iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VII **Month of publication:** July 2020

DOI: https://doi.org/10.22214/ijraset.2020.30384

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VII July 2020- Available at www.ijraset.com

A Study on Smart Regulation of Emergency Vehicles

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Abstract: This paper proposes a novel technique to assist the emergency vehicles namely ambulance to cross the traffic signal without any delay which arises due to the time taken by other vehicles to make a way for it. This is made possible by surveillance of the traffic starting from approximately 100-300 meters away from the traffic signal. Once an ambulance is detected, the signal is sent to the siren detector to identify whether ambulance is in an emergency state. The flow of traffic is then controlled by the Node MCU module.
Keywords: Audio Fingerprinting, Image detection, Node-MCU, Thing Speak, Traffic Regulation, YOLO

I. INTRODUCTION

India is the second-most populous country in the world and is a fast-growing economy. In traffic environments, traffic sign recognition is used to regulate traffic signs, warn the driver, and command or prohibit certain actions. Traffic jams may arise due to large red light delays which are hard coded and are independent of traffic. As there are limited resources provided by the current infrastructure, smart traffic control will become an important issue in the near future. Due to this massive traffic, often traffic jams occur on roads due to which the emergency medical vehicles like ambulance and fire engines grind to a halt in traffic jam which may be the cause of losing human lives.

Current control systems are a static case wherein vehicles need to await a predefined amount of your time until the micro controller switches the green light for that lane.

If the ambulance is stuck near to the traffic signal, then the traffic police can give priority to the ambulance by giving necessary symbols or signs to the vehicles so that the ambulance can get out of the traffic as quickly as possible. Moreover, if the emergency vehicles are stuck during a lane far away from the traffic light, the siren of the ambulance is unable to succeed in the traffic police, in which case the emergency vehicles need to wait until the traffic gets cleared or we've to depend upon other vehicles to move aside which isn't a simple task in traffic situations.

The proposed system uses a Camera, Microphone and an ESP8266 module to build the system. The camera along with a microphone will be placed approximately at 100-300 meters away from the traffic junction. It enables the detection of the ambulance before it comes closer to the signal and thereby regulates the traffic accordingly.

The microphone allows detecting whether the ambulance is in an emergency state or not by detecting the emergency alarm. Once an ambulance in an emergency condition is detected then the ESP module at the traffic junction immediately regulates the signal by increasing the duration of green signal, so that the ambulance can cross the junction without any delay. Altogether the delay experienced by ambulance at the traffic junction will be reduced or even can be eliminated. The traffic regulation is restored normal mode, after the vehicle has cleared the junction.

II. LITERATURE SURVEY

In this paper [1] Dagade and Salunke proposed a system to detect accidents automatically using a vibration sensor, and an ambulance unit sent the vital parameter of the patient to the hospital.

This will help to save the life of the accident victim. GPS is a satellite navigation system which determine the bottom position of an object. GPS technology was first employed by the US military in 1960s and expanded into civilian use over subsequent decades. In this paper [2], they proposed a system that is used by the hospitals to track down their ambulances.

The main aim of the project is to reduce the deaths of critical victims by making sure that they reach the hospital in time for proper treatment. GPS technology is employed in order that the hospital can take quick action which could reduce the extremity. This system is more appropriate and the main advantage is that there is significant reduction in time consumption. In [3], a system was proposed that finds the quickest path by controlling traffic light signals in favour of an emergency medical vehicle.

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By this new system, the time delay is reduced by applying the RF technology that controls the traffic signals. The preference of service to the emergency medical vehicle follows the queuing technology through server communication.

This makes sure of the reduced time delay between the accident spot and the hospital. In the paper [4] Smart ambulance guidance system, they propose a system that uses a central server to control the traffic controllers. The traffic light controller is implemented using Arduino UNO.

The ambulance driver uses an internet application to request the traffic controller to form the signal green during which the ambulance is present.

