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Impact of Adaboost and Support Vector Machine Classifier in Automotive Sector

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Abstract. The automobile industry is moving towards complete automation of vehicles. While the automation of vehicles can reduce the workload to human beings, we also need to make sure that safety is not compromised in the process. One of the integral components of the automation of vehicles is the detection of several obstacles. Obstacles may include lamp post, pedestrians, animals, vehicles, etc. This project involves detection of commercial vehicles that are present in front of the host vehicle and is limited only to far and middle region. The classification is done in two steps: Adaboost Training and Support Vector Machine Training. Adaboost being a weak classifier is used to reduce the reaction time of the entire system. Even though the classifier does not produce more accurate results it will reduce the time taken for classification considerably. Support Vector Machine algorithm will produce better classification result as it makes use of a hyperplane to separate between the classes. Support Vector Machine being a strong classifier gives better result but increases the reaction time taken for classification. In order to counter this problem Adaboost Training is done. Adaboost is a set of weak classifiers which will classify at a better speed but the results may not be accurate. Therefore, this Adaboost classification is done at first and only the positive classification from the Adaboost classifier are sent for Support Vector Machine classification. This will make sure that more time will not be used for the Support Vector Machine classification. Based on the classification if the result specifies that there is an object, the distance will be computed. Based on the distance and the speed of the host vehicle, the time to avoid collision can be calculated. The needs to be a lookup table to match different time frames with reduction of gears and the speed respectively. The ECU will manage the speed variation and the gear shift required through the control system that will give the time to avoid collision as the output. Therefore, the collision can be avoided by obstacle detection and computation of distance of the object.

1. Introduction

The automobile sector is going towards automation at various levels. Even though the level of automation may vary from application to application the significance. In the automotive field, automation plays a very important role. In self driving sector there are several applications such as parking, lane changing, smart energy systems, obstacle detection and so on. Machine learning also plays an important role in the field of marketing the vehicles and in predicting the needs of the customers and the type of vehicles that will create high impact in the environment of the customers. Artificial intelligence is another blooming field that helps in creating a setup where the human beings can be mimicked and the decision making can also be monitored. When the artificial



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intelligence and the Machine Learning techniques are combined, we can improve the decision making. There is a requirement to produce a system that will be able to train itself automatically. Thereby, we can create a model that will train itself and improve the detection with any particular change that is brought to the dataset. The prediction accuracy was estimated to be 94.8 percentage. Once the deep learning is done and the data is further transferred to ECU. The data of the presence of the obstacle along with the distance of the obstacle is sent to the ECU. Before sending the data to the ECU there are certain computations such as computation of the time taken for collision, speed of the host vehicle and the speed of the movement of the obstacle needs to be done. Thus, the speed reduction can be achieved in the stipulated amount of time.

2. Literature Survey

Ye et al.,(2019) developed a decentralized resource allocation mechanism that can be used to improve the communication in between the vehicles. It is based in a reinforcement learning technique that will make use of a deep learning technique. This paper shows an autonomous decentralized mechanism to communicate between the vehicle and at the same time increase the efficiency of the communication between the systems without creating any drastic changes to the input or the output that is produced by the system. There is a mechanism that is used to produce a link so that the transmission data can be transferred easily through the system. The communication needs to be done without creating any interference with the environment. There are certain simulation results that are also produced in this paper. [1]

Moghimi et al.,(2011) has mentioned that vehicles are detected based on a boosting technique. Their proposed system are the ones that have been tested in real time life like situations and in scenarios that were taken from the surveillance scenarios. There are different conditions with various lighting techniques that are tested in several conditions. The obtained results in the real surveillance videos present in different lighting conditions show us the efficiency and the extent of practicality of the method. [3]

Chintalacheruvu (2012), has proposed a vehicle detection system that is based on certain pre-existing videos which can help in reducing the complexity involved in the calibration of the entire system. This will help in increasing the performance of the system even if the resolution of the available video is very low. Based on the distance differences, there are a different set of resolutions that need to be used. The accuracy is increased in terms of the number of vehicles that are detected and the speed of those vehicles that have been detected.[4]

Hadi et al.,(2014) has presented briefly about that various image processing techniques and the several analysis tools that were used in the several methods that were used for traffic light monitoring and surveillance techniques. The processing methods have been classified into three different categories in order to precisely explain in clarity about the traffic systems. The tracking method also takes into consideration the various motion constraints that are involved as well when it comes to detection in traffic surveillance systems. [5]

