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Real Time Toll Rate Determination Using Image Processing & Network Database

Rahul Kumar[1]
[1]*PG Scholar*
SGVU, Jaipur
rahulkumar1680@gmail.com

Dinesh Goyal[2]
[2]*Assosiate Professor*
SGVU,Jaipur
dgoyal@gyanvihar.org

Rakesh Kumar[3]
[3]*Research Engineer*
Magniva Technologies Pvt.Ltd,Lucknow
er.rkrauniyar@gmail.com

Abstract: **— The public or private road for which toll is decided for the way is called toll road also called turnpike or toll way. The charge of the toll depends upon various vehicle types, weight or number of axles because toll rate is proportional to the number of axles to have a vehicle. It is difficult to calculate the number of a vehicle by a toll booth operator so proposed an automatic system for detecting axles by Hough transform method for detecting a circle. According to this method the toll rate can be determined in a toll way. This system must be able to determine the fix amount for toll use Weather Sensor for calculating the average rain on the toll road. Also update the total number of vehicle and toll rate on network database daily, weekly and monthly.**

Keywords— **Canny Edge detection, Hough transforms, Image Processing, MATLAB, Network Database, Toll Collection, Weather Sensor.**

I. INTRODUCTION

This is the new method of electronic toll system presented by this concept analyses the vehicle axle count based on image processing and approximate the total load on toll road. The toll road maintenance cost can be calculated automatically and be updated toll rate on network database on daily, weekly ,monthly or yearly basis. This work is totally done by image process system in MATLAB. It has low complexity and the processing time has reduced largely. This system also gives the average rainfall on the toll road by use weather sensor. The charge of the toll depends upon varied vehicle sorts, weight or variety of axles as a result of toll rate is proportional to the quantity of axles to own a vehicle. This system gives the better performance in traffic management.

This research gives the real time toll rate determination using image processing and update on network database. This is often simply done by MATLAB. It also gives the total working details of toll plaza and system analyses the vehicle axle count based on image processing and thus approximates the total load on toll road, and thus the maintenance cost of the toll road, which can be calculated automatically, and thus facilitating automated calculation & updating of toll rates on daily, weekly & monthly or yearly basis. This work done by 2 methodologies initial one is Hough transform method and second is canny edge method.

II. IMAGE PROCESSING APPLICATION IN TOLL COLLECTION

Customary method for detecting vehicle axle [1] by the use of sensor (called laying sensor) in the most important way of toll plaza. In this method as the vehicle passes through the sensors, axles are to be count by the generation of signals. Although in this method, maintenance is the main issue. It is a time consuming and a costly process. This method is highly unacceptable when the traffic flow is high. Therefore, another alternative method used via Image processing in which the setup is easy to maintain.

In this paper, we described an automatic system to count the number of axle of a vehicle in real-time for toll collection purposes. The Hough transform for circle [2] is used for detecting the presence of a wheel. Our experiments show that the Hough transform is suitable for such an application. Our system setup is simple and by using commodity components, its setup cost is also low. In case of circle detection, triplets of pixels will be randomly chosen from the image and mapped to a single point in the 3-D parameter space. As the points selected from the image is not exhaustive, therefore, the number of operations can be reduced

III. WHEEL REORGANIZATION TECHNIQUES

When a vehicle passes through toll booth, the camera Captured wheel images [3]. Figure 1 shows the position of the camera relative to the road and a sample image captured by the camera is given in Figure 2.The front wheel and rear wheel of a cat taken about 2 second to pass

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through the camera and processing system completes the recognition process within the 2 second in time frame.

The image of wheel is slightly destructed due to the position of camera but it still resembles a circle. Hough transform used to [4] detect presence of the wheel and its major advantage is to capability to identify a wheel even it is only partially appearing in an image.

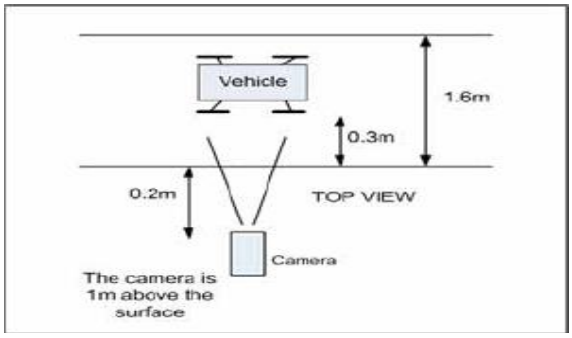

Figure 1: Camera set up for the wheel detection system

A. Hough Transform for circles

The Hough transform (HT) can be used to detect lines, circles or other parametric curves. It was introduced in 1962 (Hough 1962) and first used to find lines in images a decade later (Duda 1972).Hough transform is used to find sharp edge in image. The goal is to find the location of lines in images. Hough transform can detect lines, circles and other structures if their parametric equation is known. It can give robust detection under noise and partial occlusion. The input image must be a threshold edge image. The magnitude results computed by the Sobel operator can be threshold and used as input. It is based on transform [5] for line segments. HT describes the curve of image to be detected. It is used to determine the parameter of circle. Circle has radius R and Center (a,b) ,the equation of circle in this system is

$x = a + R (1-\sin^2\theta)$

$y = b + R (1-\cos^2\theta)$

Here x, y is perimeter of circle and parameter triplets (a, b,R) to describe each circle.

