

Four Lane Traffic Light Control by Online Video Analysis

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Abstract:- Due to increase in Traffic problems nowadays due to high number of vehicles, improper infrastructure and management. As manual control comes with various disadvantages like fixed duty hours, large manpower requirement, so there is need of hour for automatic traffic light control strategy. In this project four lane traffic detector system has been attempted here by taking into account Four videos at a time and processing them to show corresponding output in arduino.

Keywords:- Traffic lights, gaussian model, morphological operation, BLOB analysis, arduino.

I. INTRODUCTION

Now-a-days, high traffic density and congestion in urban areas is one of the major problems in today's public transportation system in the developing countries. The major cause leading to traffic jam is the high number of vehicle which is caused by the overpopulation and the growth in economy. Besides, the highway and roads are incapable of meeting the requirement of increasing number of vehicle. Instead of working on roads to accommodate the growing traffic various techniques have been devised to control the traffic on roads like magnetic loop detectors[6] which provide automatic control strategy for traffic light control. But owing to their various disadvantages such as high installation cost, requirement of continuous maintenance etc has led to need for improved traffic light control strategy by online video analysis. Computer vision is the science that is concerned with automatic extraction, analysis and understanding of useful information from a single image or a sequence of images[2]. Object detection in computer vision that deals with detecting instances of objects of a certain class (such as humans, buildings, cars) in images or videos[2].

Following are the steps involved in online video analysis:-

- Initially, four videos (two videos opposite to each other
- i.e first and fourth are considered as opposite roads) are taken as input simultaneously.
- Background frame of the videos (empty road) is extracted.
- Morphological operation is performed on image.
- Blob analysis is used to detect object.
- A threshold pixel value is taken to distinguish vehicles from background.

II. GAUSSIAN MIXTURE MODEL

Gaussian mixture model are used a lot when the underlying populations can be explained by a normal distribution and there are many heterogeneous population[2].

Gaussian mixture models (GMM) is a type of density model whose algorithm is good enough to perform background extraction process because it is reliable towards light variances and repetitive object detection conditions[2].

- Each pixel in a image frame is modelled into K gaussian distribution, where k = Number of gaussian distribution model usage[2].
- Each gaussian model represents a different pixel color, hence, grayscale image uses scalar value while RGB image uses vector value[2].
- Used model are selected on basis of image resolution, considered computer system performance, and background model complexity[2].
- For each input image frame, each pixel will be matched with every K gaussian distribution model on the corresponding pixels, starting from distribution model that carry the largest to smallest probability according to below formula[2].

A pixel is confirmed match with one of the gaussian distribution if it is included in 2.5 standard deviation(σ) range. On the other hand, if a pixel has value beyond 2.5 deviation standard, then the pixel is declared unfit[2].

- The next step is selection of foreground and background objects. If the pixel colors are categorised to one of the background model candidates the pixels will be considered as background (pixels rated 0 or black). { 1 }
- Other than that, pixels that are not included in background model category will be considered as foreground (pixel rated 1 or white) and would result into a binary image[2].

A. Detecting cars using gaussian models

Foreground detection aims to detect changes in image sequences. Foreground detection consists of a set of techniques that typically analyse the video sequences in real time and are recorded with a stationary camera. All detection techniques are based on modelling the background of image. Defining the background is difficult if it contains shapes, shadows and moving objects[3]. It is assumed while defining the background that the stationary objects could vary in colour and intensity over time[3].

This cycle continues till end of video.

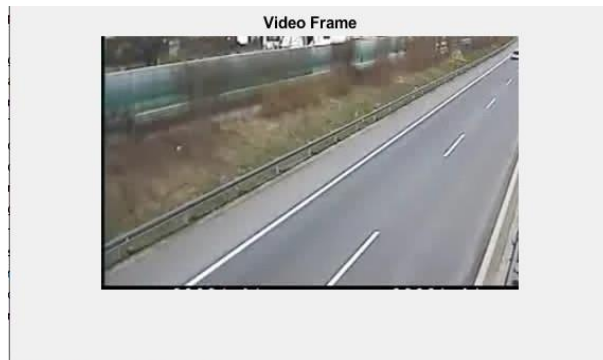


Fig. 1: Video frame of first road (empty road as reference)

