Independent Motion Detection using Optical Flow on Stereo Images

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Abstract

3D motion detection requires, on the one hand, the study of motion of the objects in the environment, and on the other hand, the depth estimation of the scene. These two tasks are computationally expensive and are not suitable for real time application. This paper proposed a method for the detection of moving objects in the stereo image sequences from a moving platform. In order to reduce the stereo matching time, moving objects are detected firstly and then a stereo vision method that uses motion information to perform depth estimation of the moving object is performed. The experimental results on real image sequences demonstrate that the proposed method can reduce the time complexity of the stereo matching and depth estimation.

Key words: Motion Detection, Optical Flow, Stereo Matching.

1. Introduction

3D motion detection from a moving stereo rig is an important problem in computer vision. For a stationary platform, moving regions can be detected by differencing successive images and segmenting the non-zero parts Zheng and Chellappa (1993), but the problem is more complicated when everything in image and camera are moving. In stereo system depth information can be extracted from two images that captured from different positions on the scene, but this system cannot separate moving objects from static objects and background without employing of motion information. There are a few approaches that fuse stereo with motion information, for example in Huang and Young (2008) Li and Hu (2010), proposed two algorithms for integrating stereovision and motion information. The first algorithm gathers the motion information due to performing optical flow on the edge images. Then, the second algorithm uses Kalmanfilter to combine stereo and motion information for object tracking. In that paper depth map is sparse, thus moving object cannot be found as a whole. Also, matching is done for whole of the scene.Dang et al. (2002)proposeda similar approach where they fused depth maps from stereo and motion using a Kalman filter. They also considered the acceleration as a noise in order to reduce the complexity of used Kalmanfilter, but came across a bigger error when car is moving with non-zero acceleration.Waxman and Duncan (1986) described a 5-step algorithm for extracting shape from motion. The authors suggested that fusion of stereovision and motion information could help to overcome the other's shortcoming. The limitation of this paper is that viewing scenes consist of white objects covered by black dots. Li and Duncan (1993)presented a method for recovering structure from motion. They considered only translational motion and the results are presented on laboratory scene consisting of surfaces covered with either grids or regular patterns of block dots.Sudhir et al. (1995**)** used Markov random fieldsto fuse stereo and motion. Their experiments are on tailored images and did not consider object grouping issues, thus their method are difficult to use on real images.

In this paper, we propose an algorithm that uses velocity vectors as correspondence seeds for stereo matching. The first step is employing of stereo images that taken from cameras mounted on a moving car. Secondly, we separate moving objects from static objects and the background. Then we compute depth information using motion information that achieved by using optical flow in the previous step. so by distinction between moving objects and statics object and the background, depth map is compute only for moving objects which means reduction of the time of the matching algorithm. Also, by using motion information as correspondence seeds, we can robustly compute the depth map from two stereo images.

The rest of this paper organized as follows: Section 2 gives the discussion of independent motion detection. Stereo matching algorithms are described in Section3. Section 4 shows experimental results. Finally Section 5 contains the conclusion.

2.Independent Motion Detection

There are three main approaches to the motion detection: temporal differencing in Hongjian(2009) andHuimin et al. (2008), background subtraction in Hu et al.(2010) Elhabian et al(2008) and optical flow in Horn and Schunck (1981) andLucasand Kanade (1981) For a stationary platform, moving regions can be detected by differencing successive images and segmentation of the non-zero partsZheng and Chellappa (1993), but the problem is more complicated since everything in image is moving along with the camera. Thus, optical flow is used approach to obtain motion information. Cyganek and Siebert (2009)described that optical flow refers to the problem of estimating a vector field of local displacement in a sequence of images. The method is based on an assumption that points on the same location have constant brightness from one frame to the next. There are many approaches for optical flow computation, but in ourpaper, theLucas and Kanade(1981)isused to compute the relative motion between an observer and the scene.

For distinction of moving objects from stationary objects and the background, we employ Nelson (1991)method depicted this fact that the apparent motion of a fixed point due to smooth observer motion changes slowly, while the apparent motion of many moving objects such as animals or maneuvering vehicles may change rapidly.In order to use this fact, four successive frames are considered and optical flow is computed for every two successive frames in left and right images respectively. Then by differencing and thresholding, moving objects can be detected in both left and right side.

