IMAGE PROCESSING BASED AUTOMATIC PELICON CROSSING SYSTEM

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Abstract- Traffic congestion and pedestrian accidents are two major issues that the Sri Lankan society face today. Many social, economic and environmental problems increase due to the two issues. Lack of effective Pedestrian Light Controlled (PELICON) crossing system in Sri Lanka is one of the reasons for road traffic congestion problems. Thus in this paper, we propose Image Processing Based Automatic PELICON System. The proposed system first takes an image input to the system using CCTV camera. Then, it identifies the particular color ranges using color detection algorithms. Next, noises are removed using filters. Finally, the system uses background subtraction and contour analysis algorithms to identify pedestrian object contours. The system then calculates the number of pedestrians. If the pedestrian object count is greater than a given threshold value or if the pedestrian waiting time is exceeded, then the system shows green signal to pedestrians and red signal to vehicles. Empirical study of our prototyping system has proved the effectiveness of our pedestrian detection approach. Further, we conducted a questionnaire survey to check the suitability of this system to the Sri Lankan society. Randomly selected people were taken to this study as the sample population. According to the study results, the system will minimize road traffic congestion and other negative impacts of the traffic congestion.

Keywords- Color detection, Background Subtraction, Contour analysis

I. INTRODUCTION

Colombo is the largest city and major economic centre in Sri Lanka with a metropolitan area of 5.6 million inhabitants, who are expected to increase up to 8.4 million by 2030. Main domestic transportation mode in Colombo, in Sri Lanka is land transportation. But, supply road space for the demand of land transportation is low. The major urban transport issues in Sri Lanka are traffic congestion, environmental pollution, increase of road traffic accidents, poor public transport system and weakness of road network. There are several factors that cause these urban transportation issues. Some of them are: high population of people in Colombo, high population of vehicles in Colombo, increase of road accidents, high pedestrian deaths, etc. These outputs interact within the prevailing social, economic and environmental aspects, and they produce negative outcomes.

Traffic congestion, pedestrian accidents and other crummy impacts of traffic congestion of Sri Lanka are the noticeable problems in Colombo city during peak periods or rush hour (Kumarage, A.S., 2004). Both vehicles and pedestrians represent as most dominant users of road space.

There are 10 major entry corridors to Colombo city, approximately 200,000 vehicles enter to the city daily

and it takes 750,000 people (Weerawardana, 2011). The balance of around 175,000 private vehicles carry 1 or 2 passengers each. Presently around 15% of the road space is utilized for bus transport even though it transports 62% of road passengers. On the other hand, 65% of the road space is used by private and hired vehicles which is sum total carry only 38% of passengers. However, there is no proper way to handle both of the pedestrians and vehicles.

Withal, traffic problem aggrandise social economic problem as well. Some of them are, loss of competitiveness in Stock market, inflationary price due to unproductive resources, migration of businesses to peripheral areas resulting in spreading of the city and increase in transport and other utility service costs, which are in turn impact above two problems, increases of environmental pollution, social discontent and loss of political goodwill, etc.

Each year over 40,887 road accidents are occurred in Sri Lanka, causing on average six fatalities every day. Nearly 9000 car and van accidents are occurred annually with over 5400 accidents are caused due to speeding. Over 740 pedestrians are died every year, recording two pedestrian deaths per day. Of the total number of road accidents that occur each year, over 2471 result in accidental deaths. Several hundred are left seriously injured, some with lifelong consequences. There are over 1000 road accident per-week with 5 or 6 people have been killed every day. The economic cost of accidents has been valued over Rs 10,000 million annually (Kumarage, Wickramasinghe, & Jayaratne, 2003).

Further, Most of the road-accidents are occurred while the pedestrian crossing the road. Pedestrian fatalities in Sri Lanka account for 40% all road deaths. In Colombo district this is high up to 70% and it represents pedestrian constitute 39% (Fernando, M., 2017). According to the World Health Organization, without any sustained action, road traffic crashes are predicted to become the seventh leading cause of death by 2030.

A. Introduction to PELICON

The PELCON Crossing is standard for PEdestrian LIght CONtrolled Crossing. It is used pair of poles with standard traffic light system and in between that the road is on-going. It is facing oncoming traffic, it has a push button on the pole that is for pedestrian who wants to cross the road to press and it uses two illuminated and coloured pictograms facing the pedestrian from across the road. It uses red, green and yellow signal as usual.