A low-cost system that can be implemented throughout the city thereby reducing the number of deaths due to traffic situations has been aimed at. When the regulation module can be best executed by using a wireless sensor network, namely ESP8266 which a low-cost Wi-Fi microchip, with a full TCP/IP stack and micro controller capability.

In the paper[5] ESP8266 based Implementation of Wireless Sensor Network with Linux Based Web-Server, they proposed a concept where the occurrence of a Wi-Fi based Sensor Network management exploitation using Linux board Raspberry Pi and IoT technology using ESP8266 Wi-Fi module.

III.PROPOSED SYSTEM

A. System Architecture

As the video surveillance of the traffic proceeds in a steady manner, and when it captures an insight of ambulance from a farther distance away from the traffic signal. It immediately sends the call for siren detection in order to identify whether the traffic needs to be urgently managed so that the ambulance can cross the junction without any delay.

The result from this segment is soon updated on the field using the channel provided by the ThingSpeak. The node MCU frequently polls the field and conclude about the decision to be executed.

If the value received from the field is valid, the time interval for green light among the three traffic signal lights is put for an increased time interval .After an assumed period of time which is calculated from an average traffic felt on each area, the signal delays are restored to normal intervals.

B. Object Detection of vehicles in the traffic

This module uses the principles of object detection to detect the presence of an emergency vehicle in the video-stream read by the camera module.

You Only Look Once (YOLO)}: A novel approach to object detection. Prior work on object detection re-purposes classifiers to perform detection. Instead, YOLO frames object detection as a regression problem to spatially separated bounding boxes and associated class probabilities.

Single neural network predicts bounding boxes and class probabilities directly from full images in one evaluation. Since the entire detection pipeline may be a single network, it is optimized end-to-end directly on detection performance.

Unified architecture of YOLO is extremely fast. Base model of YOLO processes images in real-time at 45 frames per second. Compared to state-of-the-art detection systems, YOLO makes more localization errors but is a smaller amount likely to predict false positives on background.

Finally, YOLO learns very general representations of objects. Previous methods for this, like R-CNN and its variations, used a pipeline to perform this task in multiple steps. This will be slow to run and also hard to optimize, because each individual component must be trained separately. YOLO, does it all with one neural-network.

The YOLO training comprises two phases. First, we train a classifier network like VGG16. Then we replace the fully connected layers with a convolution layer and retrain it end-to-end for the detection.

It trains the classifier with 224*224 pictures followed by 448*448 pictures for object detection. YOLOv2 starts with 224*224 pictures for the classifier training on the other hand re-tune the classifier again with 448*448 pictures using much fewer epochs. This makes the detector training easier and moves mAP up by 4%.

