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Traffic Density Estimation and Mechanical Condition Determination of Vehicles using Acoustic Signals

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***Abstract* – In this paper we will estimate the vehicular traffic density by using cummulative acoustic or sound signals. Here we will estimate three probable conditions of traffic that is heavy flow traffic (0-10km/h), medium flow (20-40km/h), and free flow (above 40km/h) traffic. Cumulative sound signals consist of various noise signals coming from various parts of vehicles which includes rotational parts, vibrations in the engine, friction between the tires and the road, wind effect, gears, fans. Noise signals are tire noise, engine noise, engineidling noise, occasional honks, and air turbulence noise of multiple vehicles. These noise signals contains spectral content which are different from each other, therefore we can determine the different traffic density states and mechanical condition of vehicle. For example, under a free-flowing traffic condition, the vehicles typically move with medium to high speeds and thereby produces mainly tire noise and air turbulence noise and less engine-idling noise and honks. Similar vehicles working in comparable conditions would have a similar sound signals that could be used for recognition.**

***Keywords* – Acoustic Signal Processing, Vehicles Transportation, Pattern Recognition, Adaptive Neuro-Fuzzy Classifiers, SVM.**

I. Introduction

Now a days Density of traffic on roads and highways has been increasing constantly due to motorization, urbanization, and population growth. Usually Traffic congestion reduces the efficiency of the transportation infrastructure of a city; it also increases travel time, fuel consumption, and air pollution; and leads to increased user frustration and fatigue in developing countries like India and South Asia. As number of vehicles are constantly increasing, it becomes necessary to facilitate effective control of traffic flows in urban areas [1]. Especially in rush hours, if there is a poor control at traffic signals it may result in a long time traffic jam causing a hours of delays in traffic flows and also CO2 emission[2]. In developed countries intelligent transportation system (ITS) plays a vital role for traffic congestion where traffic flow should be orderly and lane driven and mostly homogeneous. For this purpose they have used multiple sensors such as magnetic loop detectors, speed guns and video cameras. But the cost of installation and maintenance is very high during their life cycle. Therefore over the past decade, researchers have been developing several nonintrusive traffic monitoring technologies based on laser, ultrasound, radar, video and audio signals. Video image processing is very natural and impressive technique for the traffic. However the computer vision technology is not still adequate to handle variable and poor lightening condition and visual occlusions. In order to overcome such drawbacks, some researchers provide excellent references which provides robust traffic monitoring techniques using video signals, ranging from vehicle tracking to vehicle occlusion handling. In [3], Cucchiara detected vehicles in urban traffic scenes by means of rule-based reasoning on visual data. In [4], Kamijo introduced a hidden Markov model - based computer-vision technique. It detects accidents and other events such as reckless driving at road intersections which further causes accidents. However, these techniques do not directly indicates the problem of average speed estimation. In [5], Coifman proposed and feature based computer vision technique for vehicle tracking. He uses some of the "corner" features of the vehicles, which are used to track them and then estimate traffic parameters such as average speed and volume of the vehicles. They provided impressive results on free way traffic. However, it is not clear if this tracking technique could still work in the chaotic and nonlane-driven city traffic conditions and the probable conditions are heavy, medium, and slow traffic. Such traffic conditions are very common in developing countries like India and South Asia and this is the focus of this paper. As the sensors such as magnetic loop detectors[6] are widely used for traffic monitoring in developed countries but they Still have very high cost of installation and operation and maintenance as well as they required traffic flow to be orderly, lane driven and mostly homogeneous. All these conditions of magnetic loop detector not met at all in developing countries like South Asia and India, where the traffic is highly chaotic and nonlane-driven, and heterogeneous. Therefore, traffic monitoring is an even severe problem in developing countries, where the ITS systems such as loop detectors and computer-vision-based tracking techniques are not so effective. In such situations, the roadside acoustic signal seems to be a good approach for traffic monitoring due to its inherent low cost of installation and operation. Therefore, several researchers have been developed various traffic monitoring techniques based on audio modality. Doppler frequency shift provides a theoretical description of single vehicle speed. from this description it can be Assume that distance to the closest point of approach is known the solution can accommodate any line of arrival of the vehicle with respect to the microphone. Therefore he got the solution for speed estimation of single vehicle is more applicable as compared to several vehicles. In presence of several vehicles the interference of noise signals is combined with acoustic waveforms[7], [8]. Sensing techniques based on passive sound detection are reported in [9], [10]. These techniques utilizes array of microphones to detect the sound or acoustic waves generated by road side vehicles and are capable of monitoring traffic conditions with lane-by-lane and vehicleby-vehicle basis in a multilane carriageway. Here he used Correlation based algorithm [9], [10], [11], It extracts key data which reflects the road traffic conditions, for exa. The speed and density of vehicles. S. Chen introduces multilane traffic sensing concept based on passive sound which is digitized and further processed by an on-site computer which also uses a correlation based algorithm. This system having low cost of installation, maintenance and operation, safe passive detection, immunity to adverse weather conditions, and competitive manufacturing cost. The system performs well for free flow traffic but for congested traffic it is difficult to achieve best performance [11].