B.Research Problem

For example, some roads like Galle road have several button clicking PELICON systems. Sometimes, one vehicle may have to stop each and every PELICON Crossings while they ride from Ratmalana to Fort using Galle road. Because, this kind of PELICON Crossing systems are responding to single pedestrian either group of pedestrians. This system response evolves high traffic congestion.

The use of PELICON crossing system in an effective way is for more reliable solution to minimize road traffic, road accident and other social, economic and environmental problems of traffic congestion. In this research paper we proposed a system using image processing techniques that can be used to PELICON crossing system and questioner survey to check the suitability of this system for Sri Lankan society.

Main requirements to the system are taken by Colombo Municipal Council's Engineering Division. CMC's Traffic Division is already using image processing technique in their newly developed PELICON Crossing systems. But, they do not considering about the number of pedestrians.

C. Aims and Objectives

The aim of this research is to minimize the traffic jam and pedestrian accident of the Colombo city. Furthermore, minimize environment pollution, flue wastages and all other negative impacts of traffic congestion.

Objectives of this research are: to analyse the existing research work and identify the issues, to develop image processing algorithm to identify the number of pedestrians, to write the algorithm to control the traffic light system, to evaluate the system with existing system and to do a systematic survey, whether this system is suitable for the Sri Lanka society.

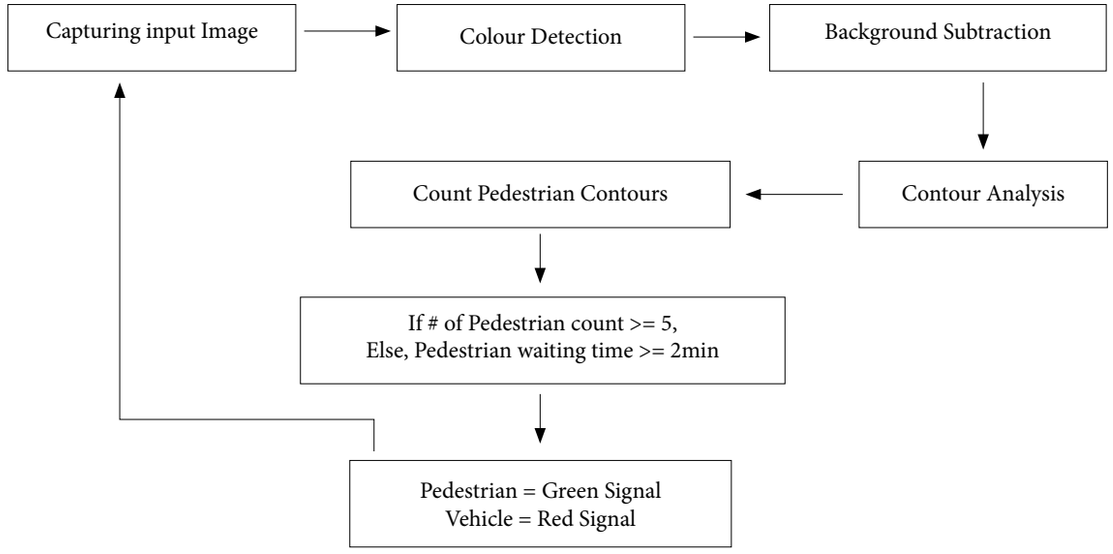

Figure 1. Proposed Approach

II. METHODOLOGY AND EXPERIMENTAL DESIGN

A. Proposed Approach

Figure 1 is the architecture of the proposed approach. Input image to the system taken from CCTV camera (Jaison A., Varghese E., Gopika K.G., and Krishnadas J., 2018) which is located behind of the traffic light pole. CCTV video runs 24 frames per second and one of the image is been taken as an input image to the system with specific time interval. Then, the system is used three major steps to produce the output; color detection, background subtraction and contour analysis.

The first step of the system is the use of color detection algorithm. Then, the system used background subtraction to remove the noises and tune the image. Finally, contour analysis used to analyze the contours and analysed contours are matching with template contours, those are already stored in the system in initiation stage. If the image contours matches with the template contours, the system identifies the contour as a pedestrian object contour. Then, the identified pedestrian object contour count is taken to a variable. If the variable value is greater than 5 or pedestrian waiting time exceeds, then the system shows green signal to pedestrian and red signal to vehicles.

We used C# programming language and Visual Studio 2013 with OpenCV wrapper to implement the image processing module and logical part of the proposed system.

