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Real Time Stereo Vision System for Safe Driving Distance Measurement-A Survey

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Abstract —The paper presents a model of stereo vision system for intelligent vehicles for distance measurement to avoid forward car collision. The system consists of two cameras of parallel optical axes and separated horizontally from each other by a small distance and these two cameras are combined together in a single frame. Many approaches have been proposed for effective distance measurement. In this paper, we have shown the detail survey on distance measurement of vehicle and obstacle using stereo vision system.

Keywords- *Distance; stereo vision; intelligent vehicles; parallel optical axes; collision*

I. INTRODUCTION

Car accidents are the major problems of today's traffic world. Particularly this strongly felt in urban areas having large car density. Most of car accidents happened due to human factor such as somnolence, inattention, absence of mind and slow reaction. These factors are critical for a driving safety. To prevent the roadside collisions between vehicles or vehicle parked and vehicles on the roads, the research of automatic bump-shielded system becomes a hot topic in the world currently. Method presented which measure the safe driving distance of the target vehicle.

These methods of distance measurement reduce the traffic accidents and also improve the car's active safety and avoid traffic collision. There are many methods active and passive methods used to determine the distance of object (target) or obstacles. Active methods uses some signals which are send to the target such as laser range finder, ultrasonic range finder, radio waves, microwaves, infrared, etc.

The most popular among the passive are those relying on stereoscopic measuring method due to its advantages of hidden, safe, simple hardware and so on. Scientist and many famous car manufacturers are developing durable, accurate and real time car driver assistance systems. Many of works done by researching and developing vision system for lane tracking [13], driver monitoring [9], pedestrian or bicyclists detection [14], or car detection [15].

Rest of the paper is organized as follow. Section II, is literature review of various distance measurement using stereo vision systems by various researchers. Last, Section III concludes the survey.

II. LITRATURE REVIEW

This Literature, review explores the every phase of distance measurement using stereo vision system

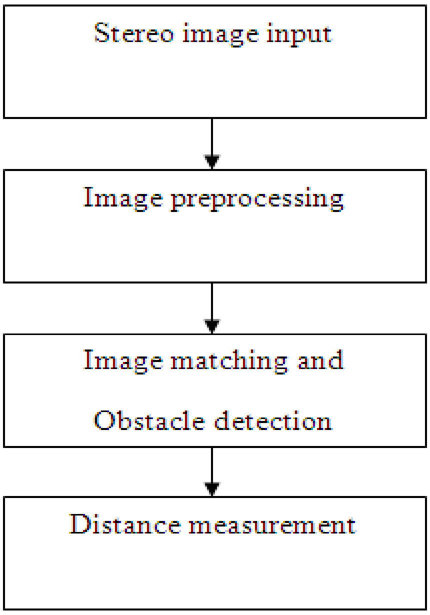

Figure 1.Frame work of stereo vision system for distance measurement

2.1. Acquisition

Image acquisition is the process of acquiring the input image from the stereo camera. Stereo image capture is done by using two video cameras which are aligned in parallel with a fixed relative distance and position. The object distance can be measured when it enters the overlapping views of the two cameras. Figure 2 illustrates the stereo vision setup.

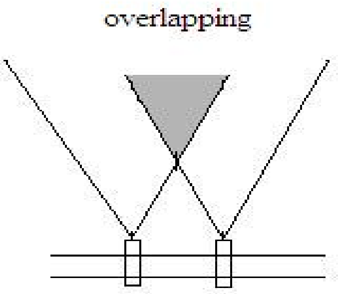

Figure 2.Stereo vision setup [4]

2.2. Image preprocessing

Image preprocessing is an important and common method in a computer vision system. Preprocessing can enhance the images quality and improve the computational efficiency. In reference paper [4], after the stereo images are captured, the resolution of the images is down-scaled to improve the computation speed. For example, the original resolution which is 2784x1856 pixels is downscaled to 320x240 pixels [4]. The result shows that the reduction of resolution does not affect the accuracy of the system.

Another way we used to improve the speed is through converting the images from RGB color space to gray scale color space [4]. DSP processor [5] is used to measure the distance it uses A/D convertor [5]. Preprocessing detects features in both images and extract feature descriptors [4]. In reference paper [8] algorithm transforms stereo perspective images into a virtual top-view [5]. To make image smaller in size and to decompose, a two dimensional discrete wavelet transform is used to down-sample [11].