Beymer et al.,(1998) developed a tracking system that can help in detection in several challenging conditions based on certain features that have been extracted from the total set of features that are present with the vehicular data. The major advantage is that it works without showing much change in efficiency when it comes to different lighting conditions. After the tracking of the vehicles is done they are segregated and labelled as separate vehicles thereby helping in the process of tracking the vehicles continuously. [6]

Avery et al.,(2002) has presented a method to detect the width of the vehicle based on a width based distance calculation algorithm. This algorithm can be useful in detecting the distance at which an object is present from the the host vehicle and at the same time aids in accurate prediction of the presence of obstacles. This method is of greater use when it comes to detection any obstacle present.[9]

Based on the above mentioned literature survey it is learnt that adaboost and SVM have been used for detection in several fields, but have not been used together for the application of reducing the reaction time of classification. Using a classification technique used for detection of obstacles to vary the speed of the vehicle to avoid collision is something that has not been in any of the aforementioned literature work.

3. Impact in Obstacle Detection

In the automotive industry automation is becoming a field of at most importance because there seems to be a need for the automation of several parts in the vehicle. There are several levels of automation, which can vary from assisting the driver in the completion of any task to the extent of automatically driving the entire vehicle. The major constrain in the automation of vehicles is the ability to extract necessary data from the computer vision system that already does exist. Therefore, the field of obstacle detection becomes one of at most importance. Obstacles will include the lamps, sidewalks, vehicles of all kinds, pedestrians and several other things. Therefore, it is required to create a model where the various obstacles can be detected using a computer vision based machine learning technique.

Obstacle detection is about detecting different things that come in the way of the host vehicle. The obstacles may include lampstands, dividers, pedestrians and several types of vehicles. Pedestrian detection is a long-standing problem not only in automotive sector in ADAS but also in robotics. Nowadays, there is a lot of improvement in the field of vehicle detection. It has further been taken into dividing further into several other types of vehicles. Thus, the machine learning will have an effect on the detection of several objects. Sensor fusion is another field that will have greater impact on this.

Frame capture is done from the existing vehicle videos. The images required for the dataset need to be generated by this process only. Based on the annotation that has been done on the videos, a csv file is created. Using this csv file the images are cropped out of the respective videos. It is required to separate the positives and negatives in these images. These images are used as positive and negative images while training the adaboost or the SVM model. The positive and negative images need to be generated for both the far region and middle region based on the requirement. The far region needs to be in HD as the clarity needs to be high when the distance is more as there is a need for more pixels in the same screen size. Whereas for the middle region we need only VGA images as the IHOG classification can be done for lesser pixels as the distance is less in comparison with far region.

4. Pre-processing and Feature Extraction

There are certain pre-processing steps that need to be taken into account whenever there is a need for classification. These pre-processing steps need to be done only once and need not be done every time the code is run for the classification of vehicles and in the real time detection. The three main pre-processing steps that are used before the implementation of the training process using the given set of images are mentioned below. The cropping of images needs to be done in the respective regions in order to generate the required images in the required resolution and the correct detection. Next the resizing of the cropped images needs to be done in order to make all the images in the same region of the same region. This will help in creating a particular uniformity within the images, thereby making the classification region. The Contrast Limited Adaptive Histogram of Variants (CLAHE) needs to be done in order to increase the contrast but within a limit in order to make the images seem similar in both the day and night times. The contrast variation using CLAHE will help in making the edges more prominent in order to make the IHOG feature extraction easier. The above-mentioned pre-processing steps are more or less same in both the far and middle regions.

5. Feature Classification

Classification is done in order to help any system to know which particular class the given sample falls into. Therefore, while using certain machine learning techniques the classification of data can be done with a greater extent of ease. In this method we are using mainly two classifications they are Adaboost and Support Vector Machine.

5.1. AdaBoost

Adaboost is a weak classifier where it is having 100 iteration. The output of the adaboost is having 5 set of values they are alpha, direction, dimension, threshold and error. The output of the Adaboost is given as the input to the Support Vector Machine classifier. SVM being a strong classifier where it will actually classify the window which contains vehicle and non-vehicle. AdaBoost is the best used algorithm in boosting the performance of any decision tree when implemented on any binary classification related problems. Adaboost is used to increase the efficiency of the system by reducing the reaction time of the system. It can be used to boost any particular machine learning algorithm. In our case we are using adaboost along with Support Vector Machine algorithm.

Error is calculated by calculating the difference between the correct classification and the total number of classifications and then normalizing it with respect to the total sample.

$$\text{error} = (\text{correct} - N) / N \quad (1)$$

Error can also be called as misclassification rate. This misclassification rate needs to be reduced as much as possible. If we take for example the number of correct classifications to be 72, then the misclassification rate can be calculated as: $((72-100)/100)$ which will come to 0.28 or 28 percentage. This is how the misclassification rate is calculated.

