Road Congestion Detection using Image Texture Analysis

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Abstract - *Extensive number of traffic on roads and improper methods of control of that traffic creates traffic jam. Bad traffic management leads to wastage of time, person-hour and increase in pollution. Existing methods work well in free-flow traffic but in the case of heavy congestion, these methods have to face challenges. Therefore, for better traffic management image processing methods serves as a better option. In proposed system, for the vast increase in congestion problem and problems related to existing detectors, an intelligent traffic controller based on the concept of real time image processing is proposed. Through image grayscale relegation, gray level co-occurrence matrix calculation and feature extraction, the energy and entropy features that reflect vehicle density will be obtained from vehicle area. The density is calculated for every 50th frame(approx. 2sec). While calculating the density we have calculated the vehicles manually from every 50th frame and then to verify results ,correlation graph is plotted between x-axis(no. of vehicles) & y-axis(density).After feature training, the decision threshold will be obtained and traffic congestion is detected. Extensive experiments on four different videos demonstrate that the proposed framework achieves good performance for road congestion detection.*

Key Words: Traffic management, congestion, gray level co-occurence matrix, energy, entropy, density, correlation

1. INTRODUCTION

Traffic congestion is a situation on road networks that arises as use increases. It is distinguished by slower speeds, longer journey times and increased vehicular queuing. Extreme traffic congestion happens as demand exceeds the capacity of a road. When vehicles are stopped for periods of time, traffic jam occurs. There are number of situations which cause or magnify congestion; most of them reduce the capacity of a road at a given point or over a certain length or increase the number of vehicles required for a given volume of people or goods.

According to a study of vehicles, around half of traffic congestion is attributed to sheer weight of traffic; while most of the rest is attributed to traffic incidents, road work and weather events. Traffic research still cannot fully predict under which conditions a “traffic jam” may suddenly occur. It has been found that individual incidents may cause wave effects which then spread out and create a sustained traffic jam. Road traffic monitoring involves the collection of data describing the characteristics of vehicles and their movement through road networks. Vehicle count, vehicle speed, vehicle path flow rates, vehicle density, vehicle length, weight, class (car, van, bus) and vehicle identities via the number plate are all examples of useful data. Such data can be very useful for traffic surveillance applications.

Through the continuous efforts of researchers, there is a set of relatively fixed process of road congestion detection based on image processing, which contains training monitoring background, road foreground detection, features extraction and training, road congestion estimation. However, in this process, training background is time-consuming, and some factors can easily influence the result, such as scenes change, camera shaking, and the light changes. But in reality, accurately obtaining traffic conditions in real time is the key to relieve road congestion. In this project, a real-time road congestion detection algorithm based on texture analysis is proposed, which deals with image data from road surveillance systems and carries out the accurate identification of vehicle density in different scenes. It is considered to successfully provide quick and reliable traffic information to the traffic administrative departments. The proposed project aims at development of system to detect congestion of traffic based on image processing approach using video of traffic on the road.

The rate of accident is increasing very speedily in today’s fast moving world, The over-speed of vehicles is one of the main reason for this. Speed detection of moving vehicle using speed cameras is one of the major steps taken towards this issue so as to bring down the rate of accidents and enhance road safety. As the single biggest cause of road accidents is speed most of the research is going on to detect speed of vehicle. Many speed detection instruments are available for moving vehicle speed detection. The need to use radar systems is growing in importance. This is not only for military applications but also for civilian applications. The latter includes (but not limited to) monitoring speeds of vehicles on high ways, sport competitions, airplanes, etc. The spread of use of radar systems is affected negatively with the high cost of radar systems and also with the increasing requirements on the accuracy of the outputs. This motivated the research on alternative technologies that offer both higher accuracy and be more cost effective. The field of image processing has grown considerably during the past decade.

This has been driven by

1) The increased utilization of imagery in myriad applications
2) Improvements in the size, speed and cost effectiveness of digital computers and related signal processing technologies.

Image processing has found a significant role in scientific, industrial, space and government applications. Nowadays many systems are being replaced by the system which uses image processing and gives better performance than former one.

