Fuzzy Logic Based Vehicular Congestion Estimation Monitoring System Using Image Processing and KNN Classifier

Kent Edve Neil T. Rabe, Edwin R. Arboleda, Adonis A. Andilab, Rhowel M. Dellosa

Abstract— Vehicle is one of the most valuable mode of transport human developed. This allows us to travel faster from point to point or different multiple destinations. But through years, population increase and congestion occurs on public road. The study proposes a different method of image processing – morphological feature extraction, KNN classifier and fuzzy logic on classification of common vehicular transport mainly found on the road namely bus, cars and motorcycle. The images were taken using a smartphone camera 8mp and 12 inches range from the 240 sample miniature vehicles. It is then processed using a laptop with MATLAB 2012 installed. The extracted feature is area and shows ranges of 42,000 to 57,000 for busses, 13,000 to 35,000 for cars and 4,000 to 13,000 for motorcycles. The data extracted were used for KNN classification for determining the vehicular type and for fuzzy logic decision making as the output is the degree of congestion which is dependent on the road area of the image taken and decision is converted to percentage (0-40% light, 41-70% moderate, 70-100% heavy). Input parameter is the number of area on a certain image which is rated as few (0-40%), moderate (41-70%), heavy (71-100%) for all vehicle samples. Consequently, the result of the study shows a great potential on vehicular congestion monitoring system using image processing, KNN and fuzzy logic algorithm used.

Index Terms— Classifier, Fuzzification, Fuzzy Logic, Image Processing, Vislabels, KNN, Vehicle Monitoring System, MATLAB

1 Introduction

Before technology was developed, people travelled long distance through feet or by means of riding animals [1]. With critical thinking of humans, technology is developed and travelling from one destination to another is faster than before and easier to access. Population increase is expected as technology is rapidly developing [3]. Overpopulation caused congested route on different part of the world. With the fast going and busy lifestyle of the general public, traffic congestion is a blunder. Different approaches have been conducted to solve this kind of problem including re-routing, distance estimation application, etc [4]. Other studies related on this paper use a Soble Edge Detection [5]. To assists rules and decision making Fuzzy rules is set to implement under different situation [7]. Size and shapes of vehicles is very useful in traffic management [2]. However, precise time prediction on traffic congestion is still a problem. In this paper, the researchers propose a data for estimation on vehicular congestion using KNN, fuzzy logic and image processing and utilization of morphological feature extraction with vislabels function.

Kent Edve Neil T. Rabe is from Department of Computer and Electronics Engineering, College of Engineering and Information Technology of Cavite State University.
Edwin R. Arboleda is from the Department of Computer and Electronics Engineering, College of Engineering and Information Technology of Cavite State University.
Rhowel M. Dellosa is from computer engineering department of Asia Technological School of Science and Arts.
Adonis A. Andilab is interested in decision support system and artificial intelligence researches.

2 Research Methods

2.1 Vehicles

The vehicles used in this research are mainly bus, cars and motorcycle. Using fuzzy logic and KNN the vehicles will be classified according to type of vehicle and make decision such as light, moderate and heavy congestion based on its area generated using image processing techniques. The miniature vehicles were collected based on the real size of vehicles which is mainly common on public road. The images were captured by the use of Lenovo A5000 smartphone equipped with 1 gb of RAM, 8 gb of ROM, Quad Core 1.4 Ghz processor and 8-megapixel rear camera. Images were stored on a Lenovo Ideapad S300 laptop equipped with 500 Gb harddrive, 2 gb of RAM and Windows 7 Ultimate 64 – bit installed operating system. It is later processed using MATLAB 2012 using vislabels [7] commands.

