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Systematic Pricing in Toll Roads using Unmanned Toll Collection Methods

Harshitha B[1], Maria Rufina P[2],Shilpa B L[3]
[1,2,3] Assistant Professor,
Department of Computer Science & Engineering,
GSSSIETW, Mysuru, (Karnataka), INDIA

Abstract: **Most of us are aware that every highway in India that is the state highway or the national highway is taxed by the Indian Government for raising funds and their maintenance. In India, the tolling is generally under the open system, whereby fee payable is a fixed amount based on the length of stretch under one project which is normally 60 kilometers. If a stretch is of lesser length, user fee of actual length only is collected. To circumvent this extra fee paid, here we would like to put forward an efficient way of collecting tolls which calculates the usage of the highway by a specific vehicle. Here usage refers to the actual distance travelled by the vehicle in the highway. First, all the opening wedges of highway will have a system to notice the vehicles entering the highway. Alongside its individual number plate will also be noted. If the same vehicle is detected at the exit, distance travelled between the entry and exit points will be calculated systematically and the amount can be deducted consequently. In this paper we intend to employ the SVM based multiclass classification to recognize the vehicle type and read the number plate of the vehicle.**

Keywords:. Machine Learning, Support Vector Machine, Supervised learning, Unsupervised learning

I. INTRODUCTION

Due to increasing population the need of vehicles also increased. This has indirectly resulted in huge number of vehicles on roads. This has resulted in increased demand for proper infrastructure. To meet these demands, almost every country has its own network on roadways. Nations are spending huge amount of money on developing infrastructure especially on laying highways. These highways usually connect major cities across the country and help in easy transport of goods, fast commuting for vehicles due to less disturbance unlike in county side roads where lot many domestic vehicles ply. Governments charge for usage of these highways in the form of tolls and some highways will be free to use. The toll fee varies depending on the type of vehicle. Typically, a car will pay lesser fee when compared to truck carrying some goods or buses plying with passengers. Ideally vehicles should be charged toll fee based on the usage of roads. Currently the prices are standard per type of vehicle and there is no means of measuring the actual distance covered by that vehicle in the highway. Highways will be used by both kinds of vehicles wherein one set of vehicles cover a longer distance in highways itself and other set of vehicles travel only lesser distance in highways. With the existing means of collection, the toll booths are only set up in such a way that irrespective of the distance covered every vehicle ends up paying the dedicated amount in every toll booth in the entire stretch of highway.

With this paper we would like to propose a systematic method of collecting tolls which takes into consideration the usage of the highway by a specific vehicle. Here usage refers to the actual distance travelled by the vehicle in the highway. In this approach first, all the entry points of highway will have a system to detect the vehicles entering the highway. Along with it, its respective number plate will be detected. Likewise, all the exit points of highways also will have a similar system [1]. By using the vehicle detected at the entry point as reference, if the same vehicle is detected at the exit, distance travelled between the entry and exit points will be calculated systematically and at the exit point the amount can be deducted accordingly.

In this paper we propose to use the SVM based multiclass classification to identify the type of vehicle and to read the number plate of the vehicle.

II. SVM BASED MULTICLASS CLASSIFICATION

With advent of new technologies almost every day, there is a need to be equipped latest trends in order to be a competent force. Nowadays the most heard and major developments are seen in machine learning. In machine learning we have set of algorithms which fall in to one of the categories namely supervised and unsupervised. Support Vector machine algorithms falls into category of supervised algorithms and these are widely used in classification or regression problems. In our approach we consider every type of vehicle as one of the feature. So if we have images of n number of vehicles then we assume that there are n-dimensions of data and hence consider a plane with n coordinates. Where in each feature or vehicle represents a coordinate. In SVM algorithm [7] we call each of these features as classes. So in n-dimension space, each of the features has to be segregated and that is done with the help of hyper-planes. Hyper planes can be assumed to be kind of lines which help to differentiate between any 2 classes. Support vectors represent the co-ordinates of these unique features. A sample SVM can be shown as below in figure 1:

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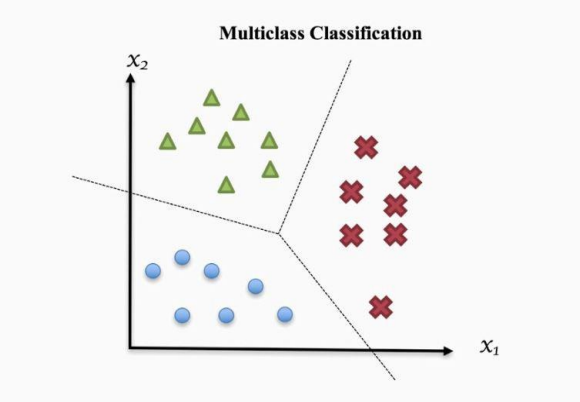

Fig. 1. Multiclass Classification

Here x1-x2 represent an n-dimensional plane. The blue, green and red symbols represent the 3 different set of features. The dotted line separating the 2 classes represent hyperplane.