1.1 Causes of Traffic Congestion

1. Private encroachments

2. Unscientific road design

3. Lack of freeways / exit ways where local roads and main roads intersect

4. Lack of demarcated footpaths

5. Lack of bus bays

6. Non cooperation among drivers

7. Lack of cycle tracks

8. Lack of coordination among various government departments (e.g. digging of roads by telecom/water department and leaving it open)

1.2 Countermeasures

Listed below are the countermeasures:

1.2.1 Road infrastructure

A) Junction improvements

a) Grade separation, using bridges (or, less often, tunnels) freeing movements from having to stop for other crossing movements

b)Ramp signaling, 'drip-feeding' merging traffic via traffic signals onto a congested motorway-type roadway

c) Reducing junctions

i)Local-express lanes, providing through lanes that bypass junction on-ramp and off-ramp zones

ii)Limited-access road, roads that limit the type and amounts of driveways along their lengths

B) Reversible lanes, where certain sections of highway operate in the opposite direction on different times of the day(s) of the week, to match asymmetric demand. These pose a potential for collisions, if drivers do not notice the change in direction indicators. This may be controlled by variable-message signs or by movable physical separation

C) Separate lanes for specific user groups (usually with the goal of higher people throughput with fewer vehicles)

a)Bus lanes as part of a bus way system

b)Express toll lanes

c) HOV lanes, for vehicles with at least three (sometimes at least two) riders, intended to encourage carpooling

1.2.2 Urban planning and design

City planning and urban design practices can have a huge impact on levels of future traffic congestion, though they are of limited relevance for short-term change.

a) Grid plans including fused grid road network geometry, rather than tree-like network topology which branches into cul-de-sacs (which reduce local traffic, but increase total distances driven and discourage walking by reducing connectivity). This avoids concentration of traffic on a small number of arterial roads and allows more trips to be made without a car.

b) Zoning laws that encourage mixed-use development, which reduces distances between residential, commercial, retail, and recreational destinations and encourage cycling and walking. Cycling modal share is strongly associated with the availability of local cycling infrastructure.

c) Car free cities, car-light cities, and eco-cities designed to eliminate the need to travel by car for most inhabitants.

d) Transit-oriented development are residential and commercial areas designed to maximize access to public transport by providing a transit station or stop (train station, metro station, tram stop, or bus stop).

1.2.3 Supply and demand

Congestion can be reduced by either increasing road capacity (supply), or by reducing traffic (demand). Capacity can be increased in a number of ways, but needs to take account of latent demand otherwise it may be used more strongly than anticipated. Critics of the approach of adding capacity have compared it to "fighting obesity by letting out your belt" (inducing demand that did not exist before). For example, when new lanes are created, households with a second car that used to be parked most of the time may begin to use this second car for commuting. Reducing road capacity has in turn been attacked as removing free choice as well as increasing travel costs and times, placing an especially high burden on the low income residents who must commute to work.

Increased supply can include:

i) Adding more capacity at bottlenecks (such as by adding more lanes at the expense of hard shoulders or safety zones, or by removing local obstacles like bridge supports and widening tunnels)

ii) Adding more capacity over the whole of a route (generally by adding more lanes)

iii) Creating new routes

iv)Traffic management improvements (see separate section below)

Reduction of demand can include:

i) Parking restrictions, making motor vehicle use less attractive by increasing the monetary and non-monetary costs of parking, introducing greater competition for limited city or road space. Most transport planning experts agree that free parking distorts the market in favour of car travel, exacerbating congestion.

ii) Park and ride facilities allowing parking at a distance and allowing continuation by public transport or ride sharing. Park-and-ride car parks are commonly found at metro stations, freeway entrances in suburban areas, and at the edge of smaller cities.

iii) Reduction of road capacity to force traffic onto other travel modes. Methods include traffic calming and the shared space concept.

iv)Road pricing, charging money for access onto a road/specific area at certain times, congestion levels or for certain road users

v) "Cap and trade", in which only licensed cars are allowed on the roads. A limited quota of car licenses are issued each year and traded in a free market fashion. This guarantees that the number of cars does not exceed road capacity while avoiding the negative effects of shortages normally associated with quotas. However, since demand for cars tends to be inelastic, the result are exorbitant purchase prices for the licenses, pricing out the lower levels of society, as seen Singapore's Certificate of Entitlement scheme.

vi) Congestion pricing, where a certain area, such as the inner part of a congested city, is surrounded with a cordon into which entry with a car requires payment. The cordon may be a physical boundary (i.e., surrounded by toll stations) or it may be virtual, with enforcement being via spot checks or cameras on the entry routes.

