Road Traffic Density Estimation using Roadside Acoustic Signals

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Abstract : The problem of Road Traffic Density Estimation using roadside acoustic signals is consider in this paper, depending on the vehicles condition like speed, load, mechanical condition etc., it will produce various noise like tire noise, air-turbulence noise, engine noise, engine-idling noise and occasional honks. These signals having their own different spectral content which are different from each other hence classify between them in three classes such as jammed flow traffic (0-10km/h), medium flow traffic (10-40km/h) and free flow traffic (40km/h and above).Based on these extract the features from acoustic signals using Grey Level Co-occurrence Matrix(GLCM) use a discriminative classifier such as Gaussian Mixture Model(GMM) classifier. Which gives high efficiency results.

***IndexTerms* –Acoustic signals, Gaussian Mixture Model(GMM), Grey level co-occurrence matrix(GLCM)**

I. INTRODUCTION

Increase the motorization, urbanization and population growth it will produce road traffic. Hence the road traffic density is very big problem all over the world. It will also increase user frustration. In many developed countries there are intelligent transportation systems (ITS) is used. In that system there are many costly sensors are used. They are magnetic loop sensors, speed guns and video cameras. However all these sensors are very expensive and its installation and maintenance cost is very high. In [1] use the Gaussian-Mixture Model(GMM) to extracted the features from a audio signals by mel frequency cepstral coefficients . In [4], proposed the traffic signals in real time to optimizing the network. The SCOOT method. Kato et.al. has presented vehicle tracking system on basis of hidden markov model using segmentation method for et.al. vehicle tracking[5]. However, the method does not give any idea about average speed.Vehicle speed using wheelbase length and tire track length by it's acoustic wave pattern proposed by volkan cehever[7].Shiping chen et.al. detect the sound wave generated by the vehicles using a microphone to detect the traffic monitoring using digital sound field mapping[9]. In[11] evaluation of traffic parameters by fusing visual perception using CNN processing of webcam images. Road traffic condition estimation based on road acoustic ,they extract the features from acoustic signal using Mel-frequency cepstral coefficients (MFCC) and classify with three different classifiers. The proposed method uses Omni-directional microphone which is a cost effective approach compared to existing high cost techniques such as video processing, magnetic loop detectors etc proposed by Vasant Warghade et.al.[2]. Vehicular condition and traffic estimation using MFFC and artificial neural network , from various part of vehicles which includes rotational parts, vibrations in the engine, friction between the tires and the road, exhausted parts of vehicles, gears, etc. Noise signals are tire noise, engine noise, engine-idling noise, occasional honks, and air turbulence noise of multiple vehicles presented by Minal Bhandarkar et.al [3]. Vehicles detection using rule based visual data in urban traffic scenes. For traffic the vehicle a separation between low-level and high-level image processing module provides a general-purpose knowledge-based framework . This module in day time extracts visual data using spatio temporal analysis and morphological analysis of headlights at night proposed by Rita Cucchiara[6]. Scott A. Amman et. al. gives automotive engine sounds modelled and synthesized by using a deterministic-stochastic signal decomposition and deterministic component extracted by synchronous discrete Fourier transform (DFT) method and this is subtracted out from the original signal. Stochastic component is modelled and synthesized using a new multi pulse excited time-series modeling technique [8]. Shunsuke Kamijo et. al. described traffic monitoring system for tracking vehicles and detected the accident by using Hidden Markov model [12]. The number of deaths and injuries from traffic accidents has been rapidly increasing. In these paper, road side acoustic signals are characterize by different classes which is free traffic, medium traffic and jammed traffic using Gaussian Mixture Model (GMM) classifier and extracted the features from audio signals using Gray level co-occurrence matrix (GLCM)is used.

The paper is organized as follows: section II proposed method is described, section III database mentioned, the experimentation are elaborated in section IV. The evaluation and performance is presented in V. The conclusion is presented in section VI.

II PROPOSED METHODS

In proposed methods, there are three different traffic classes are proposed which are Jammed traffic (0-10 km/h), Medium traffic (10-40 km/h) and Free traffic (40 km/h and above). Which is shown in Fig. 3.1, 3.2, 3.3 respectively. That traffic classes is used to detect the traffic density from different recorded audio signals.