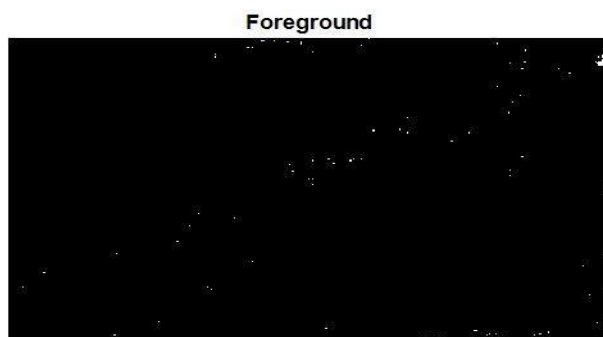


Fig. 2: Foreground of first road (empty road as reference)



Fig. 3: Video frame of second road



Fig. 4: Foreground of second road (without filtering)



Fig. 5: Video frame of third road

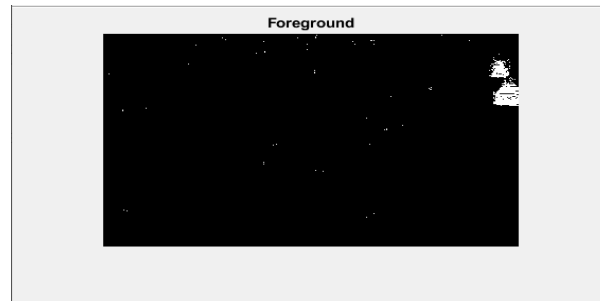


Fig. 6: Foreground of third road (without filtering)



Fig. 7: Video frame of fourth road

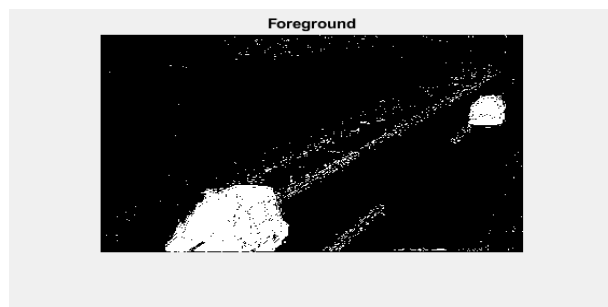


Fig. 8: Foreground of fourth road (without filtering)

The output of foreground segmentation process often includes undesirable noises. Morphological operation now used to remove noise and fill gaps in detected object[1].

III. MORPHOLOGICAL OPENING AND CLOSING

Morphology is a powerful solution to many numerous image processing problems. Sets in mathematical morphology represents objects in a image. Example:- The set of all white pixels in a binary image is a complete morphological

description of image[1]. Morphological opening and closing are two important operations from mathematical morphology. They are both derived from fundamental operation of erosion and dilation.

A. Erosion

In binary morphology, an image is viewed as a subset of euclidean space[1]. The basic idea in binary morphology is to probe an image with a simple predefined shape; drawing conclusions on how this shape fits or misses the shapes in the

image. This simple probe is called structuring element.

B. Dilation

Dilation is one of the basic operations in mathematical morphology[1]. Originally developed for binary images, it has to be expanded first to grayscale images. The dilation operation usually uses a SE for probing and expanding the shapes contained in input image.

C. Morphological opening

An morphological opening is defined as erosion followed by a dilation using the same structuring element for both operations[1]. The basic effect of an opening is somewhat like

erosion in that it has to remove some of the foreground pixels from the edges of regions of foreground pixels. However, it is less destructive than erosion in general. Opening smooths boundaries of an object and eliminates thin protrusions.

D. Morphological closing

Closing is opening performed in reverse[1]. It is defined simply as dilation followed by an erosion using the same structuring element for both operations. Closing also tends to smooth sections of boundaries, but unlike opening, it fuses narrow breaks and long thin gulfs, eliminates small holes and fills gaps in contour.



