DISPARITY MAP CALCULATION FOR VARYING ILLUMINATION STEREO IMAGES

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Abstract

Stereo vision is widely used research topic. Several algorithms were used to find the disparity map from the given stereo image pairs. But, when these matching algorithms are used for real world images, especially sequence of outdoor under sunlight, they do not produce expected result as they produce for standard stereo image pairs. Here, we proposed a method based on histogram equalization (HE) and homomorphic filter to reduce the illumination effect in stereo images. The results indicate that the result obtained after pre processing through our method performs better than using stereo matching algorithms directly.

Index Terms: Histogram equalization, Homomorphic filter, Stereo Matching.

I. INTRODUCTION

There is a lot of research going on in computer vision that focuses on restoring the 3D depth information from 2D images. The most difficult problem in stereo vision is the establishment of visual correspondence among images. The stereo correspondence is a problem of determining the matching pixels in the pair of stereo images. The stereo correspondence is mainly divided into two types; they are local based method [1–7] and global based method [8-9]. Local stereo correspondence algorithm makes use of information available within the small area, where as global based methods optimize certain global function. Most of the stereo matching algorithms assume illumination invariant stereo image pair. However there exist numerous real and difficult situations in which illumination variation between stereo images is unavoidable. There are many constraints that make stereo an ill-posed problem. One type of issue is associated with the scene itself, specifically texture less areas and occlusions. The others issues are camera-related issues like image noise, imperfect calibration, and camera orientation. The use of multiple cameras to capture images induces certain problems such as differences in exposure and other radiometric properties. Stereo algorithms should be useful in real-time applications. Nonuniform illumination between two images frequently occurs in real scenario. Stereo algorithms should be capable to handle such type of difficult illumination conditions [10]. Similarity measures such as sum of absolute difference (SAD) and absolute difference (AD) [11] are used to calculate the matching costs to find the corresponding pixels. These methods suppose that matching pixels between left and right images will have the same color value. But due to illumination variation the corresponding pixels will have different color values [12]. Thus in case of illumination variation the estimated disparity map is extensively degraded as compared to the ground truth. In the proposed method, a homomorphic filter is used after performing histogram equalization(HE) to make the pixel intensities of the two images more contiguous. We tested our method using images from Middlebury dataset and obtained better results .

This paper is structured as follows. Section II specifies the flow chart and details of the proposed method. Section III shows our results on different kinds of images. Section IV contains the conclusion.

II. PROPOSED ALGORITHM

Many stereo matching algorithms assume illumination invariant stereo image pair. However there exist numerous real and difficult situations in which illumination variation between stereo images is unavoidable. When corresponding pixels between left and right images have dissimilar colours because of illumination variations inaccurate disparity map is generated. A new stereo vision algorithm is proposed which gives disparity map from illumination variant stereo pair. Illumination variation between two stereo images affects the quality of the disparity map generated. When images of a stationary scene are recorded by camera at different timing interval, illumination variation occurs due to fluctuation in environmental illumination and the variation in the position of the light sources. Hence there will be illumination variation between left and right images in many real-time situations. This illumination variation degrades the performance of stereo matching algorithms. If illumination variation is not suppressed in pre-processing stage, then that will lead to false matching and in turn will result into inaccurate disparity map estimation[14-15]. So in order to get accurate disparity map as output, illumination difference between two images must be suppressed before starting matching process. Illumination variation suppression is done by histogram equalization and homomorphic filtering to make the pixels of both images more or less illumination invariant.

The flow chart of our proposed method is shown as follows

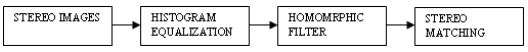


Fig. 1: Flow chart of the proposed method

A. Histogram Equalization

In order to process the stereo pair we process the images using histogram equalization(HE) as the initial step. HE is the widely used technique for global contrast enhancement. Histogram equalization aims to distribute uniformly the whole range of gray level over the histogram of an image, thus increasing the contrast of the image.

(a) Left image (b) Right image(c) HE left image (d) HE right image

Fig 2: Results after applying histogram equalization

B. Homomorphic filter

Homomorphic filtering method has been used in various imaging applications such as robotics, biometrics, and image enhancement. Image can be viewed as a product of illumination component and reflectance component of scene. The low frequency components due to illumination can be removed by taking the log of the image and there after applying high-pass filtering. In this way, enhancement of details within an image is done by homomorphic filtering. Illumination variations can be treated as a multiplicative noise and can be reduced by filtering in the log domain. The brightness across an image is normalized by homomorphic filtering and it also enhances contrast. Multiplicative noise can be removed by using homomorphic filtering.The basic model is as shown below

Fig. 3: Homomorphic filtering process

The results obtained after applying homomorphic filter to the left HE image and right HE image is as shown

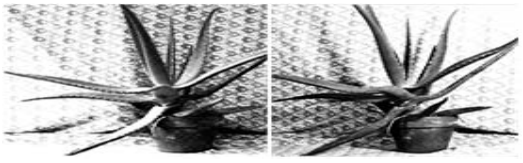


Fig. 4: The pre processed image pair after applying homomorphic filter

C. Stereo matching

A basic SAD algorithm is used in the proposed algorithm. The SAD algorithm is commonly used metric in stereo images for block matching. It computes the difference between every pixel in

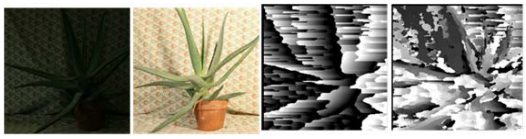
the original block and the relative pixel in the block that is used for comparison. The simple measure of block similarity is calculated by summing the differences obtained. This algorithm is based on pixel based approach which is used for finding the disparity.

$$\sum_{(i,j)\in W} |I_1(i,j) - I_2(x+i, y+j)| \quad (1)$$

III. EXPERIMENTAL RESULTS

In our proposed algorithm, to evaluate the result we used images from Middlebury dataset[13]. Stereo algorithm such as SAD with window size 9 x 9 is compared with the proposed method. To analyze illumination effect the index of illumination is varied. Figure 5 shows the Baby and Aloe stereo image with varying illumination condition and disparity maps obtained before and after pre-processing. Change in illumination will yield to local variations. Many stereo matching algorithms are affected by this local variation and gives poor disparity. The proposed method shows better disparity than the others.

(a) (b) (c) (d)



(a) (b) (c) (d)

Fig. 5 Results on Middleburry datasets for images Baby Aloe. (a) *left* reference image ,(b) right reference image,(c) the results of SAD ,(d)the results of the proposed method.

Root mean square error(RMSE) method is used to find the quality of the computed disparities. The RMS error is calculated between the computed depth map $dC(x,y)$ and the ground truth map $dT(x,y)$, that is

$$RMS\ Error = \left(\frac{1}{N} \sum_{(x,y)} |d_c(x,y) - d_t(x,y)|^2 \right)^{\frac{1}{2}} \quad (2)$$

where N denotes the number of pixels.

Table 1 shows the RMS calculated for results obtained by SAD algorithm and the proposed method for the test images. The root mean square error(RMSE) of the proposed method gives better results than the SAD algorithm.

Table 1:RMSE

	SAD	Proposed method
Baby	0.301376	0.285969
Aloe	0.242274	0.210943

IV. CONCLUSIONS

This paper proposes a new technique for preprocessing the stereo images. In the proposed system, histogram equalization and homomorphic filtering is used for preprocessing the stereo images.The result of the proposed method is compared with SAD method. The results show that the proposed method yields a good disparity map .

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