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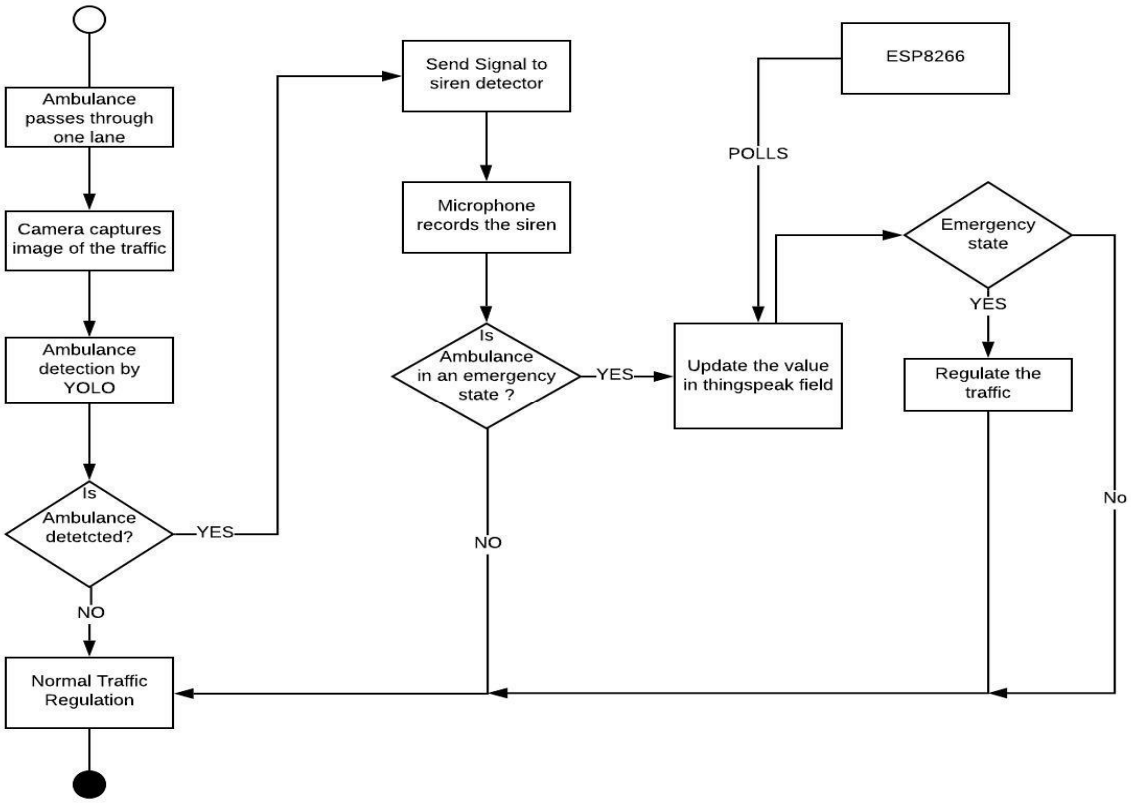

Fig. 1 Block diagram of the system

C. Detection of Ambulance Siren

This module uses the concept of audio or acoustic fingerprinting.

An acoustic fingerprint is often a digital summary in a condensed form which can be used to identify similar audios in an audio database.

In this project, we are using Fast Fourier Transform (FFT) for the creation of spectrograms. FFT computes the Discrete Fourier Transform (DFT) of a sequence, or its inverse (IDFT). It is a cool way to multiply polynomials in 0(nlog(n)) time, doing signal processing ,its canonical usage. It turns out, is digitally encoded as just a long list of numbers. In an uncompressed .wav file, there are a lot of these numbers ~44100 per second per channel. This means a 3 minute long audio has almost 16 million samples. The initial step is to sample the audio signal.

1) *Sampling:* Sampling is a process of converting a signal (for example, a function of continuous time and/or space) into a sequence of values (a function of discrete time and/or space). Since there are 44100 samples per second which seems quite arbitrary, but it relates to the NY Quist-Shannon Sampling Theorem.
2) *Spectrograms:* Since these samples are a signal of sorts, we can repeatedly use an FFT over small windows of time in the songs samples to create a spectrogram of the siren. The spectrogram is a 2D array with amplitude as a function of time and frequency. The FFT shows us the strength (amplitude) of the signal at that particular frequency, giving us a column. If we do this enough times with the sliding window of FFT, we put them together and get a 2D array spectrogram.
3) *Peak Finding:* Once we got a spectrogram of the audio signal, we next start by finding peaks in amplitude. We define a peak as a (time, frequency) pair corresponding to an amplitude value which is the greatest in a local neighbourhood around it. Other (time, frequency) pairs around it are lower in amplitude, and thus less likely to survive noise. We are treating the spectrogram as an image and using the image processing toolkit and techniques from scipy to find peaks. A combination of high pass filter and scipy local maxima structs did the trick. Once we have extracted these noise resistant peaks, we have found points of interest in a siren that identify it. We are effectively squashing the spectrogram down once we have found the peaks. The amplitudes have served their purpose, and no longer needed.

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4) *Fingerprint Hashing:* During the peak finding process, we might have similar peaks. So we are combining peaks into fingerprints using a hash function. A hash function takes an integer input and returns another integer as output. With respect to the spectrogram peaks and combining peak frequencies along with their time difference between them, we created a hash, representing a unique fingerprint for the siren.