1.2.4 Traffic management

Use of so-called intelligent transportation systems, which guide traffic:

a) Variable message signs installed along the roadway, to advise road users

b) Navigation systems, possibly linked up to automatic traffic reporting

c) Traffic counters permanently installed, to provide real-time traffic counts

d) Automated highway systems, a future idea which could reduce the safe interval between cars (required for braking in emergencies) and increase highway capacity by as much as 100% while increasing travel speeds

e) Parking guidance and information systems providing dynamic advice to motorists about free parking

2. PROPOSED METHODOLOGY

In the proposed system, road congestion detection algorithm based on texture analysis is proposed, which deals with image data from road surveillance systems and carries out the accurate identification of vehicle density in different scenes. It will be considered to successfully provide quick and reliable traffic information to the traffic administrative departments.

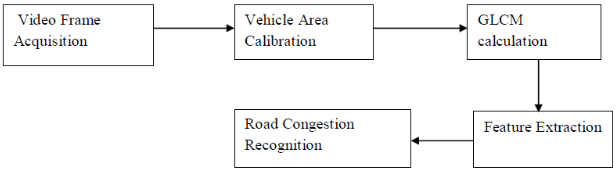


Fig2.1 Block Diagram for Proposed System

2.1 MODULES & DESCRIPTION

1. Video Frame Acquisition
2. Vehicle Area Calibration
3. GLCM Calculation
4. Feature Extraction
5. Road Congestion Recognition

2.1.1 Video Frame Acquisition:

To design advance traffic control system firstly a camera will be set up at certain height. Record video from the camera and perform multiple operations on it.

2.1.2 Vehicle Area Calibration:

The current method of congestion detection will be carried out at background however the proceeding is not only time-consuming, but easily affected by many factors. For time-saving, the proposed project will artificially set vehicle area firstly, and then use the texture analysis method for congestion estimation. After setting, the gray value of vehicle area will remain same, while the other area will set to zero, which means the background.

2.1.3 GLCM Calculation:

A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix.

The standard gray image is 256 gray scale, the corresponding GLCM is 256x256. Computing GLCM with this size is both time-consuming and not necessary. It is well known that mostly the color of vehicle is single, so in image the gray value of vehicle should be single or several successive values. But because of the light reflection, actually the gray value of vehicle area may have dozen choices. It results in that GLCM histogram distribution is more homogeneous than real, therefore the extracted texture features cannot truly reflect the density of vehicles. To solve this problem, we can reduce the gray levels. After testing, it is suitable to reduce 256-level to 32-level. In 32-level image, the pixel value in the area of black vehicle only has less than 3 choices.

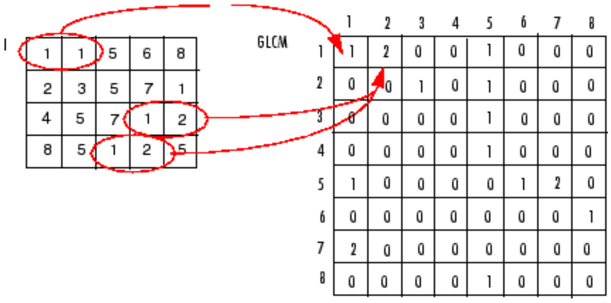
The GLCM can be calculated after gray scale reduction. In our approach, d is set to 1, that is to calculate the distribution of adjacent pixels. As for θ, we set four angles, which are 0°, 45°, 90° and 135°. These four GLCM can represent texture of different directions, including horizontal, vertical and diagonal direction. This method can be applied to deal with images taken from different places. As mentioned before, after gray scale reducing the area with zero pixel value was treated as background. When carrying out texture analysis on the image, the background area should be abandoned. So, the first row and the first column of GLCM are removed.

