Recognition of Highway Workzones Based on Kalman Filtering for Autonomous Driving

Arya Krishnan G, Nishy Reshmi S

Abstract— Road sign Recognition is a field of computer vision.Fast real-time and robust automatic traffic sign detection can significantly increase driving safety and comfort. Automatic detection and recognition of traffic sign is also important for an automated intelligent driving vehicle or for driver assistance systems. For facing such problems,computer vision algorithms are available,by recognizing workzone traffic signs in the input images,aim at identifying the bounds of a workzone. This paper focused on how to accurately detect the boundary of a workzone by means of two methods: Detection by Adaboost and Tracking with Kalman Filter. This filter is intended to be robust without being prog rammed with any environment-specific rule.Thus this approach was able to perfectly identify the boundaries of workzones.

Index Terms— Classification confidence propogation, Computer Vision, Highway workzone recognition, Intelligence vehicle, Kalman Filter, Tracking , Traffic sign classification.

1 Introduction

Autonomous vehicles are the ones which can sense their surroundings using radar, GPS and computer vision. Advanced control systems interpret the sensory information and can suitably identify appropriate navigation path and the obstacles, seen during their path.The vehicle is provided with a map in advance, which provides a complete description of the road geometry and traffic signs[1],[3]. They have the capability for updating their maps based on their sensory information. But the problem occurs when an unexpected event occurs, such as a road work or traffic accident[13]. In such a case, the vehicles has to face a problem that the traffic conditions may change due to the presence of the workzones since it alters the details provided by the map[2]. If the vehicle doesn't have the capability for dealing such an unexpected event, catastrophic results may occur.

For effectively handling such events,an autonomous vehicle should first be able to recognize them and to respond them accordingly[13]. This paper provides various computer vision methods, used to track the events. The aim of these methods is to identyfing the bounds of the workzones. This should lead to safe and reliable autonomous driving. An automated road sign recognition system playing an important role in alerting drivers for making driving safer[4]. Main challenges faced during recognition is the identification of the system with respect to variying natural background conditions.

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Traffic sign recognition system mainly consists of two phases : Detection and Tracking [13],[14].

1.1 Detection Phase

In the detection phase,the acquisition image is preprocessed, enhanced, and segmented according to the shape and color of the traffic sign. These images are investigated to separate the possible road sign images from the complex background. Then these objects are normalized to a specified size, and input to the next phase[5]. That is, given an input image at t, the sign detector localizes the potential sign region and represented it as a target probability density for the image at time t + 1, and give it as input to the tracker[13].

1.2 Tracking Phase

It is the process of locating an object or multiple objects over time. A sign appears multiple times in different scales before it disappears from the viewpoint. When this happens, the sign images subregions appearing on two consecutive image frames overlap each other[9]. Tracking is used to reduce the errors, introduced in the detection phase. Main aim is to increase the accuracy of obtaining the ROI.

2 Related Work

Intial requirement of any computer vision mechanism is to locate the potential sign image regions from the entire image. Researchers introduced many techniques for the ROI detection. Some system utilizes the color of the image while other utilises the shape. Some researchers have manually surveyed the color values[2]. Other method is, by using machine learning techniques to obtain the optimal thresholds of the target color[6]. Manually identifying color values is simple in its implementation, but tends to be error prone.

Another method of sign detection is by means of shapes. Some researchers utilize the geometric property, to locate the centroids of traffic signs. To understand the traffic rule enforced by the sign, one needs to read the contents of the sign. For the sign classification, most work uses existing machine learning techniques, such as neural network[6], linear discriminant analysis[7], support vector machine[5] etc. For reducing the detection errors, sign detection methods can be combined with a tracking method[13].

3 PROPOSED METHODOLOGY

The motivation of workzone recognition is the techniques used for traffic sign detection. The latest study by Young and Zhang[13] introduced the concept of detection by Adaboost algorithm and tracking with Meanshift. Their work focused on how to reliably detect and accurately classify the workzone regions appearing on the consecutive image frames of a perspective video.

For an input image at time t, the sign detector localizes the corresponding sign image region and represented it as a target probability density for the image at time t + 1 and give it as input to the tracking phase. In the tracking phase, by using suitable computer vision algorithm, identifies potential sign regions from multiple image subregions at t + 1. These are represented as candidate probability densities. By computing the similarity between a target density and the identified candidate densities, candidate density with the highest score will be the output of the tracking phase and will be the new target for the next image frame at time t + 2. Then the classifier categorized the potential sign image region into one of the predefined classes.

Two algorithms are used in the existing method : detection by Adaboost algorithm and tracking by Meanshift algorithm.

3.1 Detection By Adaboost Method

Most commonly detection is performed based on its color. But due to the presence of varying illumination or other interrupting factors, the color may change. This leads to the problem of intraclass appearance variation[7]. For meeting such a problem, binary color classification is needed. For binary classification, AdaBoost mechanism is used. It is a strong learning algorithm,since it can be used in conjunction with various weak learning algorithms. The output of the weak learning algorithms are combined into a weighted sum, which represents the final output.