2.2 Image Acquisition

The images of the vehicles were taken by placing it on a white background aiming for lesser noise present on the image. The smartphone camera was held at a still position on the top of the miniature vehicles with a distance of 12 inches. 240 images were captured in a JPEG (Joint Photographic Expert Group) format. The miniature bus was retrieved from (https://www.pinterest.com/pin/466052261411560353/). The bus is actual modeled after Mercedes Benz O 364 single decker series. Size of the actual bus is 12.2 m x 2.5 m [8] based on Mercedes Benz O405 which is in series size of chassis of O364 but only differ on engine performance. Miniature car was retrieved from (https://www.pinterest.com/pin/339529259395876031/).

Modeled after the actual car MG 1300 with 3.73 m x 1.53 m [9] dimensions. The motorcycle model is modeled after Batavus Whippet G50 and retrieved from (https://www.pinterest.com/pin/259027416045455640/) with actual size of 1.775 m x 0.555 m. Private account on Pinterest website is necessary to fully access the images. Miniature vehicles were printed and measured manually by its length and width for extraction of the area. Getting an area of 0.001722 m2 (0.082 m x 0.021 m) for miniature bus, 0.000702 m2 (0.039 m x 0.018 m) for miniature car, 0.001161 m2 (0.129 m x 0.009m) for motorcycle.

The miniature vehicles were resized which is used in the study. Resulting an area of 0.00049 m2 (0.035 m x 0.014 m) for bus, 0.0003 m2 (0.03 m x 0.01 m) for car, and 0.000171 m2 (0.019 m x 0.009 m) for motorcycle. Scaling for each of the vehicles were computed by dividing area of the actual vehicle to miniature vehicle, miniature to study used, and actual to study used. Thus, resulting of scale in actual to miniature of 1:177120 for bus, 1:8144 for cars, 1:848 for motorcycle. Actual size to the study used size result with scale of 1:622449 for bus, 1:19057 for cars, and 1:5760 for motorcycle. Scaling for miniature vehicles to the size study used results with 1:4 for bus, 1:2 for car and 1:7 for motorcycle. Reference images of actual vehicular congestion were captured from the official social media account of CNN Philippines [10]. It is simulated using miniature vehicles and extracted features such as area.

2.3 Study Flow chart

The study focuses on determining the area based on the processed image of vehicles. KNN will be used as a classifier tool for the vehicular images based on the data extracted on image processing. Using fuzzy logic, it is set make decision and output light congestion, congested, heavy congestion respectively. The study flowchart mainly starts at gathering the images required based on real life simulation, image processing to get the area and perimeter and setting rules using fuzzy logic based on the data acquired on image processing.

2.4 Traffic Count

On point of intersection of the road, path or particular road usually lies traffic monitoring system provided by government or private establishment. Two methods are undertaken on traffic count first is the automatic which pertains to installation of a temporary or permanent electronic traffic device and second method is by estimation manually observation and counting the traffic with traffic sheet [11].