Figure 3.1: Jammed traffic

Figure 3.2: Medium-Flow traffic

Figure 3.3: Free-Flow traffic

In developing countries there are heterogeneous traffic density is observed which is major problem . Hence instead of the volume and speed measures there are used three different traffic classes as free, medium, and jammed. In this proposed method used features extracted from the spectrogram this three classes and estimates the traffic densities. To extract second order statistical texture features for motion estimation of spectrogram images used an application of gray level co-occurrence matrix (GLCM). By extracting the features of an image by GLCM approach, the image compression time can be greatly reduced in the process of converting RGB to Gray level image. Gray level image are equal number of rows and columns of GLCM matrix. The matrix element $\boldsymbol{P}(\boldsymbol{i},\boldsymbol{j}|\Delta\boldsymbol{x},\Delta\boldsymbol{y})$ is the relative frequency with which two pixels, separated by the distance $(\Delta\boldsymbol{x},\Delta\boldsymbol{y})$. Occurs within the given neighborhood, with two intensities "i" and "j". The matrix element $\boldsymbol{P}(\boldsymbol{i},\boldsymbol{j}|\boldsymbol{d},\boldsymbol{\theta})$, contains second order statistical probabilities values for change between gray level "i" and "j" with displacement "$\boldsymbol{d}$" and angular displacement "$\boldsymbol{\theta}$". Using a large number of intensity levels G implies, large temporal data, i.e. G×G matrix for each combination of $(\Delta\boldsymbol{x},\Delta\boldsymbol{y})$ or $(\boldsymbol{d},\boldsymbol{\theta})$ Dimensionally GLCM matrix is very large, but it is very sensitive for size. Hence gray level often reduced.

Using GLCM features extraction after that apply the classifier which is Support Vector Machine (SVM) for traffic density classes free traffic, medium traffic, and jammed traffic.

III. DATABASE

The acoustic signals are recorded at different places and different time in the city.

- Microphone: Omni directional
- Sampling frequency: 16 KHz
- Channel: mono,
- Data type:16 bit PCM,
- Duration: 2-3minutes(approximate)

Recorded signals are labeled as free, medium and jammed traffic.

IV. EXPERIMENTATION

A. Plot spectrograms

For recorded audio signals plotted the spectrograms. Extract the features for GLCM using these spectrogram.