B. Canny edge detection

The Canny Edge Detector [6] is one of the most commonly used image processing tools, detecting edges in a very robust manner. It is a multi-step process, which can be implemented on the GPU as a sequence of filters. It is very useful toll in noisy environment .Canny edge method first smoothest the image to eliminate noise from image. The Canny edge detection algorithm is known to many as the optimal edge detector. It has low error rate. Canny edge detection controlled by two thresholds R1 and R2, where R1>R2. Tracking is only start when ridge higher than R1.Tracking on both directions is start when the height of ridge falls below R2. Canny edge detection method is used for detecting the axle of vehicle. It takes as input a gray scale image, and produces as output an image showing the positions of tracked intensity discontinuities. The result of applying canny edge detection to figure 2 is given in figure 4. On comparing figure 3 and 4 most of the unwanted edge point can be removed by canny edge detector and finally the circle can be detected with the help of Hough transform method.

In this paper we apply canny edge detection for reorganization the axle of vehicle.

Ex. BW = edge (I, 'canny') specifies the Canny method

Fig 2: Original image of Wheel

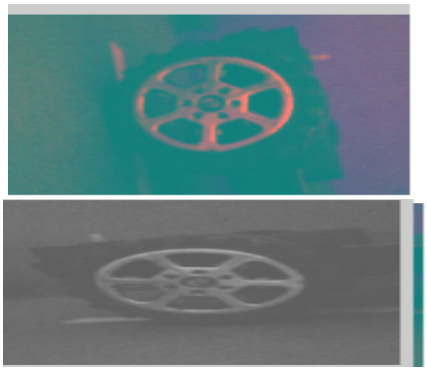

Figure 3: Sample image capture by the system after Image processing

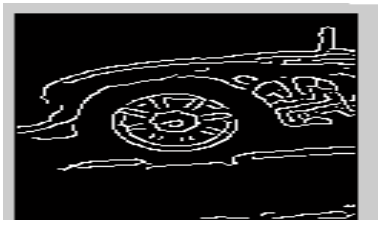

Figure 4: images after canny edge method

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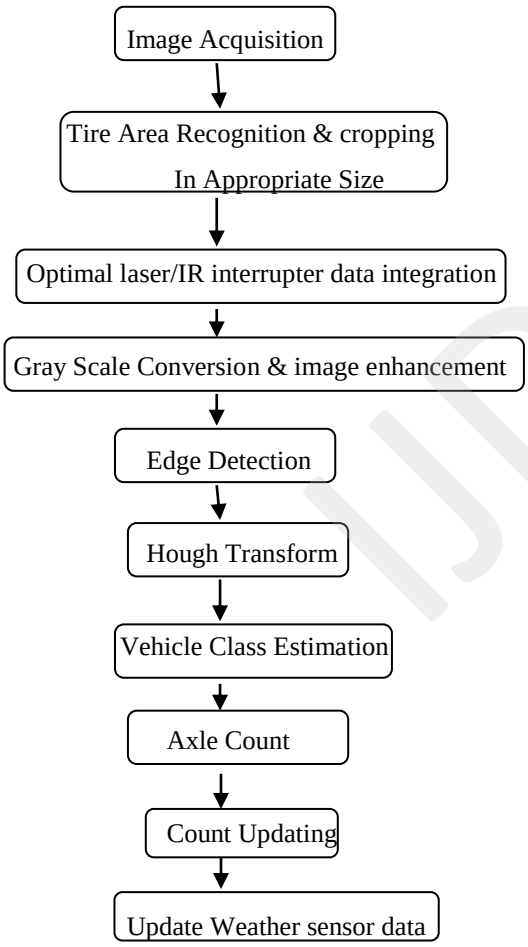
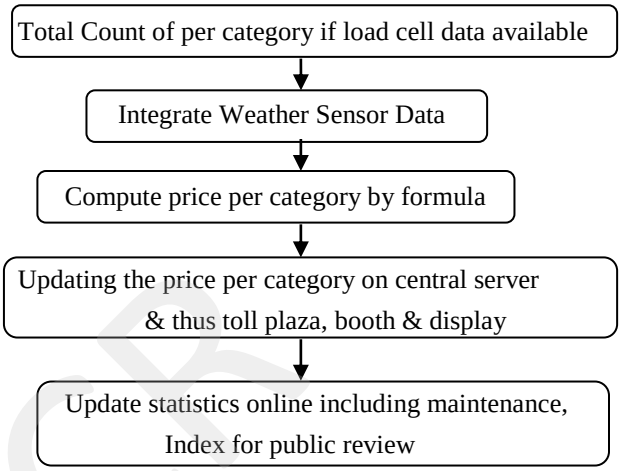
Figure 5: Edge detection of wheel