In SVM, the classification is achieved with the help of these hyperplanes. Finally, we end up identifying the right hyper plane which differentiates the classes. Determining the right hyperplane involves selecting the hyperplane which separates the classes better. In some cases where all the classes are segregated and if there are more than one hyper planes, then the distance between the nearest data point and the hyperplane is taken into consideration. This distance is known as margin and whichever hyperplane has highest margin will be chosen as the right hyperplane.

In the below figure 2, A, B, C represent the hyperplanes segregating 2 classes of stars and circles. As can be seen, all the hyperplanes clearly differentiate both the classes. Hence margin is calculated for each hyperplane. Compared to other 2 hyperplanes, C has highest margin and thus C is considered as right hyper plane for the given example.

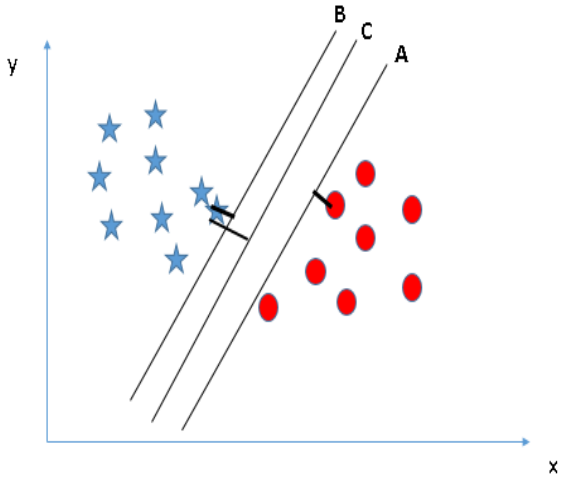

Fig. 2. Hyperplane Data

In the next example we look at a scenario where in one of the data points is far from rest of the data points within a class. Due to this all the data points were not able to map it under one hyperplane. The extreme one is considered as outlier for this class. The SVM algorithm ignores such outliers and considers hyperplane with maximum margin as the right hyperplane.

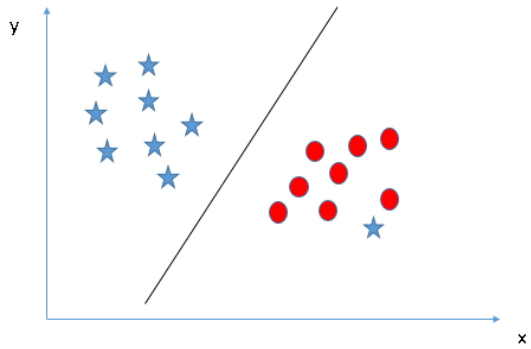

Fig. 3. Outlier Class Example

The basic principle behind working of SVM is binary classification which makes it easier for classification as only 2 classes would be present in binary classification. In order to use SVM for multi-class scenarios [11], we need to preprocess the data before training the model. There are two approaches that are generally followed while considering SVM for multiclass classification. Namely, "one versus all" and "one versus one". Both these approaches help in reducing the multi-class problem to a set of binary problems so that SVM can be efficiently used for classification.

A. One-versus-all:

As can be seen in the below figure 4, n number of classifiers and each classifier segregating one of the class against the remaining entire classes. In the below example, there are 3 classes and 3 binary classifiers.

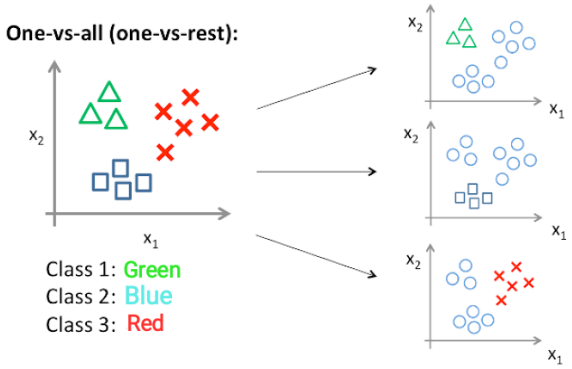

Fig. 4. Classifiers and their Segregating

The data items can be one of the three different classes. As the name of the approach itself suggests, we have to generate 3 different classifiers differentiating each of the classes against the rest of the classes. After classification, first the green data items are segregated against rest of the data items. Later the blue data items are differentiated from rest of the items and same is followed for red items. So to conclude if there are n numbers of classes, then we need The block diagram of classification is as below in figure 5.

