ABSTRACT

This paper describes the application of stereo vision to reverse engineering for manufacturing. Previous area-based stereo matching algorithms generate relatively many matching errors around depth discontinuities and smooth deformations, since SSD (Sum of Squared Difference) function may fail to achieve the minimum in such areas because of varying disparity profiles. In this paper, a new correlation function based on robust estimators is proposed for the selection of potential matching points which can effectively improve matching accuracy in the areas. Also, it utilizes other 4 directional line masks besides a rectangular window. A 3d array is constructed from selected points corresponding to a pixel and disparity. The proposed matching algorithm also finds the variable window which has a constant disparity around a pixel, and performs differential matching based on the window for computation of sub-pixel disparity. It has been turned out that the proposed algorithm significantly reduces matching errors around depth discontinuities and smooth deformations, and also applies to 3d coordinate acquisition. Experimental results show better performance than those of previous algorithms in synthetic and real images.

1. INTRODUCTION

In recent years, CAD/CAM techniques are widely used in manufacturing industries. Reverse engineering is considered one of an important process in design and manufacturing processes. In order to create an accurate geometric model, high quality 3d range data have to be acquired from an object. The 3d coordinate acquisition is indispensable for the reverse engineering.

Among various techniques available for 3d coordinate acquisition, stereo vision[1] which measures depths of 3d shapes using two images acquired from different viewpoints is one useful non-contact measurement technique. In machine stereo vision, the most challenging problem is to find corresponding image points. This problem is called stereo matching. Based on [2,3], we can classify stereo algorithms into three classes: feature-based, area-based, and pixel-based.

Feature-based stereo matching methods[4] use signed zero-crossings and line segments as features for matching. Despite clear identification performance of these features, physical constraints like a disparity continuity are needed to resolve remaining ambiguities. Advantages of using these features are robust against photometric variations. However, since the features are sparse, interpolation processes are required to fill gaps later.

Area-based stereo algorithms[5-8] are based on the assumption that disparities within a rectangular window centered at a pixel in each image are constant. So, intensities in the window can be used to find corresponding pixels. A general method of such algorithms is correlation[5,6]. In this method, although the size of the window is made adaptive to local intensity variations or determined to minimize uncertainties of disparities, the essential assumption of constant disparity inevitably causes matching errors around smooth deformations[7,8]. Besides, due to projective distortions, rectangular windows in one image correspond to deformed windows in the other image. Although the differential matching[9] is able to alleviate this problem, it also generates matching errors in the vicinity of depth discontinuity.

Pixel-based stereo algorithms[10] perform matching at each pixel with the intensity of a single pixel. Dynamic programming has been applied for the matching. Since this is only performed independently to along each scanline, estimated disparities exhibit obvious discontinuities. They are often sparse because of the lack of robustness against noise.

In this paper, to reduce matching errors for 3d shapes with depth discontinuities and smooth deformations, and improve robustness against noises, an area-based correlation function based on robust estimators is proposed for the selection of potential matching points. Also, it utilizes other 4