To create a GLCM, use the graycomatrix function. The function creates a gray-level co-occurrence matrix (GLCM) by calculating how often a pixel with the intensity (gray-level) value *i* occurs in a specific spatial relationship to a pixel with the value *j*. By default, the spatial relationship is defined as the pixel of interest and the pixel to its immediate right (horizontally adjacent), but you can specify other spatial relationships between the two pixels. Each element (*i,j*) in the resultant glcm is simply the sum of the number of times that the pixel with value *i* occurred in the specified spatial relationship to a pixel with value *j* in the input image.

The number of gray levels in the image determines the size of the GLCM. By default, graycomatrix uses scaling to reduce the number of intensity values in an image to eight, but you can use the NumLevels and the GrayLimits parameters to control this scaling of gray levels. See the graycomatrix reference page for more information.

The gray-level co-occurrence matrix can reveal certain properties about the spatial distribution of the gray levels in the texture image. For example, if most of the entries in the GLCM are concentrated along the diagonal, the texture is coarse with respect to the specified offset. You can also derive several statistical measures from the GLCM. To illustrate, the following figure shows how graycomatrix calculates the first three values in a GLCM. In the output GLCM, element (1,1) contains the value 1 because there is only one instance in the input image where two horizontally adjacent pixels have the values 1 and 1, respectively. glcm(1,2) contains the value 2 because there are two instances where two horizontally adjacent pixels have the values 1 and 2. Element (1,3) in the GLCM has the value 0 because there are no instances of two horizontally adjacent pixels with the values 1 and 3. graycomatrix continues processing the input image, scanning the image for other pixel pairs (*i,j*) and recording the sums in the corresponding elements of the GLCM.

Process Used to Create the GLCM



1	1	5	6	8
2	3	5	7	1
4	5	7	1	2
8	5	1	2	5

	1	2	3	4	5	6	7	8
1	1	2	0	0	1	0	0	0
2	0	0	1	0	1	0	0	0
3	0	0	0	0	1	0	0	0
4	0	0	0	0	1	0	0	0
5	1	0	0	0	0	1	2	0
6	0	0	0	0	0	0	0	1
7	2	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	0

2.1.4 Feature Extraction:

After the calculation of GLCM, extract energy and entropy feature from the GLCM.

For vehicle density estimation, we choose the energy and entropy features from GLCM. Because the energy shows whether the texture is thick or thin, if the image had thick texture, the energy value would be high. The entropy reflects whether the elements in GLCM are uniformly distributed proved that if the gray histogram distribution of image was uniform, the entropy feature would be high. For road traffic monitoring images, when there is large number of vehicles which are quite regularly running along the lane line, the gray histogram of image should be distributed uniformly and the texture of the image should be thin, therefore the energy feature value should be small and the entropy feature value should be big. In the opposite, if there are a few cars randomly running, the energy value should be big and the entropy value should be small. So, the value of energy is inversely proportional with vehicle density and the value of entropy is proportional with vehicle density.

We use Eq. 1 and 2 to extract energy and entropy feature from the four GLCM.

$$S_g(d,\theta)=\left(\sum_{i=0}^{L-1}\sum_{j=0}^{L-1} f(i,j|d,\theta)^2\right) \text{........(1)}$$

$$S_p(d,\theta)=\left(\sum_{i=0}^{L-1}\sum_{j=0}^{L-1} f(i,j|d,\theta)\ln f(i,j|d,\theta)\right) \text{......(2)}$$