3. Stereo Matching

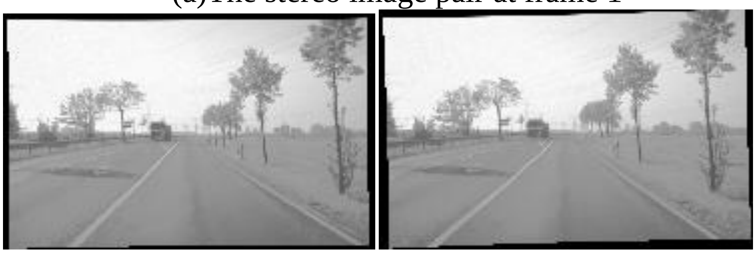
Stereo vision is ability to perceive the depth of the observed scene based on two cameras, located on the same horizontal line, called the baseline. The fundamental problem in stereo vision is correspondence problem that tries to solve the problem of finding correspondence between left and right images. The correspondence problem is classified into three methods: pixel-based, area-base, and feature-based. Pixel-based approaches compute the

disparity for every pixel in image which is a time consuming process. The second class is area-based approaches that solve the correspondence problem for each pixel in image within a finite neighboring window. The important problem in area-based approaches is selecting size of window, Kuhl (2005) illusteratedthat small window led to less correct map but short run times whereas a large neighborhood led to more exact maps at the expense of long run times. The second class is feature-based approaches that try to correspond features such as edges, corners, line segments and geometric figures in left and right images. An important disadvantage of these approaches is that they yield sparse disparity maps. In this paper fusing of area-based and feature based in order to achieve advantage of two approaches is used.
After detection of moving objects, next step is to compute the depth map for them. In order to perform stereo matching and find a semi-dense disparity map, GCS algorithm proposed in Cech and Sara (2007) is involved, but instead of random seeds, point with positive velocity are used as correspondence seeds for stereo matching. This algorithm works by growing from a set of correspondence seeds that guarantees matching accuracy and correctness, even in the presence of repetitive patterns.

4. Experimental Results

During the tests, proposed method is tried on real images that taken from stereo camera mounted on a moving car. Fig1 shows two stereo image pairs at consecutive time frames.

(a)The stereo image pair at frame 1



(b)The stereo image pair at frame 2

Fig1: Consecutive stereo image sequences.

Results after performing GCS algorithm and our proposed algorithm that we called OFGCS are shown in Table 1. As shown in following tables the matching time is reduced roughly %11 after performing our proposed algorithm.

Algorithm / Data set	GCS	OFGCS
Overheadwires	2.07481 sec	1.84081 sec

Table 1. Stereo matching time of GCS and OFGCS algorithms on Overheadwires data set.

In order to independent motion detection considered four consecutive frames, as shown in Fig 2.

(a) The stereo image pair at frame 1

(b) The stereo image pair at frame 2

(c) The stereo image pair at frame 3

(d)The stereo image pair at frame 4

Fig 2: Consecutive stereo image sequences

Computed depth map of whole images at frame 4 is shown in Fig 3.

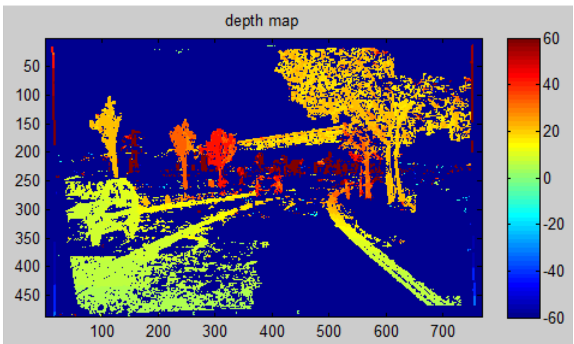


Fig 3: Depth map of stereo image at frame 4

After performing the proposed method of Section 3 for independent motion detection the moving object is shown in Fig 4. As see in this figure the border of moving object detected in reasonable form.

Fig 4: Border of detected moving object

In final step depth map for detected moving object is shown in Fig 5.

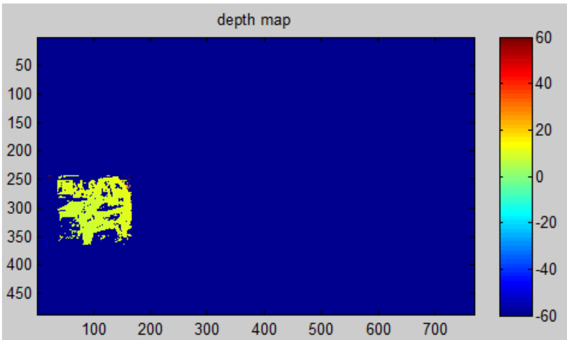


Fig 5: Depth map of moving object at frame 4

The result of comparison time between matching time for whole of image and only for moving objects is illustrated in Table2. As seen in that table the matching time is decreased around %82, for MOFGCS algorithm that performs only moving objects matching.

Algorithm / Data set	OFGCS	MOFGCS
Overheadwires	2.87042 sec	0.514803 sec

Table 2.Matching time of OFGCS and MOFGCS algorithms on Overheadwires data set

5. Conclusion

This paper proposed a method for the detection of moving objects in the stereo image sequences from a moving platform. In order to reduce the stereo matching time, moving objects firstly detected and then a semi-dense stereo matching algorithm that uses velocity vectors as correspondence seeds is applied. Using of motion information as correspondence seeds decreases the matching time roughly %11. Also, since we need to extract the depth map for moving objects, independent motion detection and computing depth map only for moving objects reduce the matching algorithm time around %82.

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