Vehicle Classification and Distance Estimation using Support Vector Machine

J. Jayasurya, R. Seenu, M. Jagannath

Abstract*: *While driving a vehicle, the driver must pay attention to the environment around the vehicle. If the driving period increases, the driver loses his attention that would eventually lead to road accident. There are literatures which address the prevention of road accidents by considering several factors like environmental conditions, traffic density, psychological nature of the driver, etc. Among the factors, the detection of vehicle in front is considered as one of the road safety measures. In this paper, the datasets are collected from GTI vehicle image database and KITTI vision benchmark suite. The algorithm is developed for vehicle classification and the distance estimation by employing a conventional computer vision technique called Histogram of Oriented Gradients (HOG), combined with a machine learning algorithm called Support Vector Machine (SVM). The proposed algorithm could be implemented on autonomous vehicle system to assist the driver effectively and also reduce the vehicle collision.

Keywords: Vehicle Collision; Automatic Guided Vehicle; Histogram of Oriented Gradients; Support Vector Machine.

I. INTRODUCTION

Since the evolution of automobiles it was controlled manually with a human driver. When it is for a long period of time the concentration of the driver in controlling the vehicle is reduced and the risk of accident gets increased. Now the human power required to control the vehicle is reduced by self-driving vehicles. Self-driving vehicles are the future vision of automobile industries and most of the countries started using it. Those vehicles use RADAR & LiDAR and also ultrasonic sensor and infrared sensor to classify the vehicles in front of the source vehicle and also the distance between the source and destination vehicles. This paper is about designing a computer vision for the self-driving vehicles that overcomes the disadvantages of the existing systems using Support Vector Machine (SVM) and an imaging technique called Histogram of Oriented Gradients (HOG).

II. RELATED WORKS

Odat et al. [1] proposed a new sensing device which can monitor urban flash floods as well as traffic congestion. The new sensing device is based on the combination of passive infrared sensors (PIRs) and ultrasonic rangefinder. In the wireless networks, these devices are used for estimating the speed, classifying the images and also for real time application in vehicle detection. This proposed model will be based on dynamic Bayesian Networks for fusing the heterogeneous data for vehicle detection. Cross correlation and wavelet transform-based methods are used to estimate the time delay of the signals in different sensors. Aqel et al. [2] proposed a good monitoring system that monitors, detects, counts the number of vehicles on road and they carried out detection using invariant charlier moments.

Belen et al. [3] proposed a system which monitors the traffic and counts the number of vehicles on the road using SVM cubic classifier and said that it has the higher accuracy than other SVM classifier models, also used HOG feature for vehicle classification and distance estimation. Min et al. [4] proposed a system especially for intelligent vehicles uses Vibe algorithm for robust and accurate detection of multiple vehicles, they combined thresholds of Local Binary Pattern (LBP) and SVM to the CNN classifier to remove the interferences between the vehicles and other objects on the road and the proposed system improves the detection and accuracy compared to other existing systems. Chen et al. [5] proposed a system for vehicle and pedestrian detection using computer vision and uses SVM and HOG descriptors to detect the pedestrians as well as the vehicles. Chen et al. [6] developed a framework to find the vehicle type using images extracted from the traffic videos, used frontal and rear view of images from the traffic videos to classify the type of vehicle and CNN classifier for classification.

Chen et al. [7] proposed a systematic approach using kernelised SVM that can be installed in a camera placed near roadside and they had obtained the foreground details of the vehicle using Gaussian mixture model background subtraction algorithm and classified the vehicle using width, aspect ratio, and size, in addition they implemented 3D color histograms for feature vector encoding color.

Kul et al. [8] proposed a system using image processing technique based video surveillance system for traffic management. Here the videos are analyzed for vehicle detection and classification and the videos are from traffic cameras. Pen˜a-Gonz´alez and Nuno-Maganda [9] proposed a vision based system that classifies, counts and detects the vehicles on the road which uses HD-RGB cameras on the road made possible by clustering and classification. Yabo et al. [10] proposed system was a real time vehicle classification and speed estimation system that used to analyze the videos of traffic to detect the moving objects as well as the speed of the vehicle also, they used foreground segmentation techniques for vehicle detection and nearest tracking algorithms for speed estimations. Hicham et al. [11] presented a system automated vehicle classification system based on image processing.