1) **Color Detection:** The colour range is needed to be set in the system to identify all the coloured pixels that have been available on the image or the input image. The color detection used to identify the particular color ranges of the input image.

HSV color model is used in color detection. Because, HSV color mode is performed well in color detection than RGB color mode. The color is manually selected in color selector. First, the input image stored in RGB color mode image typed variable and then, it converted into HSV color mode image variable. The image is then used to find out the areas with a particular color range, where it help to create color recognition. According to the amount of hue saturation and value that system has set the maximum and the minimum color range detected in the system

The users can clearly see the object which is with the selected colours in the triangle; it represents the areas where the color is present in the image. The triangle is being controlled by manipulating the HSV colour amount. The needed colour range is being chosen by use

of the colour palate as shown in fig 2. The system provided default HSV values. But using this interface, which is shown in fig. 2 the user, facilitates to change the HSV values for particular image.

Figure 2. Selecting and specifying the required colour range by the colour range finder with default HSV values

2) **Background Subtraction:** After successful detection of the colour, the system sends the color detected image to the background subtraction step. The system background subtraction is done to remove the background and highlight the foreground. The system is used three algorithms for background subtraction step. First, the system starts checking pixel by pixel of the input pixels of the image; flood fill method is used to fill the areas that are not belonging to the particular region. The other areas that do belong to the specifically needed regions are flooded, and the non-belonging areas are left away. In the system is used Gaussian smoothing algorithm to remove the noises of the image. By the use of eroding method on the image, the system identifies the particular color areas of the image; it thinner the bright areas and bigger the dark zones. The use of these three algorithms for the color detected original image is results in an image with foreground only. This result of this step is displayed in the system interface. The background subtracted image/ foreground extracted image is focused the threshold to turn the image into a binary image. It enhances the boundaries of the edges that are presented on the foreground.

Figure 3. Background subtraction of an image

3) **Contour Analysis:** First the system captured an image from CCTV video. Then, identified and extracted objects that are closer to pedestrians using colour differences. After that, the system will checked the identified pedestrian features using contour analysis. Contour analysis use to solve the main problems of the pattern recognition (Liu S., Luo Y. and Yang S., 2007). The contour is an outline of the object, a population of pixels and extrication from background. In this contour is encrypted by the sequence consisting of complex numbers. Opening point of contour is a fixed pixel. Then, it scanned clockwise and each vector of the offset is noted by a complex number (a+bi). Here, the point of the x-axis denoted by "a" and the point offset of the y-axis is denoted by "b". The system used two basic/major project libraries to analyse the contours. That is ContourAnalysis project library and ContourAnalysisProcessing project library.

The ContourAnalysis project library is used to implement basic operations for contours; contour creation, equalization, evaluation of ICF (Intercorrelation Function) and ACF (Autocorrelation Function), comparison, searching of base templates, etc. The methods called ICF and ACF are used to search contour similarities of two contours. ACF does not depend on a choice of opening point of the contour. ACF is shape descriptor of contour and reduction of time of comparing using apply wavelet convolution of ACF. The minimum norm of ICF is measuring of the similarity of two contours.

The project library ContourAnalysis consist with four classes; Contour class, Template class, TemplateFinder class and FoundTemplateDesc class. The Contour class contains the basic operations of contours. The Template class is used to create base templates. The TemplateFinder class implements the fast searching of the template for the given contour. The FoundTemplateDecs class contains similarity rate angles of rotation and scale of contour relative to templates.

In initiation stage the system, template human object contours have to store on the system. In operation stage, the identified contours of the input image are search and match with the template contours. Then, the matching contours are identified as human object contours. Following fig. 4 illustrates the sample of contour analysis and contour selection processes. White color outline is the source vectors and red color outline is the equalized vector.

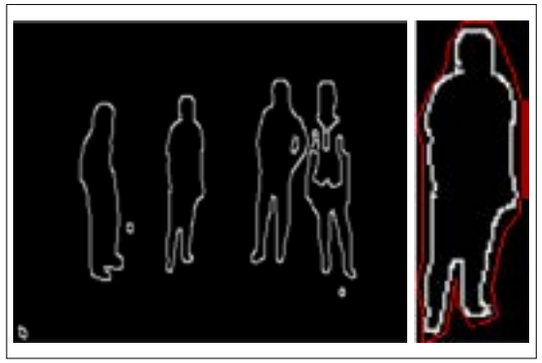

Figure 4. Initial handling of the selection of contours of the image and extracted contours of the image

The identified human object contours are highlighted using green color rectangle. Figure 5 shows sample output of pedestrian object identification and human object counting process.

