Segmentation-based Disparity Plane Fitting using PSO

Hyunjung, Kim¹, Ilyong, Weon², Youngcheol, Jang³, Changhun, Lee ⁴

¹, ⁴ Department of Computer Engineering, Konkuk University,
120, Neungdong-ro, Gwangin-gu, Seoul, Korea
² Cyber Hacking Security Seoul Hoseo Technical College,
420, Gangseo-ro, Gangseo-gu, Seoul, Korea
³ Department of Digital Motion Picture, Kyungmin College,
545, Seobu-ro, Uijeongbu-si, Gyeonggi-do, Korea
{nygirl, chlee}@konkuk.ac.kr, clccclcc@naver.com, jdear@daum.net

Abstract. In this paper, the segmentation-based disparity matching method is introduced. K-means was used to make segmentations for reference images. PSO was applied for disparity plane fitting. The suggested methods were verified through experiments, and meaningful results were acquired.

Keywords: segmentation-based stereo matching, K-means, PSO, Segmentation, outlier, NP-hard problem, Disparity Plane Fitting, Optimization

1 Introduction

Among the resolution methods for the stereo matching issue, pixel-based is fast, however it is difficult to acquire exact disparity. Humans recognize things by color, texture, and shape, and segmentation-based stereo matching is one of the approaches that use such principles to solve the stereo matching issue [1].

The segmentation-based approach shows good results from textureless regions or boundaries between objects in images. Furthermore, each plane of a target image matches with at least one homogeneous color segment of reference images [1,2]. Generally, segmentation-based stereo matching goes through four consequence steps. First, a robust area segment method is used as a reference image. Second, a local match method is used to acquire the initial disparity map. Third, plane fitting [3,4] is used to acquire the disparity plane. Finally, optimal disparity plane assignment is approximated by using optimization methods [5].

A meta-heuristic method—which has been showing effective results recently—was applied to solve segmentation-based stereo matching problems and to verify its effectiveness through experiments. The perspective of interpreting the issues of plane fitting steps in segmentation-based stereo matching is introduced as the optimization issue of NP-hard.

In chapter 2, we explained how to make segmentations and acquire initial disparity. In chapter 3, our disparity plane fitting and a disparity plane assignment using a meta-
heuristic method were designed. In chapter 4, experiments details and experiment results were mentioned. Finally, conclusions and future challenges were mentioned.

2   Image Segmentation and Obtaining the Initial Disparity

2.1   Color Image Segmentation

In our proposed, the region segmentation about the reference image is used for the color-based K-Means Algorithm[5,6]. It first calculates the center value of clusters and the distance with each pattern. It then includes the pattern in the closest cluster.

2.2   Obtain Initial Disparities

Similar to most local approaches, the aggregation of costs within a frontal-parallel support window implicitly assumes that all of the points within the support have the same disparity.

3   Segmentation-based Disparity Plane Fitting

3.1   Disparity Plane Fitting

In textureless areas, it is difficult to find appropriate plane parameters from disparity values that were acquired in the one-dimension.

Fig. 1. Disparity Plane Fitting. It is the whole segmentation area cannot be assigned as the plane. However it is difficult to acquire the optimal disparity plane. This is called outlier.

To find an optimal plane, an optimal value has to be found from the values acquired from the initial disparity value then needs to be compared and analyzed with neighbor segments to find an optimal plane again to apply so it takes a long time. In order to solve such problem, PSO was applied to find an optimal value effectively. The fitness function used in our proposed can be acquired by calculating the distance from the points in the segmentation to the disparity plane. This is the cost function.
3.2 Segmentation Labeling

In order to effectively solve noises generated from outliers in the process of making segmentation, a large segmentation needs to be made by merging segmentations and including those noisy area groups. It will reduce the inefficient ratio that was caused from the noise. In our proposed, WTA was applied.

\[ E_{data}(f) = \sum_{S \in \mathbb{R}} C(S, f(s)) \]  

\[ C(S, P) = \sum_{(x,y) \in S} |ax_1 + by_1 + c| \]

Where, \( E_{data} \) is a data-dependent energy term containing the cost of assigning plane labels to the segment S.

\[ E_{smooth}(f) = \begin{cases} 
\sum_{(s,s')} D(f(s), f(s')), & \text{if } f(s) = f(s') \\
0, & \text{otherwise} 
\end{cases} \]

Where, \( D(f(s), f(s')) \) is distance between a plan \( f(s) \) and a plan \( f(s') \).

4 Experiments and Analysis

The effectiveness of the suggested method was experimented by using a Middlebury dataset [7].

Representative images were used for the experiment as shown in Fig 3, and the calculation on the segmentation proved to be the most consuming step. Where the percentage of pixels with an absolute disparity error greater than one pixel is shown for different regions: non-occlude (nonoccl.), whole image (all) and pixels near discontinuities (on disc). And pixels with a disparity error greater than one pixel are
displayed in the ‘bad pixel’ maps, where mismatches in non-occluded areas are indicated in black and occluded areas in gray color.

5 Conclusion

In this paper, we proposed the segmentation-based stereo matching method. For color-based segmentation, K-Means was used instead of Mean-Shift which was normally used in the past from the idea that the objects that we are actually interested in the input image when acquiring disparity map are only a few from close-range.

![Fig. 3. Result of Middlebury Datasets. (a) Original (b) Ground truth (c) using K-means segmentation result (d) disparity](image)

This way can be very beneficial in the fact that it will simplify images to analyze, however the calculating time may increase rapidly as the number of interesting objects increases. PSO was suggested for the process of analyzing each segment to acquire the plane and to adjust the segmentations. While existing number of algorithms tried to find optimal plane parameter, the algorithms of PSO include such concept already, so this kind of issue can be easily solved as long as evaluation function is properly decided. In order to label each segment, WTA method was adapted instead of other complicated methods such as Graph-Cut or BP which decreased the complexity of the entire algorithms.

In the future studies, the ways to decide appropriate number of segmentations for each input image need to be researched and qualitative analysis on various images based experiments are also required. This paper is aimed to shorten the calculation time in entire algorithms to apply them to the real-time system.

References