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They followed two steps in this method; first data augmentation is done to attenuate the imbalanced dataset problem. Second, a CNN network was built with parameters acquired from the first step. Thus integrating these two steps allows the system automatically manages traffic light system and vehicle type detection. Tram and Yoo [12] proposed an intelligent transport system and positioning method that estimates the distance between two vehicles using sensor based visible light communication. The system uses two sensors and an LED to estimate distance and images from the camera which has a low resolution is used to detect the coordinates of the pixel and simulated the results.

Mazaheri and Mozaffari [13] proposed an algorithm for real time vehicle detection and lane also. The algorithm classifies the vehicles in three types using the camera on roadside i.e., heavy (bus, lorry), semi-heavy (vans, mini bus) and light (cabs, cars) followed by two steps. First, kernel detection and second detecting sets which are nearest in correlation to the kernel. Used Background subtracting and morphological binary image segmentation for vehicle detection and this algorithm eliminates the facts that affect the quality of vehicle detection such as cross shadows, headlights or any light illuminations. Garcia et al. [14] presented a system sensor fusion methodology for intelligent vehicles which provides augmented information and knowledge. This system is carried out by vision based system, LASER and GPS which enables detection of vehicles and road signs on the road.

Rezaei et al. [15] proposed a collision warning system that detects the vehicles and obstacles on the road and also the distance between the vehicles which assists the driver diverted efficiently and avoids collision. The system uses global Haar like features to detect vehicles and tail light segmentation for detecting the vehicles even in night time also. It can also detect vehicles in long distance in all lighting conditions. Lim et al. [16] presented a vehicle detection system for Automatic Braking System (AES) using stereo vision. Used CNN classifier for classifying the images extracted and distance estimation was carried out by the pixel density of the images.

Lin et al. [17] proposed a system to detect the moving objects and also estimation of distance for autonomous vehicle driving systems. Cars and bicycles are classified using LiDAR clustered data and clustered support vector machine. Rezaei and Klette [18] published three books that covers object detection, vehicle classification, speed estimation, and the use of machine learning with computer vision completely.

III. METHODS AND MATERIALS

The existing system uses RADAR and LiDAR and passive components for detecting vehicles and estimating the distance between the source and destination vehicles. The proposed system uses computer vision and classifiers for classification and distance estimation. Datasets are collected from GTI vehicle image database and KITTI vision benchmark suite. The images in the datasets are of size 64*64 length and breadth. Now the images are normalized for the feature extraction process.

The framework of the proposed system consists of data acquisition, feature extraction, classification using SVM and classification of vehicles and distance estimation. In the data acquisition part the data were collected using camera in real time application but here datasets are used from GTI vehicle image database and KTTI benchmark suite for the implementation. In Feature extraction the HOG process is carried out. As explained earlier the classification is done using SVM.

A. Histogram of Oriented Gradients (HOG)

The histogram of oriented gradients is the graphical representation of images. Where the images are converted to numbers ranging from (0 to 255) and it is plotted in the graph. For classifier, it is hard to classify as an image so HOG was implemented. Thus, the RGB images are converted to grayscale and then each color was represented with values from 0 to 255 because it is easy to classify when compared to classify using images. Once the HOG is completed the images i.e., images converted as values (integers) is classified using the SVM classifier.

Figure 1. Typical vehicle image used for HOG extraction.

