances of data loss/interruption/override, thus bringing out an uninterrupted connectivity.

The data acquisition by the master controller is implemented with the help of virtual instruments (VIs) developed in LabVIEW. The easy to implement graphical programming features combined with the block diagram approach and the extensive set of toolkits available with the software, makes the image processing and data acquisition process quite simplified, and hence the architecture. Arduino development board is used as the prototyping interface between traffic lights and its timer with the master controller. Virtual Instrument Software Architecture (VISA) in LabVIEW is used for serial communication with Arduino development board.

III. ALERTS

![Figure 2. In-vehicle navigation alert display](image)

“Figure 2” is a snapshot of the GUI screen installed inside the vehicle displaying various alerts and information. The speed limit of the currently traversed road is displayed along with traffic signal status, signal timer and total fine till date. In case of pedestrian crossing and over-speeding, the corresponding LEDs glow.

A. Over-Speed detection

In recent years, extensive research has been done for speed detection of the vehicles. [3] Presents a Speed Detection Camera System using Image Processing Techniques on Video Streams while [4] proposes a vehicle speed detection system by developing software that use image processing techniques on a captured video shot. [5] Provides a hardware module used for moment detection in surveillance area using a sensor and a camera with LabVIEW as the software platform.

In our model, this feature of the system is achieved using image processing in LabVIEW. The tool used in LabVIEW called NI Vision Assistant, is a rapid prototyping tool for image processing. It is a collection of numerous vision functions for programmers and thus makes the design of image processing algorithm effective and faster. Along with this, NI Vision Acquisition is used to integrate external camera with LabVIEW.

The cameras are installed on the poles along the road for capturing images. These images are processed to determine speed of the vehicle using background subtraction algorithm which is implemented using the following steps,

![Figure 3(a). Background subtraction method](image)

![Figure 3(b). VI blocks used for vehicle blob extraction](image)

**Step I:** A reference background image is captured (with no client i.e. vehicle present on the road).

**Step II:** With the establishment of connection with the client, the processing is initiated and the camera continuously captures the images of the road. “Figure 3(a)” shows the absolute difference (D) of current frames (Im(t)) and background image (Im(ref)) resulting in higher intensity of pixels that have changed from the background,

$$D = |Im(t) - Im(ref)|$$  \hspace{1cm} (1)

“Figure 3(b)” shows vision tools that are applied in series to extract the vehicle blob from the foreground. To get clearer and brighter image of the blob of desired object, its brightness, contrast and gamma values are adjusted. The images are captured in low quality so the average value (smoothing) of the pixels at the edges do not vary largely and hence yields a vehicle blob with other undesirable particles. These particles are then filtered out by applying a threshold value to the image. Hence, the objects with intensity less than the applied threshold value (T_H) are removed from the image,

$$D > T_H$$  \hspace{1cm} (2)

The application of advanced binary morphological operations provided in NI Vision Assistant tool further filters out the unwanted noise and therefore extracts an accurate vehicle edge from the foreground. These morphological operations include the following applications in series:-

- Remove particles: This removes small objects/noises from the image that are not in the area of interest on the basis of applied iteration value.
- Filling holes: The small areas in the image are filled with the structuring elements. This improves the foreground for better vehicle extraction.
- Convex hull H of an arbitrary set of points S is the smallest convex set containing S. Convex envelope of set X of points reforms the blob shape of the edges.
Step III: After the morphological operations, the exterior contours of the particle are extracted to detect the edge using the gradient out function which yields the edges of the vehicle blob as shown in "Figure 4(a) and 4(b)".

Step IV: Once the vehicle blob is obtained, the centroid function is used to find the centroid of the blob (values of x and y pixel) by \( z = \sqrt{x^2 + y^2} \) and its trajectory is determined by difference in two values of centroid obtained from the two consecutive images captured of vehicle at a short interval (say 100 ms). Due to difference in the coordinates of the pixels (x, y) at the two time instants, the speed of the vehicle is determined by dividing the difference of the two centroids obtained with the time duration between the instances (Figure 5). Since the obtained speed is in the pixels/ms, the exact value of the speed of the car in real time is obtained by multiplying pixel frame value by a proportional factor which is calculated experimentally.

Step V: The calculated speed is compared with the speed limit of the road. If the speed of the vehicle is less than the speed limit of the road, the car passes through the road without any alert or fine. However, if the speed is higher than the speed limit, an over speed alert is raised in the vehicle which on pressing raises an alert at the client’s end and initiates a timer for a duration of 10 seconds (sample time indicating the probable time for pedestrian to cross the road) at the backend. This makes the driver vigilant about the pedestrian ahead on the road and hence dictates him to manage his speed accordingly to avoid pedestrian casualties and saves fuel.