There are certain changes that are carried over to make it feasible for all the available training instances. The equation after making the changes are mentioned below:

$$\text{error} = \text{sum}(w(i) * \text{terror}(i)) / \text{sum}(w) \quad (2)$$

The adaboost model file that was used after repeated alterations done to the dataset and after balancing of the positives and negatives so that the detection has increased is mentioned below:

{1.024641, 120, 0.015100, -1, 0.114125}, {0.892237, 1472, 0.004014, -1, 0.114125}, {0.678667, 1411, 0.135415, 1, 0.059877}, {0.693005, 1224, 0.006608, -1, 0.054248}, {0.651721, 527, 0.045992, -1, 0.041965}, {0.681770, 1403, 0.289748, 1, 0.038895}, {0.581958, 1014, 0.001396, -1, 0.031218}, {0.611232, 1327, 0.050055, 1, 0.030194}, {0.547301, 113, 0.034173, -1, 0.024565}, {0.559930, 1488, 0.003952, -1, 0.020471}, {0.593717, 25, 0.096921, 1, 0.015353}, {0.565087, 424, 0.118433, -1, 0.014841}, {0.598132, 989, 0.030135, -1, 0.013306}, {0.597178, 344, 0.021429, -1, 0.011771}, {0.504489, 332, 0.098198, 1, 0.009724}, {0.591283, 1432, 0.003367, -1, 0.007165}, {0.472304, 604, 0.162644, 1, 0.006141}, {0.496130, 395, 0.173487, -1, 0.005118}, {0.547841, 1192, 0.001335, -1, 0.003582}, {0.534296, 1344, 0.029758, 1, 0.002559}, {0.484472, 935, 0.133996, 1, 0.002047}, {0.545644, 1215, 0.028317, -1, 0.001024}, {0.529149, 595, 0.282335, 1, 0.000512}, {0.515515, 200, 0.142500, -1, 0.000000}, {0.480180, 1495, 0.000677, -1, 0.000512}, {0.443694, 1542, 0.009537, 1, 0.000512}, {0.520398, 180, 0.181511, 1, 0.000512}, {0.480547, 222, 0.071252, 1, 0.000000}, {0.483433, 426, 0.015580, -1, 0.000000}, {0.531209, 993, 0.037307, -1, 0.000000}, {0.484859, 1351, 0.017728, 1, 0.000000}, {0.501244, 866, 0.096911, 1, 0.000000}

5.2. Support Vector Machine

The Support Vector Machine is a machine learning technique that is used to classify any particular object based on the attributes that are extracted. There will be certain features that are extracted, these features need to be passed into the SVM module in order to detect the necessary object. Support Vector Machine algorithm makes use of a hyperplane in order to segregate or classify the given sample into its particular class. The number features and the respective attributes need to be specified in order to increase the value of each feature and to make the detection process more precise.

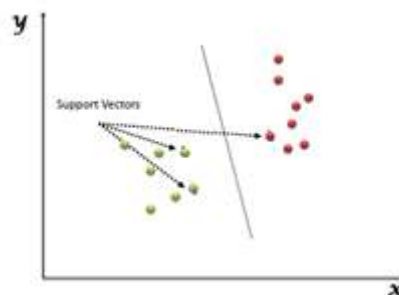


Figure 1: SVM Classification

Support Vector Machine being a strong algorithm gives more accurate results, but the limitation of this process is that the time taken for the classification is more in comparison with the other weaker classifiers. SVM library is used in order to make the development of the module easier.

The Support Vector Machine weight values need to be calibrated. The detection accuracy will vary based on how these weight vectors are. The weight vector values used when combining both adaboost and SVM for the optimal dataset is mentioned below:

{28351,441,13439,3901,15736,27209,8210,7333,4248,9666,4414,-1813,1768,11620,15631,-980,1386,8228,1227,1666,-5103,8305,7365,-8560,130,-301,5997,-1069,-5555,-2748,8111,7042,3125,10926,13769,-430,305,11273,8902,-1431,-475,-3536,1509,-8180,375,-2570,6844,-9395,579,2650,6104,-1660,-5967,-2827,-8678,-9503,6116,1476,-2477,-1748,-7548,-2552,10781,5,186,-606,5546,-5848,3427,1636,-628,-11708,-3299,9602,8666,-1761,-3118,4890,-3821,-7936,7684,2986,-42,-536,-6725,2834,717,4583,13106,12981,6155,10378,7652,8799,-3811,-12364,-2228,7166,7797,-2501,-1742,6693,4391,-3990,-1540,-1112,15775,1489,511,10270,-5335,2833,10703,14321,11953,10069,5311,1245}

6. Merging of Adaboost and Support Vector Machine

In order to reduce the reaction time taken by the entire system adaboost and SVM are combined together. When adaboost is used the classification accuracy is reduced. Therefore, the number of iterations that are used in adaboost are altered and the detection varies accordingly.