In Eq. 1 and 2, *f*(*i,j*) is element of GLCM, *L* is the number of row or column of GLCM, which is 31, *Sg* is the energy and *Sp* is the entropy. Totally we can extract 8 features from all four GLCM, which are represented by vector *Ṡ,*
Ṡ = {*Sg0,Sg45,Sg90,Sg135,Sp0,Sp45,Sp90,Sp135*}.
We found that the value of *Sg* is one order of magnitude lower than the value of *Sp*, besides *Sg* is inversely proportional with vehicle density. So we use Eq. 3 to calculate new energy feature *S'g*, which is one order of magnitude higher than *Sg* and is proportional with vehicle density. That is the same as entropy feature *Sp*. Our new feature vector is *Ṡ*={*S'g0,S'g45,S'g90,S'g135,Sp0,Sp45,Sp90,Sp135*}

$$S'_g(d,\theta)=-\ln\left(\sum_{i=0}^{L-1}\sum_{j=0}^{L-1} f(i,j|d,\theta)^2\right) \text{.......(3)}$$

Then we use Eq. 4 to calculate the final texture feature *S*, *S* is used to estimate vehicle density.

$$S=\left(S'_{g0}+S'_{g45}+S'_{g90}+S'_{g135}\right)/4+\left(S_{p0}+S_{p45}+S_{p90}+S_{p135}\right)/4$$

.....(4)

2.1.5 Road Congestion Recognition:

Feature *S* reflects the density of vehicle in the image, bigger *S* means heavier road congestion, smaller *S* means unobstructed road condition. We carried out no. of experiments to obtain the threshold *ST*. When *S>ST*, there are crowded vehicles on the road, which may lead to traffic congestion. When *S<ST*, the traffic is smooth. .

3. FLOW CHART

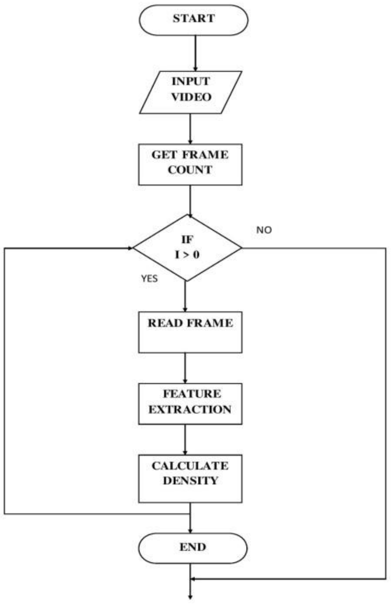


Fig 3.1 Flow diagram of proposed system

Figure shows the flow diagram of proposed system . The first step is to input video stream into the sequence of frames. Then those frames are scaled to 256x256, for better performance in MATLAB. The input videos used in proposed system are color videos. The RGB images are converted to grayscale by eliminating the hue and saturation information while retaining the luminance.

The current method of congestion detection basically carried out background training at first. However the proceeding is not only time-consuming, but easily affected by many factors. For time-saving, set vehicle area firstly, and then use the texture analysis method for congestion estimation. After the setting, the gray value of vehicle area remains the same, while the other area is set to zero, which means the background .

A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM), also known as the gray-level spatial dependence matrix. The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix. After the calculation of GLCM, extract energy and entropy feature from the GLCM. Feature reflects the density of vehicle in the image.

4. RESULT

Correlation coefficient is defined in statistics as the measurement of the strength of the relationship between two variables and their association with each other. In simple words, correlation coefficient calculates the effect of change in one variable when the other variable changes. This approach is based on covariance and thus is the best method to measure the relationship between two variables.

The Correlation coefficient has a high statistical significance. It looks at the relationship between two variables. It seeks to draw a line through the data of two variables to show their relationship. The relationship of the variables is measured with the help correlation coefficient calculator. This linear relationship can be positive or negative. The correlation coefficient formula finds out the relation between the variables. It returns the values between -1 and 1.