Valcarce. introduces the differential time delays to estimate the speed in order to achieve this which uses a Pair of omni directional microphones. It was used and technique is based on maximum likelihood principle. It directly estimates car speed without any assumptions on the acoustic signal emitted by the vehicle [12]. Mohan uses the smartphone features and basic honk signals which is used to estimate vehicles speed [13]. Simple Doppler frequency shift computations are used to estimate speed. Sen introduces Doppler frequency shift rule in which he had assumed that vehicle is moving in same direction as the straight line connecting vehicle to the microphone [14]. However, In presence of multiple honking vehicles it is not clear that how two microphone distinct honk emitted by same vehicle. The experimental setup covers at two roads, on single lane, one way and three lane bidirectional. Jien Kato introduces a method for traffic density estimation based on recognition of temporal variations that appear on the power signals in accordance with vehicle pass through a reference point [15]. Here he used Hidden Marko model for observation of local temporal variations over small periods of time which are extracted by wavelet transformation. Experimental results show good accuracy for detection of passage of vehicles. Vivek Tyagi classified traffic density state as free flowing, Medium flow and Jammed which is on speed of 0-10km/hr, 20-40km/hr and above 40km/hr respectively. They consider short term spectral envelope features of cumulative acoustic signal, and then class conditional probability distribution is modelled on one of the three broad traffic density state (i.e. free flow, medium flow or heavy flow). He uses Experimental setup of omnidirectional microphone placed at about 1.5 m height and cumulative acoustic signal is recorded at 16000 Hz sampling frequency. He uses a Bayes classifier to classify traffic density state which results in ~ 90% of accuracy, which is then improved by using discriminative classifier such as RBF-SVM [16]. Compare with the existing computer vision and traffic monitoring system in [16], [3] and [4] this technique is independent of light condition and visual occlusion and works well for developing geographies which is explained in techniques of [13], [14].

II. Proposed Work

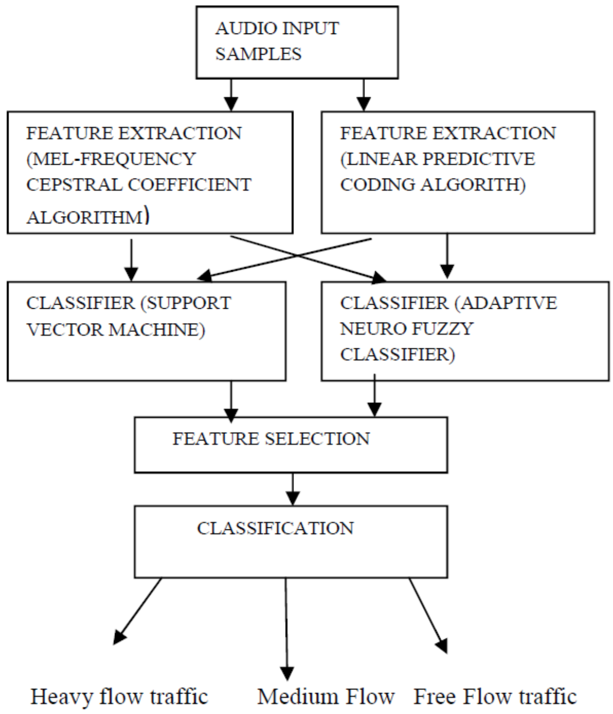

Fig1. Block diagram of proposed work

As shown in Fig.1 we will use cumulative acoustic signal which can be used to estimate the traffic density as free flow, medium flow, and heavy flow. In order to get the more accuracy we will use Support Vector Machine (SVM) and Adaptive Neuro Fuzzy Classifier(ANFC). In this paper, first we aquire 50 input samples of acoustic signal of each traffic condition. Each sample is of 60 sec long. After that we will extract feature vectors using Mel-Frequency Cepstral Coefficient(MFCC) and Linear Predictive Coefficient(LPC) algorithms. We will train the classifier with these feature algorithms. We will train the classifier with these feature vectors, this process occurs in training phase. this process occurs in training phase. after that we will take another input sample for testing and compare this signals with database which is acquired during training phase.

III. Feature Selection Algorithm

- Use Guassian distribution and describe only one fuzzy classification rule for each class.
- Set = 0.5, for i= 1,2,...,K and j= 1,2,...,D, where K is the number of classes and D is the number of features.
- Set the number of selected features (L).
- Train the neuro-fuzzy classifier with LHs. In training, $0 \leq Pij \geq 1$
- For i=1 to K. Find the *j*th feature that satisfies the maximum p value for the *i*th class. Then take the *j*th feature into the individual discriminative features set.
- The (L–K) features, which have the biggest P value which are selected as common discriminative features.
- There are L discriminative features. The new training Xnew and testing data are created by the selected features from the original data.

IV. Classification Algorithm

- Set the number of fuzzy rules (V) for every class. Then the total fuzzy rules are U= where U is the number of fuzzy rules.
- Set = 1, for i=1,2,...,U and j=1,2,...,D.
- Determine the initial value of nonlinear parameters of ANFC–LH by using K-means clustering.
- Train the ANFC–LH with Xnew training set. In training, value should be equal to or bigger than zero for every feature and fuzzy rules.
- Obtain the training and testing classification results.

V. Conclusion

We have come to this conclusion by reviewing the above literatures that we can estimate three probable conditions of traffic that is free flow, medium flow and heavy flow traffic and mechanical condition of vehicles that is good, average and bad. For concluding this we are expected the MFCC features for classification using Support Vector Machine and Adaptive Neuro-fuggy Classifier. From MFCC we get some features in the form of compressed spectrum, we will make its database and train the classifier and test other traffic signals by comparing it with the database and classify three traffic conditions. As we are using here recording system for acquiring input traffic signals it becomes independent of lighting conditions and visual occlusion problems which occurs in computer- vision or tracking based technology. As well as our technique is low cost and having easy operations and hence this technique can be used in developing countries where chaotic and non-lane driven traffic are very common.

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