Figure 5. Detected pedestrian object contours and pedestrian object contour count

Finally, the identified human object contour count taken to a variable and if the variable value is greater than given threshold value or pedestrian waiting time is greater than 2 minutes, the system shows green signal to pedestrian and red signal to vehicles.

B. Survey Analysis

When considering the survey, the sample population to the survey is taken from general public and the sample size is 100. We have considered some factors when selecting the sample; Nationality should be Sri Lankan, Race should not be considered, should be above 15 years and the majority in the sample population should be male.

The questioner was a Google document and it sent to the population using Internet via social media. The first 100 responses are taken to the study as the sample population. These 100 responses are representing different gender, 13 different job sectors and different age groups. Also both experienced and non-experienced with PELICON crossing system and driving a vehicle are participated to the survey.

The questioner consists with four main categories of questions; identification of population, identification of existing system issues and plus points in the view of both drivers and pedestrians and final category consists the questions about the proposed approach. According to the obtained responses, the answers were ranked due to provided values; 'Strongly agree'=5, 'Agree'=4, 'Neutral'=3, 'Disagree'=2 and 'Strongly disagree'=1. Then manually calculated the mean, median, mode and total of strongly agree and agree percentages values of the each question. Finally, we have made some decisions based on the median value.

III. RESULTS AND DISCUSSION

A. Proposed Approach

After doing several analysis and implementations, the result of this proposed approach has been established as an executable system. The proposed system is mainly a computer based system. The system use CCTV camera to capture the image to the system input. Then, use color detection algorithms to identify the particular color ranges. When doing background subtraction, the noises and the background of the image is been removed and highlighted the image foreground. Then, foreground image's contours are identified and analyzed using several algorithms. The identified contours are matched with template human object contours that are already stored in the system. This template pedestrian contours need to store at the initiation stage of the image. The matching contours of the foreground input image are identified as the human object contours and then, the system calculates the human object contour count. Finally, if the object count is greater than given threshold value or pedestrian waiting time is exceed, the system automatically shows green signal to pedestrians and red signal to vehicles.

The input image, background subtracted foreground image and contour analyzed image are shown in the system interface fih.3 and fig. 4. Identified human object contours are highlighted using green color rectangle; which you can see in the fig. 5 with matching percentage and identified pedestrian object count. The template contour creation, storing and deleting fractures also

facilitated in the main interface. Figure 6 illustrates the proposed approach interface.

Rather than that, this main interface facilitated to change the HSV color mode values also.

Figure 6. Proposed approach interface

B. Survey Analysis

When considering the survey, the first category of questions is for identifying the population. The responded people are representing different genders. The male responses are higher than female responses. Also, they are representing different age groups. The following fig 7 represents the summary of received responses for first two questions.

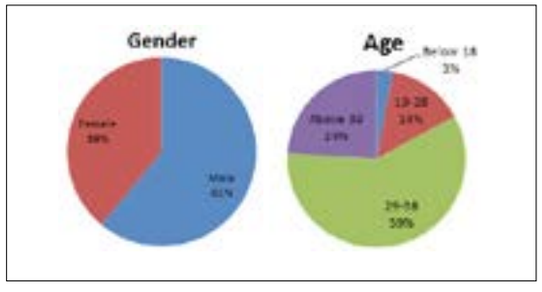

Figure 7. Results of question 1 and 2

Additionally, they are representing different job sectors you can see it in fig 8.

Also, they have different pattern in crossing the road. The question number 4 aimed to identify the pattern of crossing road. Following fig 9 illustrate the results of the question number 4 in the first category.