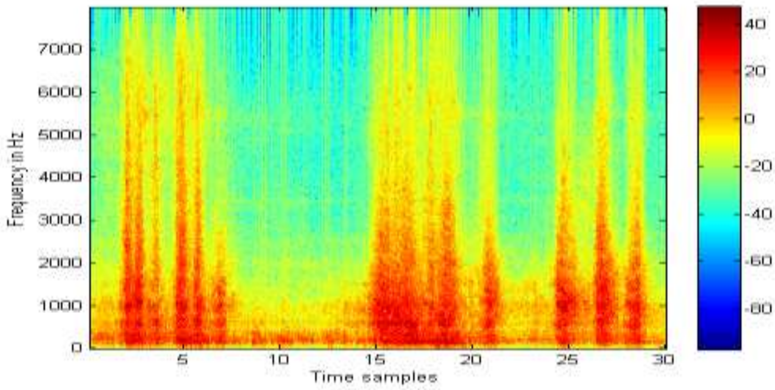

Figure 4.1 Result of free flow traffic

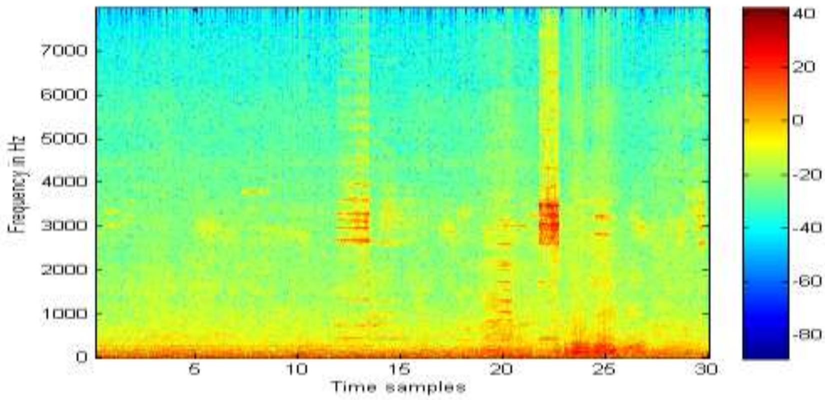

Figure 4.2 Result of medium flow traffic

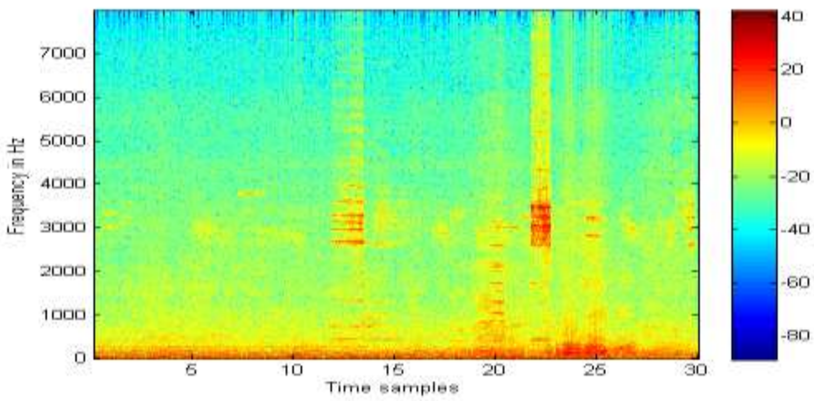

Figure 4.3 Result of jammed flow traffic

1) In figure 4.1, seen that the wideband driven noise and air turbulence noise. It is noted that there are no honks, rarely any is found for free traffic.
2) In figure 4.2, seen that the honks and some noise are present at the base of spectrogram i.e. low frequency noise also some wideband driven noise are present, for medium traffic.

3) In figure 4.3, seen that there is are air turbulence noise, wideband noise and honks are present and several harmonics are present of the horns, for jammed traffic.

B. GLCM feature extraction

Apply to the gray level co-occurrence matrix for these spectrograms and then used them for features extraction. Autocorrelation, Contrast, Correlation, Cluster Prominence, Cluster Shade, Dissimilarity, Energy, Entropy, Homogeneity, Homogeneity, Maximum probability, Sum of squares, Sum average, Sum variance, Sum entropy, Difference variance, Difference entropy, Information measure of correlation1, Information measure of correlation 2, Inverse difference (INV) is homom, Inverse difference normalized (INN), Inverse difference moment normalized. In these method using stem plot, choose only six features which gives better results (i.e. Contrast, Correlation: matlab, Correlation:[1,2], Cluster Prominence, Cluster Shade, Dissimilarity). These are twelve features which mathematically explain as below:

1) Contrast:

The GLCM which is in between maximum and minimum values of an adjoining set of pixels measure the local grey level variation in contrast.

$$contrast = \sum_i \sum_j (i-j)^2 \, G(i,j) \qquad (1)$$

Where G is the cell value and i and j are the horizontal and vertical GLCM matrix coordinates respectively. The contrast of GLCM matrix which is varying between [0, (size (GLCM,1)-1)^2], In that, for a constant image contrast is zero.

2)Correlation:

Correlation which is used to measure a gray pixel linear dependency with relative pixels in the image and displacement and measures deformation.

$$correlation = \frac{\sum_{i=0} \sum_{j=0} (i,j) G(i,j) - \mu_x \mu_y}{\sigma_i \sigma_j} \qquad (2)$$

Where $\sigma_i and\ \sigma_j$ are standard deviation of horizontal and vertical GLCM matrix, respectively, and variance ($\sigma_i^2\ and\ \sigma_j^2$) is given by

$$\sigma_i^2 = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} G(i,j)(i-\mu_i) \qquad (3)$$

$$\sigma_j^2 = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} G(i,j)(j-\mu_j) \qquad (4)$$

Where $\mu_i\ and\ \mu_j$ are means relative to horizontal and vertical component s respectively, and is given as,

$$\mu_i = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} iG(i,j) \qquad (5)$$

$$\mu_j = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} jG(i,j) \qquad (6)$$

Above features stem plot is shown as below:

1) Contrast:

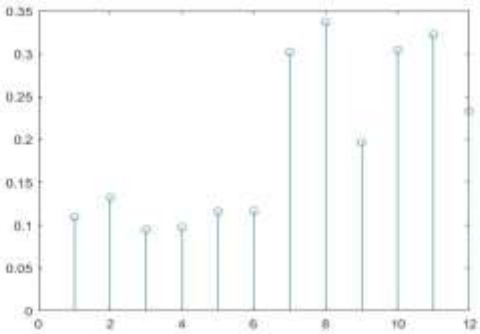

Figure 4.4 stem plot for contrast

In above fig. shows the six samples for one class and other class. GLCM gives different values for class1 and class2 which is shown in above plot, and difference between two classes.