TABLE 1
FUZZY RULES

No.	Rules
1	If (Bus is Few) and (Car is Few) and (Motorcycle is Few) then (Degree_of_Congestion is light_congestion) (1)
2	If (Bus is Few) and (Car is Few) and (Motorcycle is Moderate) then (Degree_of_Congestion is moderate_Congestion) (1)
3	If (Bus is Few) and (Car is Few) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
4	If (Bus is Few) and (Car is Moderate) and (Motorcycle is Few) then (Degree_of_Congestion is moderate_Congestion) (1)
5	If (Bus is Few) and (Car is Moderate) and (Motorcycle is Moderate) then (Degree_of_Congestion is moderate_Congestion) (1)
6	If (Bus is Few) and (Car is Moderate) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
7	If (Bus is Few) and (Car is Heavy) and (Motorcycle is Few) then (Degree_of_Congestion is heavy_congestion) (1)
8	If (Bus is Few) and (Car is Heavy) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
9	If (Bus is Few) and (Car is Heavy) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
10	If (Bus is Moderate) and (Car is Few) and (Motorcycle is Few) then (Degree_of_Congestion is moderate_Congestion) (1)
11	If (Bus is Moderate) and (Car is Few) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
12	If (Bus is Moderate) and (Car is Few) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
13	If (Bus is Moderate) and (Car is Moderate) and (Motorcycle is Few) then (Degree_of_Congestion is heavy_congestion) (1)
14	If (Bus is Moderate) and (Car is Moderate) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
15	If (Bus is Moderate) and (Car is Moderate) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
16	If (Bus is Moderate) and (Car is Heavy) and (Motorcycle is Few) then (Degree_of_Congestion is heavy_congestion) (1)
17	If (Bus is Moderate) and (Car is Heavy) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
18	If (Bus is Moderate) and (Car is Heavy) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
19	If (Bus is Heavy) and (Car is Few) and (Motorcycle is Few) then (Degree_of_Congestion is heavy_congestion) (1)
20	If (Bus is Heavy) and (Car is Few) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
21	If (Bus is Heavy) and (Car is Few) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
22	If (Bus is Heavy) and (Car is Moderate) and (Motorcycle is Few) then (Degree_of_Congestion is heavy_congestion) (1)
23	If (Bus is Heavy) and (Car is Moderate) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
24	If (Bus is Heavy) and (Car is Moderate) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)
25	If (Bus is Heavy) and (Car is Heavy) and (Motorcycle is Few) then (Degree_of_Congestion is heavy_congestion) (1)
26	If (Bus is Heavy) and (Car is Heavy) and (Motorcycle is Moderate) then (Degree_of_Congestion is heavy_congestion) (1)
27	If (Bus is Heavy) and (Car is Heavy) and (Motorcycle is Heavy) then (Degree_of_Congestion is heavy_congestion) (1)

2.5 K-Nearest Neighbor

KNN or K nearest neighbor is a method used for classification and regression. In this study KNN is used on classifying vehicular types based on the area extracted on using image processing. The data is being classified as the degree of determining the closeness of numerical digits to each other. KNN will rely on the data given or training data set which will be the basis for accuracy of classification [12]. It is automatically done using MATLAB 2012 and varying 'k' value for nearest or closest sample training data. The study of [13] used Euclidean distance to determine the closest pair of points which is similar with the K Nearest neighbor approach.

3 Result and Analysis

Images were taken as an RGB images (Figure 2) and then converted into grayscale images for feature extraction. The images were processed with the use of MATLAB image processing commands and converted to binary images for counting and feature extraction. Filling holes on the images was also done using MATLAB.

Fig 2. Original Image of Bus

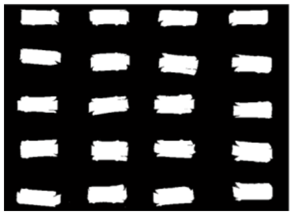

Fig 3. Binary Image

3.1 Vehicular Congestion

Reference images were taken from CNN Philippines [10] was simulated using the proposed algorithm. Images provided by CNN Philippines indicate if the traffic is light, moderate and heavy. The proposed algorithm simulates each images and aim for same result. For a certain road image, area is a factor which determines the congestion level of a certain road. Guided by the road lines and road lanes, estimation of maximum number of type vehicles within and area can be determined by looking on images. Gathered images from CNN Philippines shows light, moderate and heavy traffic reports.

Fig 3. Light Traffic

Fig 4. Binary Image

3.2 Feature Extraction

Morphology refers to shape and size of an object . Area and Perimeter is the morphological feature used in this study and calculated with the binary images generated in MATLAB. The sample command 'idx=find((11000 <=area_values)&(area_values<=22000))' to find object falling on the given range [14-15]. Data of extracted feature is summarized and tabulated based on the minimum and maximum ranges that MATLAB detected. Table 2 shows the summarized ranges for the feature extracted of the images.