Correlation coefficient formula:

$$r = \frac{N\Sigma xy-(\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2-(\Sigma x)^2][N\Sigma y^2-(\Sigma y)^2]}}$$

Where:

N = the number of pairs of scores

Σxy = the sum of the products of paired scores

Σx = the sum of x scores

Σy = the sum of y scores

Σx2 = the sum of squared x scores

Σy2 = the sum of squared y scores

The videos are taken from internet. The camera set at a height has recorded the data set (videos)which contains traffic moving from one place to another. The density is calculated for every 50th frame(approx. 2sec). While calculating the density we have calculated the vehicles manually from every 50th frame and then to verify results ,correlation graph is plotted between x-axis(no. of vehicles) & y-axis(density).Details of the video, table of density and no. of vehicles, correlation graph of different video are mentioned below:

1. Video No. -1

General Settings:

Duration = 147.0517

Name = 1.mp4

Path = E:\4videos\ad1

Type = VideoReader

UserData = []

Video Settings

BitsPerPixel = 24

FrameRate = 30

Height = 240

NumberofFrames = 4411

VideoFormat = RGB24

Width = 320

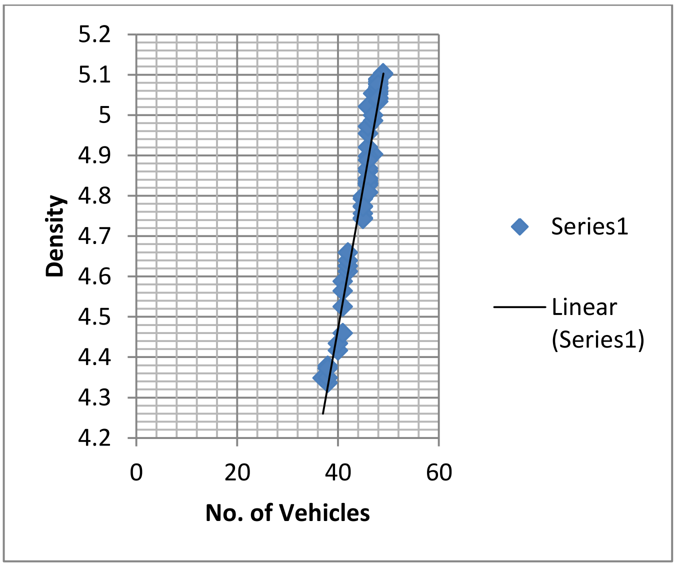


Fig. No.4.1: Correlation graph between No. of Vehicles & Density

5. CONCLUSIONS

The automatic vehicle tracking or identification facility delivers the flexibility, scalability, and responsiveness that today's organizations need. It provides accurate, up-to minute information, high- speed communication, and powerful analysis features required to make better decisions faster. The proposed system is validated using set of images taken from different traffic videos. The proposed method is applied on the various images and detect the density of vehicles i.e. First, to set vehicle area. Secondly, texture features will be extracted to estimate vehicle density.

6. REFERENCES

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Sr. No.	No. of Frames	No. of Vehicles	Density
1	Frame 50	26	4.0175
2	Frame 100	27	4.0336
3	Frame 150	28	4.057
4	Frame 200	30	4.1139
5	Frame 250	31	4.2305
6	Frame 300	32	4.2902
7	Frame 350	31	4.264
8	Frame 400	30	4.1429
9	Frame 450	33	4.3012
10	Frame 500	30	4.1717
11	Frame 550	31	4.2142
12	Frame 600	31	4.2411
13	Frame 650	32	4.2657
14	Frame 700	33	4.3235
15	Frame 750	34	4.4102
16	Frame 800	35	4.4611
17	Frame 850	35	4.4638
18	Frame 900	35	4.4422
19	Frame 950	34	4.4215
20	Frame 1000	36	4.5948
21	Frame 1050	35	4.4794
22	Frame 1100	33	4.3622
23	Frame 1150	36	4.5764
24	Frame 1200	34	4.424
25	Frame 1250	33	4.3929
26	Frame 1300	32	4.217
27	Frame 1350	33	4.3314
28	Frame 1400	33	4.3162
29	Frame 1450	34	4.4192
30	Frame 1500	35	4.4811
31	Frame 1550	36	4.5549
32	Frame 1600	35	4.5021
33	Frame 1650	33	4.3753
34	Frame 1700	35	4.5268
35	Frame 1750	37	4.5979
36	Frame 1800	33	4.434
37	Frame 1850	32	4.0999
38	Frame 1900	33	4.4003
39	Frame 1950	34	4.4477
40	Frame 2000	38	4.6407
		Correlation Coefficient	**0.956892**