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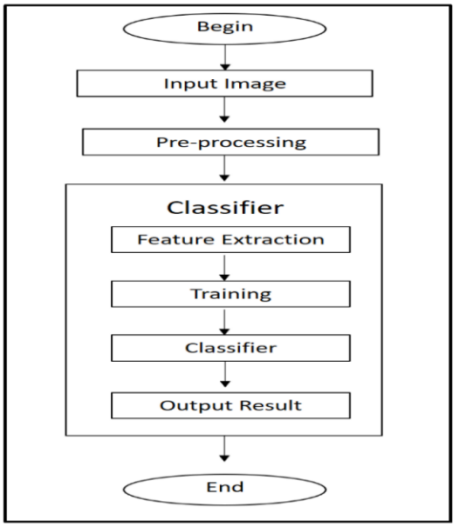

Fig. 5. Block diagram of Classification

B. One versus one:

In this approach, each class is compared against another class. And hence if there are n different classes, then we have to generate n*(n-1)/2 number of classifiers. As can be seen in the below example screenshot, in first classification all the red data items are plotted against black and in the next data items in black classes are plotted against blue and in the last red class is plotted against blue.

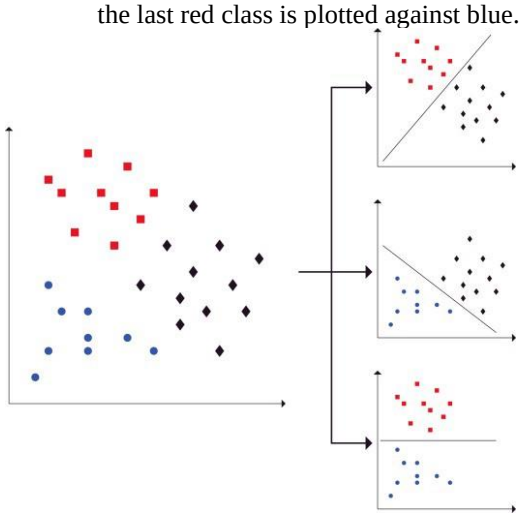

Fig. 6. One versus one Classifiers

III. RESULTS AND DISCUSSION

Experimental studies have shown that one versus all approach best suits the number plate classification.

In our approach, the captured images of the vehicles and number plates will be fed as input in the beginning. next the captured images will be preprocessed such that the features like number plate characters or only the image of the vehicle can be extracted in order to feed the model. The results can be used to train the model as well. By using the above explained steps in SVM algorithms, classification of the image is successfully accomplished, and the result will be obtained.

These images will be classified as cars, maxi cabs, tempo travelers, buses, trucks, etc. Each of these types of vehicles are different set of classes. While determining the number plate from the image, there will be 2 sets. One set denoting only the characters and the other representing the numbers in the number plates.

Through this paper we propose the following steps to effectively charge the toll fee on the vehicles.

Step 1: Once the vehicle enters the toll road zone, capture its images.

Step 2: Captured images can be fed through to SVM algorithm.

Step 3: Later on an entry can be made in a database with that number plate as key and add the entry point into the toll road as additional details in the database.

Step 4: Once a vehicle passes the last leg of the toll road, again the number will be extracted and compared against the database entry.

Step 5: The entry and exits of a toll road are known values. Calculate the amount which needs to be deducted for that vehicle. For example, if it was a mini bus which passed through the entry and exit points in toll road. Based on the distance between the entry and exit points, calculate only the amount which has to be paid for the usage of the road by the mini bus.

Step 6: By using existing RFID technology, the amount can be deducted from the registered Fast tag user.

IV. CONCLUSION

The implementation of this approach will enable users only to pay for what is used instead of paying up for the entire length of the toll road. The similar approach can be used in parking lots wherein currently users end up paying up for additional hour or 2 hour slot even if it crosses just couple of minutes in the next slot.

V. FUTURE SCOPE

At present the above approach is limited to use of users for paying tolls but this can further be extended to parking facility as well. Also few Image Processing Technique can be introduced to enhance the reading of number plates of vehicles for better accuracy.

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