TABLE 2
Summary of Vehicle Area Ranges

	Vehicles Area Ranges		
Feature			
	Bus	Cars	Motorcycle
Area	42,000 to 57,000	13,000 to 35,000	4,000 to 13,000

3.3 Classification using KNN

Classification is grouping of objects having the same features [16]. After getting the data extracted from the images, the samples undergo thru KNN classifier with k range of 1-10. KNN classifier will recognize bus, cars and motorcycle based on its nearest neighboring training data. The KNN classification shows k = 1 and k= 2 has the highest efficiency among other value tested on k. The result showed for k=1 & 2 got 98% classification out of 60 test data, k = 3 to 5 got 96% accuracy. K=7 displayed 93% accuracy and k=8 to 10 showed the same as k=3 to 5 with 96% accuracy.

3.4 Fuzzification

Based on the data, Fuzzy rules is set to match the decision of degree of congestion based on human cognitive linguistics. The data is processed in MATLAB using fuzzy toolbox and relationship is then summarized automatically. The figure below is the relationship of the number of area which is set to be the input that categorized as few, moderate, and heavy for all the three sample vehicles used in the study. For every vehicle road area of the image is considered. Few is set to be 0-40 %, moderate is 41-70%, and heavy is 71-100% for the input. To apply this on the input road area is considered. Example for this if the road can handle 20 cars and 18 cars are present then 90% is considered to heavy for car input. The output is the degree of congestion rated as light congestion, moderate congestion, and heavy congestion. The bus range is from 42,000 as the lowest area extracted on the image to 4 e+06 as the total of all busses extracted. The car range is from 13,000 as the lowest area extracted on the image to 1,716,113 the total of all cars extracted. The motorcycle range is from 4,000 as the lowest area extracted on the image to 764,318 as the total of all motorcycle extracted. The output is then rated as percentage which determines the degree of congestion 0-40 % for light congestion, 41 – 70% moderate congestion and 71 – 100% heavy congestion. Figure 62 shows the rule viewer and describe the degree of congestion based on the input parameters.

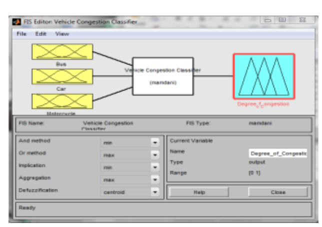

Fig 5. Fuzzy Tool Box

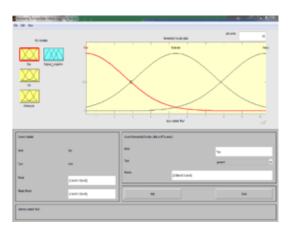

Fig 6. Binary Image

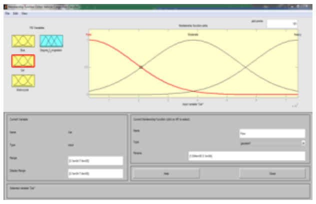

Fig 7. Car Range

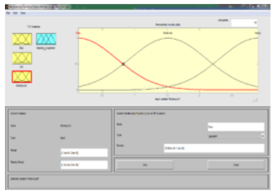

Fig 8. Motor Cycle Range

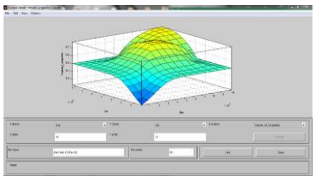

Fig 9. Surface Viewer

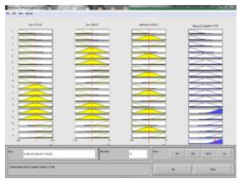

Fig 10. Rule Viewer of MATLAB

4 Conclusion

The study pictures the use and potential of fuzzy logic, KNN and image processing to identify vehicular congestion. Using this method classification of vehicles according to its area is possible with ease. In this study, three main vehicles (bus, cars and motorcycle) were used as a subject as it is the main proponent of public roadways. MATLAB algorithm was used on processing both image and classification of the vehicles from external camera unit. Image processing serves as the tool for feature extraction such as area and the data was used in fuzzy logic. All vehicle samples were given rules set such as few, moderate, and heavy and the outcome is the degree of congestion (light congestion, moderate congestion and heavy congestion) rated as percentage. Consequently, the study shows that incorporation of KNN, fuzzy logic and image processing is a great way for determining vehicular congestion.

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