The number of iterations is calculated by keeping track of the error percentage. The number of iterations will freeze at a point where the error percentage is as low as possible and is saturated at the same time. Once the adaboost training is done, only the positive classification from the adaboost model is sent for Support Vector Machine classification. Since Support Vector Machine is a strong classifier it takes more time. Adaboost will take less time, therefore when we limit the number of inputs sent for Support Vector Machine classification the reaction time will reduce to a greater extent.

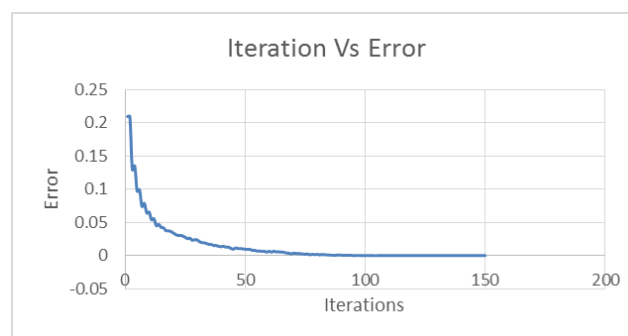


Figure 2: Iteration Vs Error Graph for Adaboost

7. Multiple Box Reduction and Evaluation

In the segmentation window every box that has the commercial vehicle in it will be displayed. In this there will be multiple boxes and will increase the density of boxes in the areas where there are vehicles present. When the density of boxes is more in one particular region, the merging of bounding boxes is done. This process is known as non-maximal suppression. This non-maximal suppression reduces the boxes if the box density in a particular region is high. Thus, the multiple boxes in the same region can be reduced to one single box that is around the vehicle.

It is required to evaluate the model after creation of it to get the desired results. Accuracy and precision are calculated in order to find out the extent to which the positives and negatives are being classified by the system. Accuracy is calculated with respect to false positives and precision is calculated with respect to false negatives.

8. Impact on Power Transmission of Vehicles

At the most basic level, automatic transmission is a simple computer. They will take in inputs such as the gas pedal position, vehicle speed and road speed, and use a basic lookup table to decide which gear to be in. Some of the older transmissions work on just two variables- generally it will shift into a higher gear as the pedal position is reduced or speed increases.

More modern, ECU-controlled transmissions being advanced are more sophisticated. More variables are being used to decide when to shift gears, including engine temperature, whether the vehicle is towing or not, and often the manual override inputs from the driver. Many of these systems are also capable of 'learning' the driver's style of driving the vehicle, by remembering the general trend of how vigorously the driver normally drives the vehicle. If the driver is calm and composed, it will tend to shift up earlier to optimize fuel economy, at

the expense of performance. A rasher driving style will make the transmission to tend to hold lower gears for longer periods of time, thereby improving responsiveness.

Therefore, the data from the power transmission needs to be transmitted to a server and it needs to be monitored continuously over a larger period of time. The data needs to be transferred in packets in order to make sure that the transmission monitoring process is carried out in a systematic manner. The speed variation needs to be achieved based on the detection of vehicles and the distance at which the vehicle is present from the host vehicle. Another parameter that needs to be taken into consideration is the relative speed of the vehicle. With the variation in the relative speed the amount of speed reduction that is required will also get affected drastically. A threshold value needs to be set in order to maintain the safety involved in the system on the whole. Based on the threshold value the transmission rate also needs to vary. Therefore, the prediction from the SVM classifier can be directly related to the transmission rate.

9. Conclusion

Thus the detection of various obstacles is achieved using a combination of both adaboost and support vector machine algorithm, based on which there has been a reduction in the reaction time taken for classification of various objects. Based on the data of the distance that has been computed in the classification process and the speed of the vehicle and the obstacle, the estimated time for collision can be calculated. This time is made use of to create a speed reduction system in order to reduce the speed of the power transmission through the electronic control unit. A dedicated controller module is used to facilitate this process in order to make sure that the speed reduction takes place faster. Thus the speed reduction of the power transmission can be achieved at a faster rate by making use of the above mentioned classification methods.

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