160	111	89	88	62	48	56	43	51	66	42	62	99	92	94	148	145	152	152	140
199	111	101	69	38	44	52	42	60	69	45	53	112	108	134	200	209	225	210	203
117	107	123	120	144	180	205	202	206	205	201	196	205	169	127	82	113	183	194	184
123	155	164	177	172	158	176	173	167	162	169	203	168	132	84	56	95	167	181	173
173	236	186	196	152	46	38	42	45	33	46	133	59	30	22	66	162	160	150	150
80	99	72	98	78	25	61	92	100	58	51	124	94	85	75	101	163	165	159	160
61	50	42	73	71	65	121	152	157	116	101	137	130	141	120	130	158	153	148	148
206	206	199	218	211	204	217	213	210	207	213	198	163	155	143	141	136	124	117	111
222	208	198	200	201	196	188	184	188	186	185	169	154	136	131	130	118	110	105	92
180	145	136	141	137	139	128	126	128	118	111	128	137	108	95	98	99	96	95	89
141	112	102	99	97	95	81	80	77	70	112	138	114	89	94	93	101	94	94	91
82	70	83	87	89	85	70	71	68	76	129	135	96	94	97	88	97	101	97	105
31	30	62	81	89	106	117	114	116	132	145	125	96	105	103	91	99	122	125	127
25	32	68	79	85	87	103	103	127	153	143	106	95	105	93	81	88	116	128	117
66	73	90	85	75	69	81	103	130	143	127	97	104	104	83	77	82	100	107	91
150	161	163	156	157	164	162	170	156	140	115	93	113	115	109	111	109	107	100	86
173	179	176	177	180	187	184	184	163	137	102	92	120	124	127	132	126	116	105	80
132	134	136	144	145	158	167	156	143	125	94	105	135	135	127	132	128	126	123	87
181	190	187	189	191	208	182	152	134	116	94	123	137	142	124	112	103	100	99	82
211	212	209	207	208	221	189	153	140	107	104	134	142	134	115	100	87	80	79	80
123	87	91	73	73	98	136	143	134	108	112	118	121	112	102	96	95	98	99	103
63	59	66	43	49	70	139	149	126	111	130	129	129	128	123	124	128	129	124	123
44	91	92	96	102	129	159	137	127	124	148	162	157	153	159	160	160	155	147	147
110	113	108	106	114	164	178	166	201	195	150	138	120	114	112	108	107	110	111	113
175	148	139	107	135	172	178	179	224	228	150	114	98	92	90	84	85	92	93	97
195	208	201	154	155	132	98	95	118	125	127	141	148	151	158	159	161	161	158	158
198	220	192	156	155	136	141	137	137	132	152	167	169	178	178	181	176	169	170	172

Figure 2. Histogram of oriented gradients of a vehicle image.

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Figure 1 shows a typical vehicle image taken from database. In HOG extraction the image is divided into 11 orientations, 14 pixels per cell and two cells per block. Figure 2 shows the HOG representation of the vehicle. HOG has two functions called *X* and *Y* gradients. First the process starts with *X* gradients where the pixels in x-axis are converted into integer values and then the pixels in y-axis are converted as integer values ranging from 0 to 255. Then the magnitude of *X* and *Y* gradients are identified and it is used for the classification process. The images are converted to integer values by using the magnitude and angle of the color present in the image.

$$\text{Gradient magnitude} = SQRT(X^2+Y^2)$$

$$\text{Gradient angle} = tan\text{-}1(X/Y)$$

B. Support Vector Machine (SVM)

The support vector machine is a supervised learning method used for classification, since it is efficient for the purpose of regression and classification. The SVM represents the data's as points in space i.e., hyperplanes or set of hyperplanes and which was separated by a wide gap and new data's are mapped into that same space predicting the data's belongs to the group or not as in Figure 3. The data points in SVM are mentioned by *ṕ* -dimensional vector and (*ṕ*-1) mentions the hyperplanes.

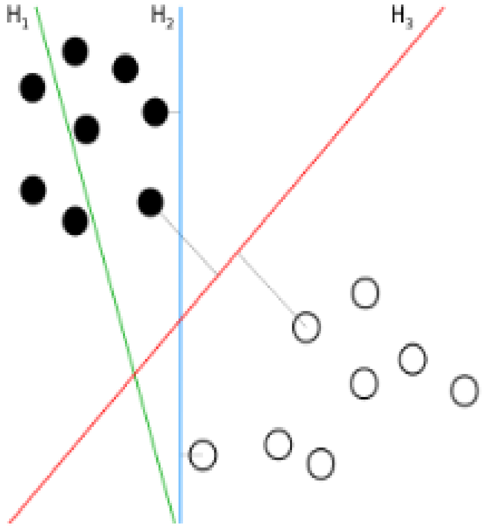

Figure 3. Prediction result from SVM classifier.