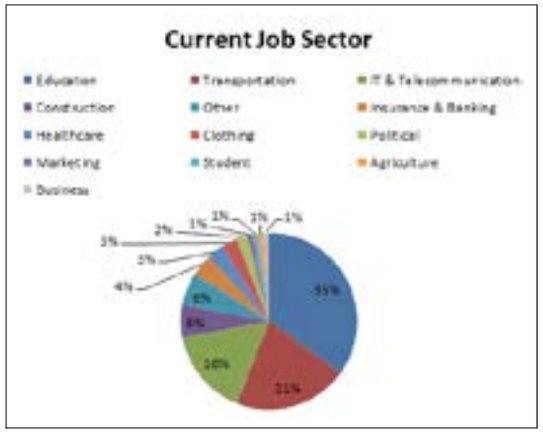

Figure 8. Result of question number 3

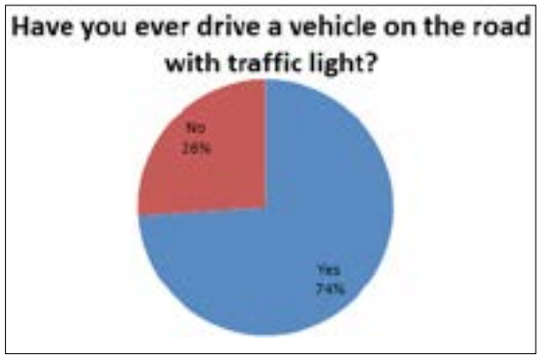

Figure 9. Results of question number 4

Many people in the sample population were used PELICON Crossing System and many people were drive a vehicle on the roads with PELICON Crossing systems at heavy traffic hours. The next figure, fig 10 illustrates it. Therefore, the sample population fair enough for the survey.

The nest two categories; category 2 (as a pedestrian) and category 3 (as a driver) are about existing system findings. Most of the questions in the questioner were received symmetric distribution as the result. Then, we were calculated mean, median, mode and total of 'Strongly agree' and 'Agree' percentages. Several decisions made, by comparing these values with each other.

Final category, category number 4 is about identifying proposed system suitability to the Sri Lankan society.

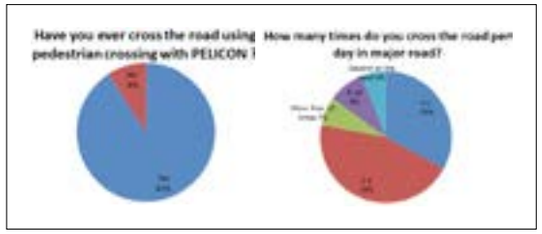

Figure 10. Results of question 5 and 6

Several decisions are made with these question results in the conclusion section.

IV. CONCLUSION

The proposed approach is about effective traffic light controlling system using image processing. As we mentioned, the input image for the system captured using CCTV camera. After several analyses, the system detects human contours and takes the count of human objects. This proposed system suitable for medium and less pedestrian volume areas rather than heavy pedestrian volume areas. Because, the system is needs a very clear input image for processing. But, in generally the pedestrians who are waiting for cross the road anchored as a bunch. So, it is difficult to capture clear CCTV image. We have to notice that, the system identifies dark colors more accurately than light colors. Additionally, at the night time mostly the camera will provide black and white video. This may casus in hard identifying of the human objects at night time. So it is better to use this system at day time. Instead of that we did a questioner survey analysis with randomly selected 100 sized sample population to check the suitability of this proposed system to Sri Lankan society. According to the responses obtained, we have made the following outcomes as a summery. Majority of the Sri Lankans think that; 'Traffic congestion' in Sri Lanka is getting increases day by day and it affects to the Sri Lankan economy badly. This proposed system will be helpful to minimize traffic congestion. The driver will feel comfortable in the cause of using this system in heavy traffic hours/peak hours. 'Pedestrian safety' is a responsibility of pedestrian themselves. This system might not help to minimize pedestrian accidents while pedestrian crossing road. As a future work, we hope to develop vehicle identification algorithm, vehicle speed measuring algorithm and vehicle count calculation algorithms to improve of this system more.

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REFERENCES

Fernando, M. (2017, June). Retrieved from Digital Library, University of Moratuwa:http://dl.lib.mrt.ac.lk/handle/123/1010

Jaison A., Varghese E., Gopika K.G., and Krishnadas J. (2018, March). Time to cross – traffic light control system using image processing. *International Research Journal of Engineering and Technology (IRJET)*, 5(3), 918-921.

Kumarage, A. S., Wickramasinghe, S. M., & Jayaratne, M. D. (2003). *Analysis of Road Accident in Sri Lanka*. University of Moratuwa Sri Lanka.

Kumarage, A.S. (2004). Urbon traffic congestion: the problems & solutions. *The Economic Review*.

Liu S., Luo Y. and Yang S. (2007). Shape-based pedestrian detection in infrared images. *Journal of information science and engineering, 23*, 271-283.

Weerawardana, W. J. (2011). *Reduction of Traffic Congestion in Colombo City by Improving Public Bus.* University of Moratuwa Sri Lanka.