B. Traffic lights and signal timer

This feature works on a dynamically run timer preprogrammed in the microcontroller to manage the traffic. In our model, the number of vehicles connected determines the signal timings required, on the basis of which the controller adjusts the timing limits to minimize the time of wait at the intersection. This timer is synchronized with the GUI installed in the vehicle which also displays the traffic light status.

Adaptive traffic control signals have their own advantages. An extended architecture for adaptive traffic control with online learning feature is presented in [6]. In this system, the author introduces vehicle detection through image processing blocks along with event detection system and an online learning feature incorporated in the traffic systems.

C. Pedestrian

Another alert incorporated in the system is for the pedestrians. While [7] involves using microwave detectors for the pedestrian alert system, in our model, a switch is embedded on the pole which on pressing raises an alert at the client’s end and initiates a timer for a duration of 10 seconds (sample time indicating the probable time for pedestrian to cross the road) at the backend. This makes the driver vigilant about the pedestrian ahead on the road and hence dictates him to manage his speed accordingly to avoid pedestrian casualties and saves fuel.

D. Database Management

Different databases are maintained for road and car details as well as there are individual database for each of the vehicles at the traffic control center. Sample databases are shown in the following tables,

<table>
<thead>
<tr>
<th>Table I. Database maintained for Road Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Name</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>ABC</td>
</tr>
<tr>
<td>DEF</td>
</tr>
<tr>
<td>GHI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table II. Database maintained for Car Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireless Address</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>abcd:efgh:1</td>
</tr>
<tr>
<td>abcd:efgh:2</td>
</tr>
<tr>
<td>abcd:efgh:3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table III. Database maintained for Individual Car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Name</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>ABC</td>
</tr>
<tr>
<td>GHI</td>
</tr>
<tr>
<td>DEF</td>
</tr>
</tbody>
</table>
TABLE IV. DATABASE MAINTAINED FOR CURRENT ROAD SCENARIO

<table>
<thead>
<tr>
<th>Wireless Address</th>
<th>Road Name</th>
<th>Speed</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>ab:cd:ef:gh:1</td>
<td>ABC</td>
<td>70</td>
<td>13/08/2013</td>
<td>16:11</td>
</tr>
<tr>
<td>ab:cd:ef:gh:5</td>
<td>ABC</td>
<td>45</td>
<td>13/08/2013</td>
<td>16:12</td>
</tr>
<tr>
<td>ab:cd:ef:gh:7</td>
<td>ABC</td>
<td>30</td>
<td>13/08/2013</td>
<td>16:20</td>
</tr>
</tbody>
</table>

The MAC address of the client’s router is extracted as soon as the client is in Wi-Fi range of the controller. This address is used as the primary key to determine various vehicle details associated with it. Furthermore, using the road name, the controller has the details of the speed limit and respective fine of the particular road on which the vehicle is running. On over speeding, the individual vehicle database gets updated with the imposed fine along with the road details and the time instant of over-speeding. Hence this system tends to manage large amount of data reliably without any manual interference.

IV. ADVANTAGES OF THE PROPOSED SYSTEM

The Proposed model for traffic management provides the following solutions:
- Synchronization helps to manage the vehicle’s speed, hence coping up with the fuel crisis.
- Due to complete automation with no manual processing, there is no chance for over-speeding offenders to skip the eye and hence the fine. Hence the system helps to reduce number of over-speeding cases.
- Ease and safety of the pedestrians with pedestrian alert system, hence avoiding pedestrian casualties.
- Reduces the possibility of corruption as the fine imposed is forwarded directly to the traffic control center.

V. CONCLUSIONS AND FUTURE WORK

With a challenge of high number of accidents on roads, the proposed model is a vital attempt to manage the traffic flow and hence save the precious lives which are crucial for the development of the nation. Apart from it, it has been analyzed that it is also an effective measure to address the environmental issue of diminishing fuel reservoirs (by helping the driver to manage the speed according to the on-road scenario) and social cause of corruption (by reducing manual interference in traffic management.) Hence, with small add-ons, the implementation of this model can prove to be great boon for Indian roads.

To enhance the effectiveness of the model, following developments shall be made in the model:
- Implementation of cloud server for universal access of imposed fine database.
- Online accessibility of the databases of the fine imposed on the individual users for transparency of the system.
- Introduction of online/prepaid/postpaid payments of the fine levied on the speed offenders.
- Alternatives of pedestrian alert by replacing the switch with microwave detectors or sensors at poles for automatic detection.

REFERENCES