The example points (data) are separated by three borders or hyperplanes H1, H2, and H3. The hyperplanes are boundaries that classify the data points, the hyperplanes in 2D are called as lines and planes in 3D features. Now the new data points are predicted with the example data points and if it is predicted as same as existing data points then it is known as classified data points. If it is not predicted as same as existing data points then it is called unclassified data points. The SVM classifier uses a Support Vector Classifier (SVC) with Radial Basis Function (RBF) kernel for better results, the RBF kernel ideal parameters are c(1, 100, 1000) and gamma(1, 100, 1000, auto), and best is achieved with c(100) and gamma(1000) values. In linear SVM, the equation for prediction of input points using dot product between the input *x* and classifier x_i can be given as,

$$f(x) = B(0) + \text{sum}(al^*(x, x_i))$$

Where, the *x* and x_i are the inner product of a new vector input and *B*(0) and *al* can be calculated from training data by learning algorithm.

Building and training of the classifier is dependent in the type of application going to be used. Here, SVM with kernel RBF is built and trained as per the feature extracted.

IV. RESULTS AND DISCUSSION

The outputs obtained are HOG of vehicles and non-vehicle images, formation of sliding windows, Heat map to locate the sliding window in the image, and the vehicle classification as given below.

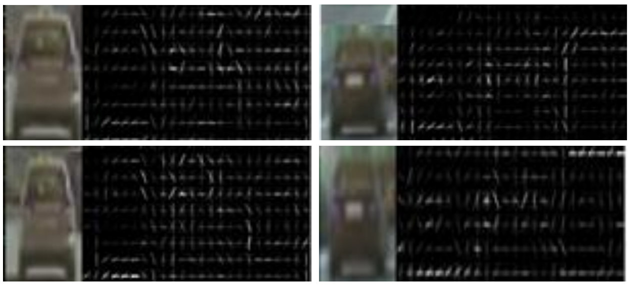

Figure 4. HOG of images with presence of vehicles.

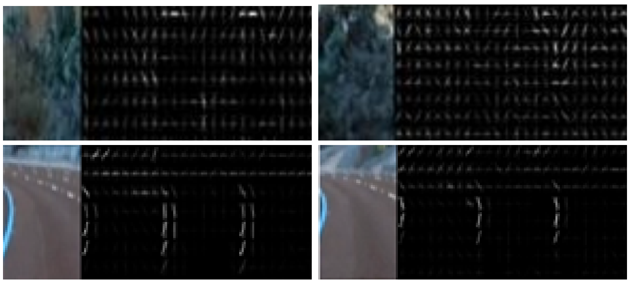

Figure 5. HOG of images without the presence of vehicles.

Figure 6. Formation of sliding windows.

As explained in proposed system, the values of HOG are used by the classifier and the output derived shows the HOG of the images with vehicles and without vehicles (Figure 4 and Figure 5). Once the HOG is done the unwanted parts rather than the vehicle were separated from the part where the vehicle is present as shown. And then formation of sliding windows follows the process.

Figure 6 shows the sliding windows are windows that locate a vehicle in an image. It is created all over the image which slides continuously on the image until the vehicle is classified. The sliding window is locked over the image with the help of heat map.

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Figure 7. Heat map of the detected vehicle image.

Heat map is method of representing data in an image using colors. In this process, a dark background was formed to the sliding windows so the image will change its color as given in Figure 7 and that part is where the vehicle is detected. Now the classification of vehicle was obtained as shown in Figure 8, and all the vehicles present in the image can be detected and classified.

Figure 8. Classification of the vehicles identified from an image.

V. CONCLUSION

Thus implementing this algorithm improves the vehicle classification which assists the driver effectively and reduces the driver stress when driving for long time. Computer vision-based vehicle safety systems may be updated to detect and identify not just other vehicles, but also road signs and traffic signals also.

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