MySQL is used for database functionality. There is fingerprint's table and siren's table. We not only have a hash and an audio ID (siren), but an offset. Only the hashes that align will be from the true signal we want to identify. The fingerprinted flag is used to decide whether or not to fingerprint a file. We set the bit to 0 initially and only set to 1 after the fingerprinting process is complete. Finally we will play siren sound from the mobile phone which will be read via laptop's microphone and the siren sound will be detected by the audio module. For regulating the traffic signal, we use the ESP8266 module. The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability. This module can be programmed with simple and powerful Arduino IDE or Lau programming.

D. Traffic Regulation Module

For regulating the traffic signal, we use the ESP8266 module. The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability. This module can be programmed with simple and powerful Arduino IDE or Lua programming.

1) *Node MCU v3:* Node MCU v3 is a development board that runs on the ESP8266 with the Espress if Non-OS SDK, and hardware based on the ESP-12 module. The device features 4MB of flash memory, 80 MHz system clock, around 50k of usable RAM and an on-chip Wi-Fi Transceiver.
2) *Thing Speak:* Device or application can communicate with ThingSpeak employing a REST API, and therefore the data are often kept either private or public. It is mostly used to analyse and act on the info. ThingSpeak is service offered by IoT analytics platforms that permits to visualize, and analyse live data streams within the cloud which enables engineers and scientists to prototype and build IoT systems without fixing servers or developing web software.

IV. EXPERIMENTAL SETUP & RESULT

Traffic stream can be read using IP-camera over the Real time streaming protocol (RSTP).Dynamic microphone can be employed instead of condenser microphone for capturing loud, strong sounds, particularly in a live setting. The mechanism of esp8266 continuously polling the Thingspeak server can removed by redesigning the module and using a custom server.

An output from the audio fingerprinting module will act as an input for the esp8266 module. The input signal will be a digital value, we can say zero or one (0 or 1).

An input value 1 corresponds to an indication that an ambulance in an emergency state has been detected and an input value 0 indicates that there is no action to be taken place. The esp module will be programmed in such a way that whenever an input signal with a value of 1 is received, the traffic signal is changed to RED so that the ambulance could not face any delay at the junction. If at the time of receiving the input signal from the audio module, the current signal was RED itself, then the delay time will be increased so that the ambulance could pass smoothly.

The server will send the signal to the esp8266 microcontroller over the internet and only when the signal from audio module is received. Custom dedicated server used can increase the security and performance of the proposed system.

Although integration of all the components was not realized, the authors were moderately successful with both the vehicle detection and siren recognition. For vehicle detection, the system was able to predict vehicle with up to 75% confidence, and the training process showed a final loss of 0.287. The accuracy of the model can be made higher by using data set of the emergency vehicles belonging to a particular state and training the model using it. Further improvisations on the training process leads to the increase of success probability of object detection process.

For siren detection, the model was responding for a particular wave file.

V. DISCUSSIONS

The authors aim to make the system very accurate and to process the data in real time. The accuracy of the result is high because of the use of YOLOv2 in the vehicle detection module. Emergency vehicles can easily cross the traffic junction without a delay. Camera can be used as a recording module which will be useful at the times of any accidents to produce digital evidence. The transfer of data from siren detection module to reach esp8266 module over the internet takes only few seconds. The system once installed can be used at a traffic junction with minimal cost of maintenance.

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ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VII July 2020- Available at www.ijraset.com

VI. CONCLUSION

The paper proposes an ambulance detection system with the help of the images and sound to regulate the flow of traffic in a highly congested area. The ambulance detection through images is achieved with the help of the camera mounted in a traffic junction and another camera on a flag stop at a distance of approximately 100-300 meters away from the junction. The camera reads the live feed of the surroundings and the frames from the stream are taken and fed into the proposed Deep Learning Convolutional Neural Network. A microphone module is attached to the camera which detects the sound to identify whether the ambulance is in an emergency state. The result from this is given to the ESP8266 module and it regulates the traffic.