IV. CHALLENGES IN REAL TIME TOLL RATE DETERMINATION

A. Flow Chat of the system per vehicle



B. Flow Chat of the system per week



C. Vehicle Class Estimation

Vehicle class estimation is based on wheel of the vehicle. On above method canny edge detection and Hough transform is gives the appropriate size of the vehicle and MATLAB classify the vehicle.

According to this system there are four types of vehicle class:-

1. CAR
2. LCV
3. HCV
4. MAV

Vehicle class estimation based on radius of the wheel which defines by the user

D. Axles Count:

In axle count process, the processing period of the frame calculated in less than 2 seconds .in this time period 24 to 26 frames is calculated. When car is entered into toll plaza then front wheel appear in front of camera then image of frame is capture and process on this image. There are many frame are capture in this process. Frame no 3 to 7 and local maxima of frame 5 is capture. When car leave the toll plaza then camera also capture the frame of rear wheel. After processing of both image frames, its show rear wheel is less than front wheel. In this phenomenon, we can easily determine the number of wheel in real time.

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E. Count Updating

We can count the total number of vehicle pass thought the toll plaza on the basic of vehicle class estimation. It is also count the total number of CAR, LCV.HCV, and MAV and update the total no of vehicle on network database with the help of the total number of vehicle .we can use the formula for estimating the toll rate on this toll plaza.

Number of Vehicles passing from XYZ Route

CAR	LCV	HCV	MAV
20000	60000	40000	70000

F. Rate calculation:-

Toll rate is proportional to number of vehicle on toll plaza .Toll tax is based on the cost of construction, repairs, maintenance, expenses on toll operation and interest on the outlay.

- Formula for Toll Rate Determination

Toll Rate = Base Rate + Annual increase Rate + (initial maintenance cost (fix) +Maintenance Rise)

$$MI = \frac{\text{Number of Vehicle per week} \times \text{Average load of Vehicle type} \times \text{Weather Factor}}{\text{Maintenance Price per Unit Load Per KM}} \times \text{Total KM}$$

Where, MI = Maintenance index

Weather Factor =Unity for normal Weather

= 1.1 to 1.3 for small Rain

=1.3 to 1.7 for moderate Rain

= 1.7 to 2.0 foe heavy Rain

$$\text{Maintenance rise} = \frac{\text{Maintenance Index}}{\text{Number of vehicle per week}} \div \text{Base Rate}$$

G. Online database updating

The toll rate can be calculated according to traffic volume on road by updating the number of vehicle passing thought the toll plaza. The information about toll collection like toll rate of CAR, LCV, HCV and MAV & number of total vehicle passes thought the toll plaza can be updated. It can be update the information weekly, monthly, yearly etc. So everyone can see the toll rate of that plaza on Network.

V. RESULT

An automatic system is described to count the number of axle of a vehicle in real time for toll collection purposed. For detecting the presence of wheel Hough transform method is used for circle. , we can process up to 24 images within 1.5s and it satisfies the timing constraint imposed upon the system. Our system setup is simple and by using commodity components, its setup cost is also low. It classify the vehicle (CAR, LCV, HCV, MAV) on the basic of circle detect by Hough transform method processed.