Fig. 9: Video frame of first road (empty road as reference) with filtering

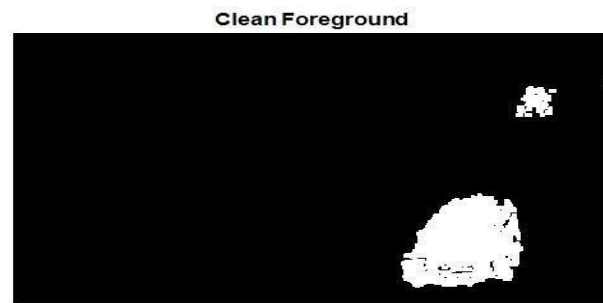


Fig. 10: Foreground of second road with filtering



Fig. 11: Foreground of third road with filtering

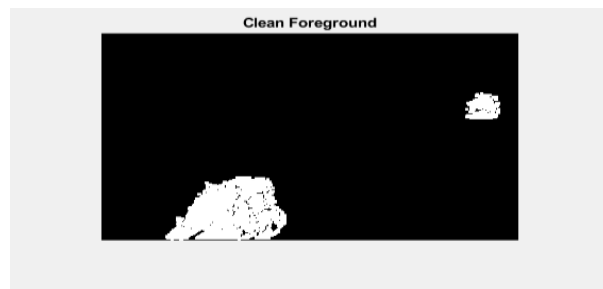


Fig. 12: Foreground of fourth road with filtering

IV. BLOB ANALYSIS

By binarization, a grey image is converted into binary image (i.e having values 0 and 1) by setting a desired threshold value. Our desired object of inspection can be found out by this process. The method of analysing an image after it has undergone binarization processing is called BLOB analysis[5].

Analysing binary images involves extracting the blobs, and then representing them compactly and finally classifying

the type of blob. BLOB stands for binary large object and refers to a group of connected pixels in a binary image[5].

The purpose of blob extraction is to isolate the blob (objects) in a binary image. A blob consists of a group of connected pixels, whether or not two pixels are connected in the defined connectivity, like 4-connectivity or 8-connectivity. The blob analysis computes statistics for connected regions in a binary image[5].



Fig. 13: Detection of cars in first video-frame (first road)

V. COUNTING OF CARS AND SCHEDULING OF TRAFFIC LIGHTS

After blob analysis, the number of cars in both cars is highlighted and the number of bounding boxes correspond to the number of cars found in video-frame.

The number of cars in both video-frame (i.e both roads) are compared and traffic light duration is assigned accordingly. Let number of cars in first video frame (first road), second video frame (second road), third video frame (third road), fourth video frame (fourth road) be $numCars1, numCars2, numCars3, numCars4$ respectively. The results are displayed as follows:-

If $numCars1 > numCars2$ then

Red light is ON for 20 seconds (in second and third road).

- Red light is ON for 20 seconds (in second and third road).
- Green light is ON for 20 seconds (in second and third road).
- Yellow light is ON for 30 seconds for manual decision (in first road).
- Yellow light is ON for 30 seconds for manual decision (in second road).
- Yellow light is ON for 30 seconds for manual decision (in third road).
- The above results are displayed via LED lights in with the help of arduino microcontroller[7]. A brief configuration of arduino is presented below.



Fig. 14: Detection of cars in second video-frame (second road)



Fig. 15: Detection of cars in third video-frame (third road)



Fig. 16: Detection of cars in fourth video-frame (fourth road)

VI. WORKING OF ARDUINO

Arduino uno is a microcontroller board based on the ATmega 328P. ATmega 328 is a single chip created by ATmel[7]. It has 14 digital input/output pins out of which 6 can be used as PWM outputs, 6 analog inputs, a 16 Mhz quartz crystal, a USB connection, a power jack and a reset button[7].

A. Parts of arduino

- Power(USB/barrel jack): The arduino can be powered from a USB cable connecting from personal computer or a wall power supply that is terminated in a barrel jack (Recommended voltage 6-12 volts)[7].
- Pins(5v, 3.3v, GND, analog, digital, PWM): The pins on the arduino are the places where wires are connected to construct a circuit in conjunction with a breadboard and some wires. They usually have black plastic headers that allows plugging a wire right into the board[7].
- GND: There are several GND (ground) pins on the arduino, any of which can be used to ground the circuit.
- 5v, 3.3v: 5 volt and 3.3 volt are used to supply the necessary powers to the simple components used with arduino[7].
- Analog pins (A0, A1, A2, A3, A4, A5): These pins are used to read a signal from a analog sensor and convert it into

digital value that can be read[7].

- Digital pins (0-13) : These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering a LED).
- PWM: [7]. Tilde is present next to some of the digital pins. These pins act as normal digital pins, but can also be used for something called PWM[7].
- AREF: It stands for analog reference. It is sometimes used to set an external reference voltage (between 0-5 volts) as upper limit for analog input pins[7].
- Reset button: Pushing it will temporarily cause connecting reset pin to ground and restart any code that is loaded on the arduino. This can be useful if the code is not repetitive but user wants to test multiple times[7].
- Power LED: It indicates arduino is ON.
- TX, RX LEDs: TX is short form for transmit, RX is short form of receive. They appear at two places on arduino uno where TX and RX appear once by digital pins 0 and 1 and second time near to the TX and RX LEDs. These LEDs will give out some nice visual indications whenever arduino is receiving or transmitting data[7].
- Main IC: The black thing with metal caps is an IC[7].
- Voltage regulator: It controls amount of voltage that is let into the board[7].