After executing the binary pixel classification, sign detector runs a connected component grouping algorithm to identify n color blobs, ie the detector removes the bounding boxes with radii smaller or larger than the predefined thresholds, generating upto k blobs as candidates for a workzone sign[13]. The confidence value of the bounding box is calculated by taking the mode of the confidence values assigned to all the pixels within the bounding box.

3.2 Tracking With Meanshift Algorithm

Sign detector works well with individual image frames, but its performance is not perfect. It would lead to inconsistencies. For improving the detection accuracy, tracking method is used. A sign appears multiple times in different scales before it disappears from the view point. When this happens, the sign image's subregion s appearing on two consecutive image frames overlap each other[9]. Tracker captures this idea. The detection output is to model a target probability density of a sign region. The tracker uses this density to search for an image subregion from the next frame. Meanshift is used to perform this task.

After sign detection, next stage is to classify the extracted region into suitable category. The main disadvantage of this existing method is, tracking with meanshift algorithm requires high time consumption and thus lead to decrease its accuracy. So for improving its accuracy and reducing its time consumption, an optimal estimator, Kalman Filter is used for tracking.

4 TRACKING WITH KALMAN FILTER

Kalman Filter is an optimal estimator, which infers parameters of interest from indirect, inaccurate and uncertain observations. It is recursive so that new measurements can be processed as they arrive.

The main features are[14] :

- Good result in practice due to optimality and structure.
- Can track multiple objects.
- Prediction of object's future location.
- Reduction of noise introduced by inaccurate detections. Etc

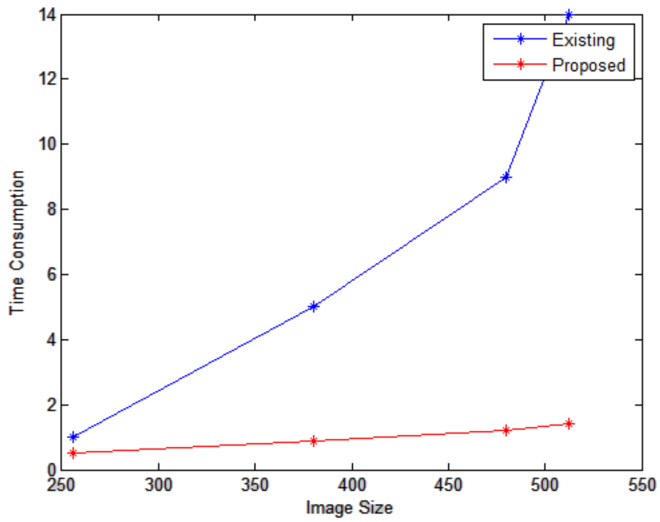
Kalman Filter has so many uses, in control, navigation, and computer vision applications. It follows two steps :

- Prediction : Uses previous state to predict the current state.
- Correction : Uses the current measurement to correct the state.

5 EXPERIMENTAL RESULTS

The proposed method is implemented in MATLAB, and test it on a video sequence, which is downloaded from[13]. Then the method is evaluated based on the detection algorithm, AdaBoost along with the tracking by Kalman Filter to achieve a good tracking performance.

Video is stored as image frames. For testing the performance based on the time consumption, each frame is resized and manually calculated the time taken to execute it. And comparing with the existing system, the resulting graph is as shown below :

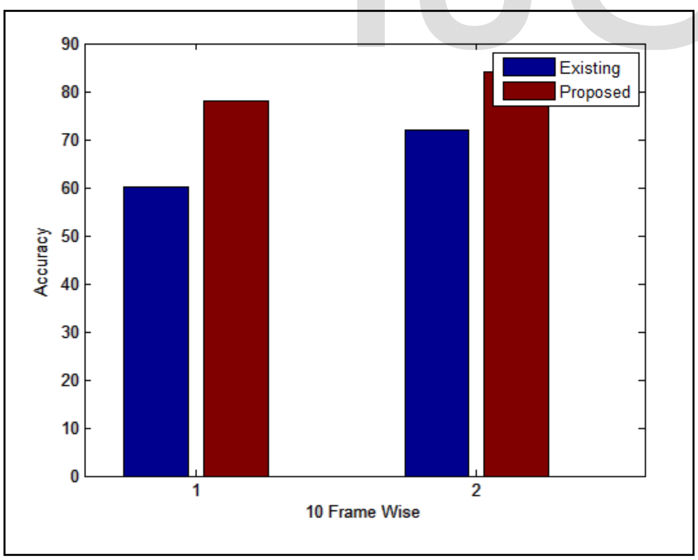


For calculating its accuracy, evaluation is done on each 10

Accuracy =

((No of hazards region detected) % (Total no of hazards region)) * 100

The result is as shown below :



6 CONCLUSION

This paper presents a set of computer vision algorithms, used to localize, detect, and classify the workzone signs for obtaining the detailed information about highway workzones, such as its boundary. This recognition system is tested using the video data and found that it is capable of obtaining the good result compared to the existing method. The time consumption is less in the case of Kalman Filtering and so the accuracy is high. Good optimal results are obtained.

The color based sign detector may not work properly in some cases, where their images were under and overexposed to different light sources. As a future work, the color and shape information can be combined for accurate detection.

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