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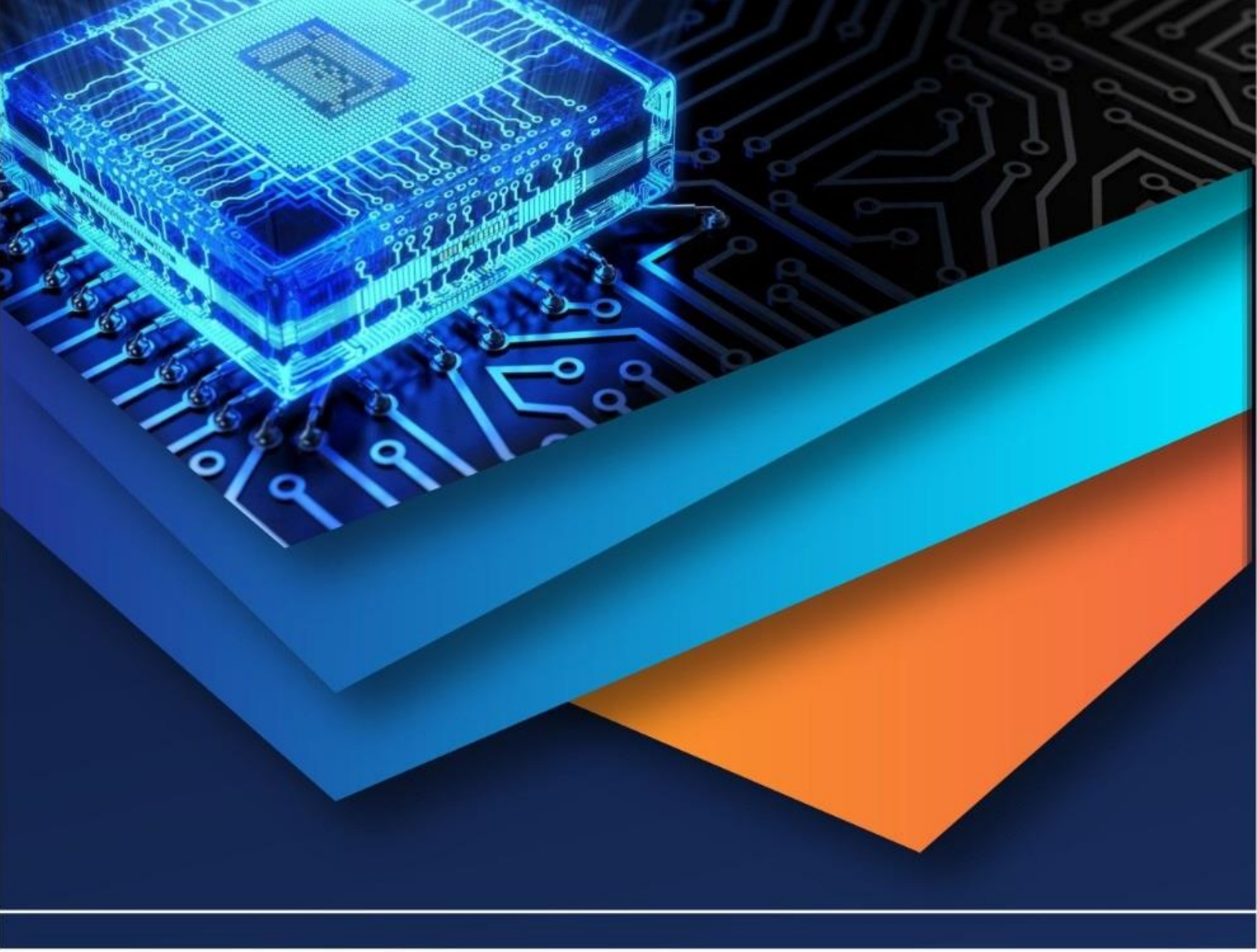

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