Fig. 17: Detection of cars in second video-frame (second road) only and corresponding output (Red in first and fourth road and Green in second and third)

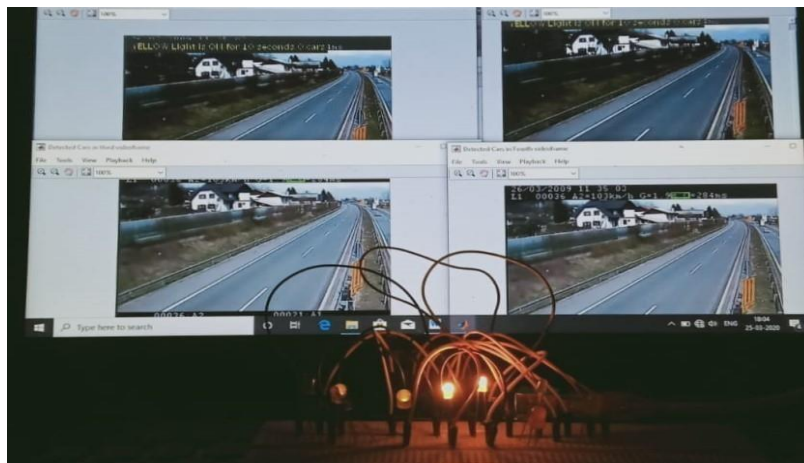


Fig. 18: Green to yellow(Colour Change) in second and third road

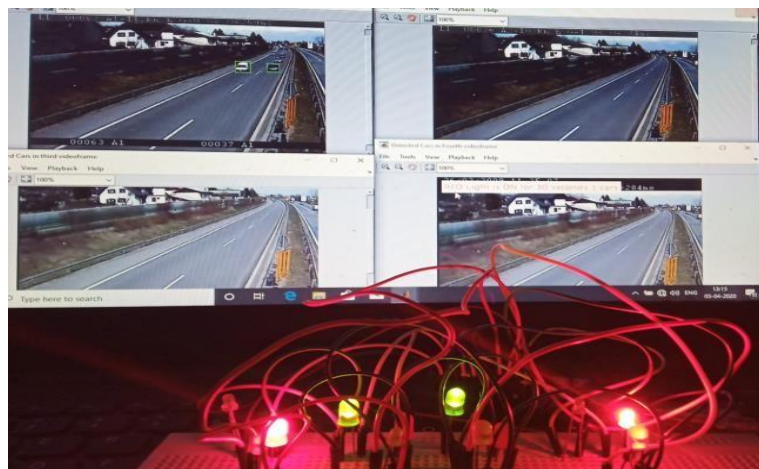


Fig. 19: (No Car in all road)Yellow light in all road



Fig. 20: Detection of cars in first,third,fourth video-frame (green in first and fourth) as total number of cars in first and fourth is more

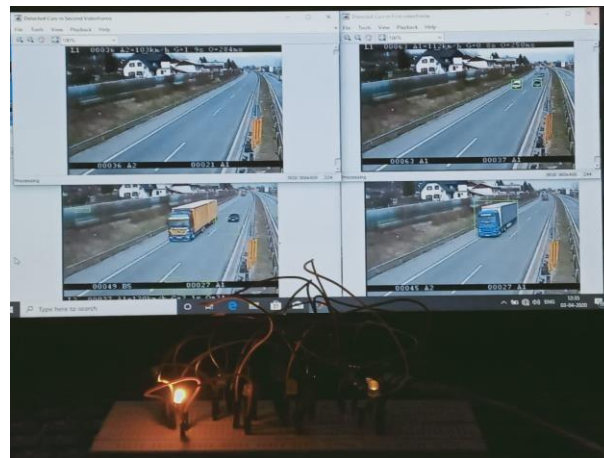


Fig. 21: Change of green light to yellow

VII. OUTPUT RESULTS OF THE ONLINE VIDEO ANALYSIS WITH ARDUINO CONCLUSION

Traffic light control by image processing methods is found to be computationally efficient over other automatic control methods as it take into account the real time traffic conditions of the road and give corresponding output. In online method, Four lanes of traffic were being compared in terms of counting the number of cars and cor-responding output was being displayed in changing of LED lights in arduino. During empty road conditions, no traffic lights were being lit which led to energy savings.

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