i) Correlation: Matlab

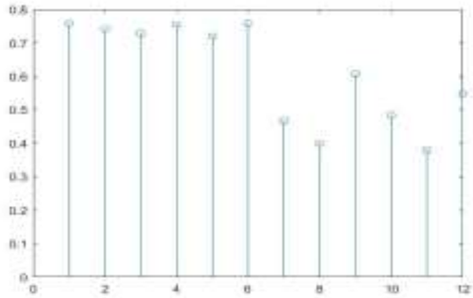

Figure 4.5 stem plot for Correlation 1

ii) Correlation:[1,2]

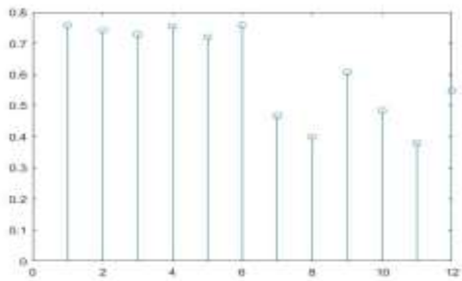

Figure 4.6 stem plot for Correlation 2

Above plot gives First six sample for one class an another six for second class.

iii) Cluster Prominenace:

In cluster prominence features shows that the six samples values approximately close and another five values are same, which distinguish between two class.

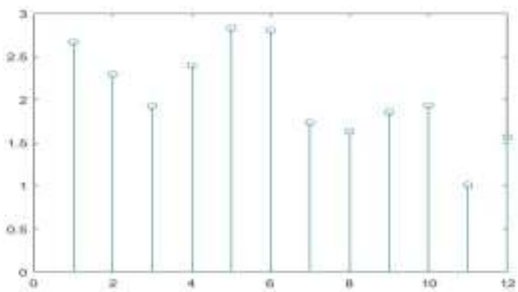

Figure 4.7 stem plot for Cluster Prominence

In fig. seen that above some features give better classification between two classes. Along with some other features studied but they not correctly classify as shown in below figures:

iv) *Autocorrelation*

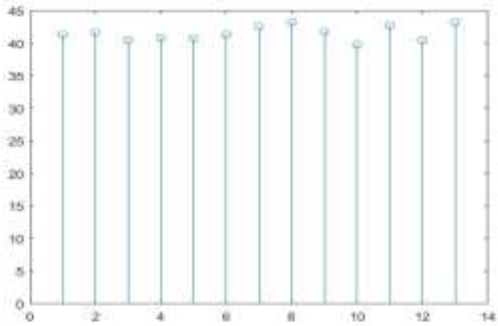

Figure 4.8 stem plot for Autocorrelation

In Autocorrelation plot shows that all the values are nearly equals. Hence it is neglected for the experiment.

v) *Sum of Varaince*

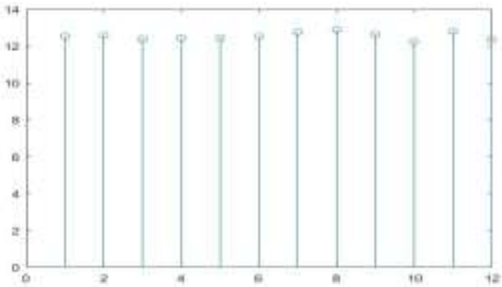

Figure 4.9 stem plot for Sum of variance

In sum of variance stem plot also gives same values hence it is neglected for experiment.

V. EVOLUTION AND PERFORMANCE

There are independent training and testing data are used for evaluation the performance of proposed method. In that Gaussian Mixture Model (GMM) classifier is used. That GMM classifier accuracy are shown as below table.

Initialization for the GMM:

• Dimension of the space = 7 (GLCM features coefficients)

• covariance type = 'diag'(diagonal matrix for each component)•

Centers = 2 (number of centres in the mixture model)

Table I

Traffic Density Classification Accuracy

Traffic Class	10 Sec	15 Sec	20 Sec	25 Sec	30 Sec
Free Traffic	96.15%	94.11%	100%	100%	100%
Medium Traffic	83.33%	62.5%	72.22%	71.42%	66.67%
Jammed Traffic	94.28%	95.83%	100%	100%	100%

With GLCM features using GMM classifier better classification results obtain with testing time 10 sec

VI. CONCLUSION

In these, we have concluded that, the proposed method is very simple technique which uses information presents in GLCM features extraction of roadside audio signals. In these method use a simple omni -directional microphone having installation and maintenance cost is very low than other methods. When lane driven is not followed then this technique is very useful for three classes such as, free, medium and jammed traffic.

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