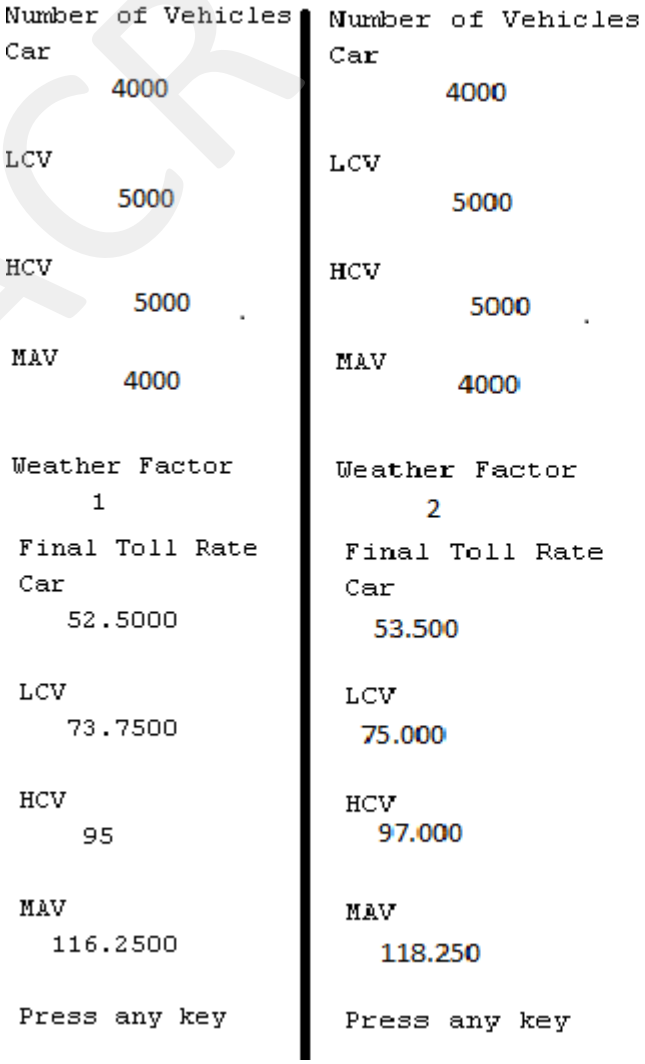

Figure 6: snapshot of result

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```
Number of Vehicles
Car
        10,000

LCV
        15,000

HCV
        12,000

MAV
        14,000

Weather Factor
        1
Final Toll Rate
Car
    50.000

LCV
    70.000

HCV
    90.000

MAV
   111.25

Press any key
```

VI. ONLINE UPDATE OF TOTAL NUMBER OF VEHICLE AND SPECIFIC TOLL RATE OF VEHICLE

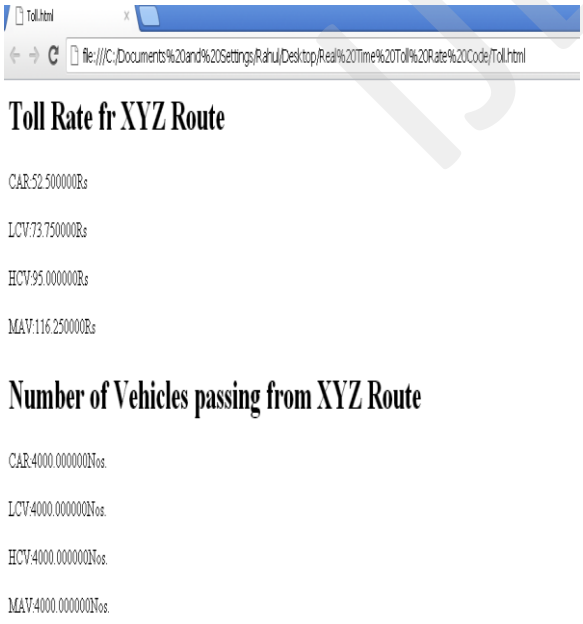

Figure 7: Network Database

VII. CONCLUSION

The techniques and methods discussed in above sections are based on the high resolution images. Most of the technique are used for circle detection [7] of wheel and count the total number of wheel or vehicle then calculate the toll rate of that toll plaza because the toll rate charged is usually proportional to the number of axles possessed by a vehicle.

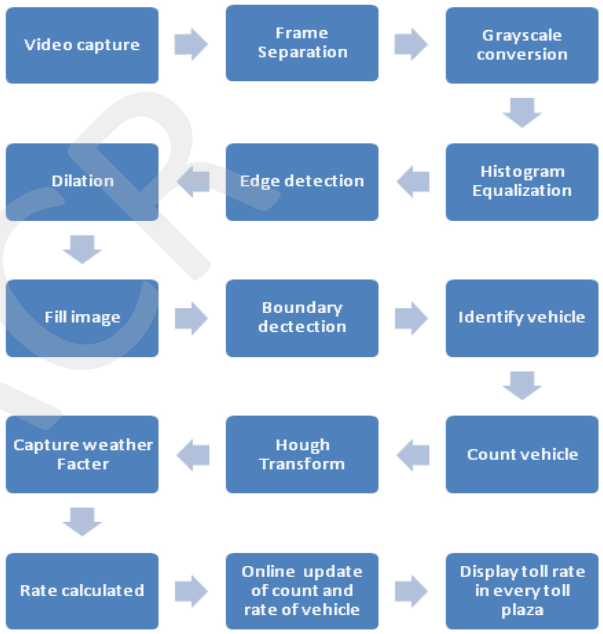

Figure 8: Block diagram of the system

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