2.3. Image matching and obstacle detection

Image matching and obstacle detection is processes of tracking the vehicle or the target. The features are matched using descriptor and taking average of every matched feature distance as the object disparity [4] can be calculated. The process is shown in Figure 3. The stereo images are transformed to top view the polar accumulation function (PAF) are formed from the edge magnitude scanned by edge detection [8]. DSP processor uses the Area-based and feature-based used for image matching [5].

Hardware FPGA [3] is used to analyze the disparity between the left and right image and calculate the depth of each pixel. 3D points are grouped and then area based correlation and the sum of absolute differences (SAD) function [1] is used as a measure of similarity, applied on a local neighborhood (5x5 or 7x7 pixels) to detect the obstacle. Parallel processing features of the processor are used to implement this function [1].

A Kalman-filter-based tracking algorithm [2] is used to track the strong pedestrian hypotheses. Morphological approach [11] is used to group the candidate points which are the potential parts of object chosen for grouping from the densities of disparities. The homographic transformation or dense stereo matching methods used to extract the obstacles regions [12].

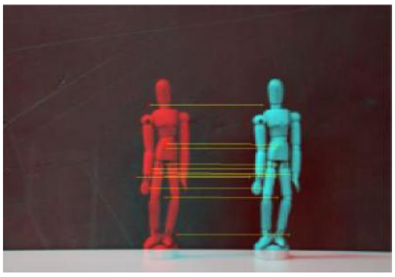

Figure 3.Calculating the matched feature distance as disparity [4]

2.4. Distance measurement

The distance of the obstacle can be calculated using simple basic triangulation rule. Figure 3 [10] shows the schematic diagram of two webcams having same parameters, right webcam and left webcam at a distance b and aligned so that their optical axes parallel from each other. The image of target T will be at x1 distance in the left camera and at x2 distance in the right camera.
Applying basic triangulation:

$$\frac{\mathrm{b1}}{\mathrm{D}} = \frac{-\mathrm{x1}}{\mathrm{f}} \tag{1}$$

$$\frac{\mathrm{b2}}{\mathrm{D}} = \frac{\mathrm{x2}}{\mathrm{f}} \tag{2}$$

Since b=b1+b2, then

$$\mathrm{b} = \frac{\mathrm{D}}{\mathrm{f}}(\mathrm{x2} - \mathrm{x1}) \tag{3}$$

$$\mathrm{D} = \frac{\mathrm{bf}}{\mathrm{x2} - \mathrm{x1}} \tag{4}$$

Equation 4 shows disparity x can be calculated and then distance of object A can be estimated.

$$\tan\left(\frac{\theta_0}{2}\right) = \frac{x0}{D} = \frac{x1}{f} \tag{5}$$

$$f = \frac{x0}{2\tan\left(\frac{\theta_0}{2}\right)} \tag{6}$$

$$D = \frac{bx0}{2\tan\left(\frac{\theta_0}{2}\right)(x2 - x1)} \tag{7}$$

Equation 7, x0 is the width of the image in pixels, x2-x1 is the disparity between the two images in pixels, b is the distance between webcams having the angle view θ_0, width of the image are constant for 3D webcam, then it can be seen that the distance D is inversely proportional to disparity (x2-x1).

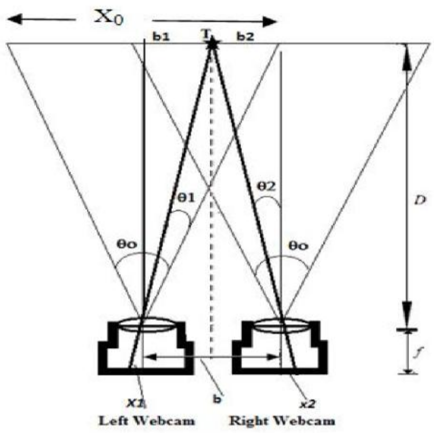

Figure 4. The schematic diagram of an object by two horizontally aligned cameras [10]

III. DISCUSSION AND CONCLUSION

Stereo vision system for distance measurement is very useful in urban area where the traffic intensity is high which avoids the forward car collision. Various researchers proposed their work in this area and achieved good accuracy rate. Very few researchers focused and managed the time complexity. After many research works, we found that there are some disadvantages of range, hardware used is complex etc. So, the systems for distance measurement still an open area of research for the accuracy in distance measurement.

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