3D Wand: A Handheld 3D Digitizing Device

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Abstract

We present the 3D Wand, a low-cost 3D shape acquisition device consisting of a laser line projector and LEDs. A user projects a plane of light to the measured 3D scene by the handheld 3D Wand. The projected light and the LED lights are captured with a DV camera. By estimating the 3D pose of the 3D Wand from the visual information of the LED lights, the distance to the surface lit by the laser is calculated. With this system, users can measure the 3D shapes of objects in real time.

1. Introduction

As a 3D digitizer has become popular in computer vision communities, the 3D digitizing specs needed for computer vision systems are varied. Several kinds of 3D digitizers have been developed, from air borne landform measurement systems to desktop range finders, with each having specific pros and cons.

Using laser range finders, long range, very precise and dense depth images can be acquired [1], but the costs of these specially designed devices are very high. Structured light based stereo or laser stereo systems are for middle or short range use, with even more precise and dense measurements [2], but they also require special light projecting devices, making their total costs expensive.

We demonstrate a vision based, low cost shape recovery system “the 3D Wand” ; the system is based on the work of Furukawa and Kawasaki [3]. The system consists of a DV camera, a PC and the 3D Wand, which is a laser projecting device mounted with LEDs. Since a DV camera and a PC are widely available, and the 3D Wand is simply assembled from a laser line projector and LEDs, we can make the total cost of our system inexpensive.

In the following sections, we introduce the actual implementation of the 3D Wand and experimental results.

2. Shape Recovery using 3D Wand

2.1. The System Configuration

Our shape measurement system consists of a DV camera, a PC and the 3D Wand (Fig.1). While measuring, the user holds the 3D Wand by hand and projects the laser onto the measured object. The sheet of laser produces a stripe on the object, and the user moves the 3D Wand so that the stripe scans the entire object surface. The projected stripe and the LED lights are observed by the DV camera. The video sequence is transmitted from the DV camera to the PC via the IEEE1394 link. The shape of the target object is recovered by analyzing the video sequence.

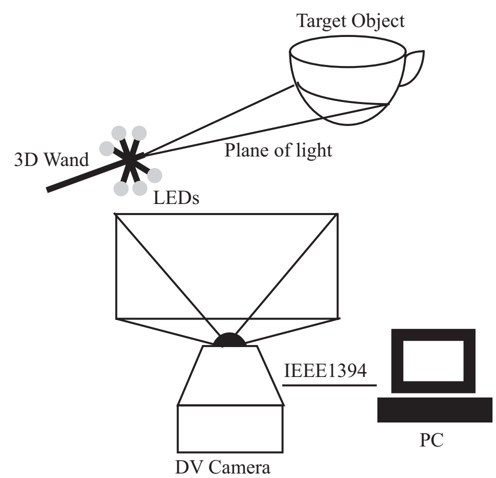

Figure 1: System configuration

2.2. Shape Recovery Algorithm

We employ a triangulation method to recover 3D shape. Since the 3D Wand and the DV camera create a base line for triangulation, the position and the pose of the 3D Wand is necessary. In our system, precision mechanical devices are avoided to be installed in order to make the system low cost, therefore, we have to estimate them by other method. In our system, we adopt computer vision techniques.

To make the estimation accurate, robust and easy, we use the six LEDs attached to the 3D Wand as shown in Fig.2. Four of the LEDs form the square which is placed on the same plane as the sheet of light. The other LEDs are located with a certain distance from the square.

These LEDs define the local coordinates in 3D space. From the 2D locations of the LED lights in the video frame, the parameters of the translation and rotation

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between the camera coordinates and the coordinates defined by the LEDs are estimated.

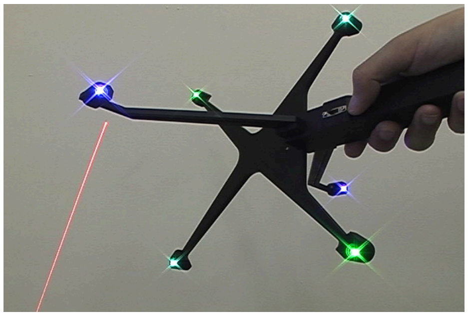


Figure 2: 3D Wand

3. Demonstration System

There are three steps in the process of our demo system. Firstly, the texture image is captured with the DV camera. And then, the user projects the laser onto the measured object. The projected light and LED lights of the 3D Wand are captured with the same DV camera and immediately 3D information are estimated. The estimated 3D information are directly visualized on a PC monitor, thereby, a user can confirm the acquired shape of each part of the surface in real time. The final step is a mesh generation and reduction [4] process after the measurement.

Figure 3: 3D digitizing scene

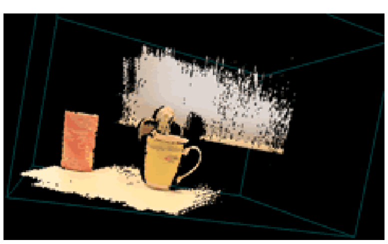
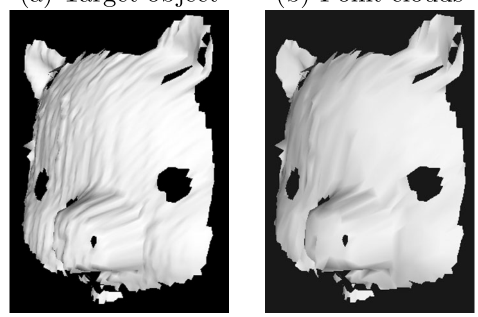


Figure 4: Captured scene

3.1. Results of Measurements

The target object is a pig vinyl doll as shown in Fig.5 (a). Fig.5 (b) shows the point clouds acquired by the system. Fig.5 (c) shows the surface with 4134 triangle meshes and Fig.5 (d) shows a example of a polygon reduction. We can see that the 3D shapes are successfully recovered by our demo system.

(a) Target object (b) Point clouds



(c) 4134 triangles (d) 1000 triangles

Figure 5: Results of a shape recovery

Acknowledgments

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