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A Consumer Level 3D Object Scanning Device using Kinect for Web-based C2C Business

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Abstract: 3D scanner captures the appearance and geometry of a real object, and forms a virtual one which can be displayed in 3D on computers. However, the high cost of 3D scanning devices inhibits the popularity of scanned 3D objects on the web and related applications. Our system targets for developing a consumer-level 3D scanning device suitable for naïve web users with the use of a novel natural depth sensing device – Kinect. As the Kinect device is a low-cost, robust and fast depth camera with color, these essential features enable us to acquire RGBD images from different views of the target object. To facilitate the registration of point clouds from various depth images, we first combine marker-based tracking system to estimate the current view angle of Kinect during capture. Then, we employ the Iterative Closest Point (ICP) algorithm with the efficiency feature detection to reconstruct a single point cloud representing the 3D object surface. To reduce size of point cloud, a down-sampling is applied to remove redundant and densely sampled points in the model. The whole process of capturing, storing, uploading and displaying 3D data on web application is done with minimal user involvements. Users can freely control the viewing angle of their favorite product with the 3D scanned point cloud object displayed in the browser; this greatly enhances user's shopping experience. We believe that the introduction of attractive and fashionable 3D product on the web will gain significant attention from customers and evolve habits and traditions in e-commerce, especially for C2C business, e.g. auction sites like ebay and taobao, in which sellers can promote their goods for sale with scanned 3D models

Keywords: 3D scan, point cloud; depth sensor; C2C business; ICP; ARToolkit; feature descriptor.

1. Introduction

Internet shopping has become an ever-increasing phenomenon among the world. People just need to get onto the network and shop anytime and anywhere. C2C business or auction site is one of the many popular online shops; famous ones include e-bay and taobao. Existing C2C online shops provide the functionality of displaying 2D images of a seller's product in order to attract buyers; and allow buyers to view and understand the size and details of the product.

Although current way of promoting the product is enough for many of the cases; we believe that the introduction of attractive and fashionable 3D visualization on the web will definitely gain attention from customers and explore new area of online shop marketing. Also from the empirical point of view, 3D visual interfaces have already proven to be effective, attractive, and are considered as a key factor to add value to several application domains including entertainment, eLearning and e-commerce. With this motivation, we try to develop a comprehensive system which allows seller to create 3D model for their products placing online, as well as enables the buyer to browse the products in 3D easily on the web.

However, to facilitate the provision of 3D contents on C2C website, an affordable 3D scanner is necessary. Unfortunately, current market lacks a suitable low-cost 3D scanning device for similar purposes. In this project, Kinect is chosen as the basic technology in the development of such an affordable and tailor-made 3D scanning device in our system, because of its popularity, low-cost and real-time depth sensing capabilities. To successfully remove background objects and combine scanned point clouds from different view angles, we have used marker-based AR technology together with the well-known registration method: Iterative Closest Points (ICP) in our post-processing.

After the registered point clouds form a complete scanned 3D object, our system provides automatic uploading and storing on the e-Commerce website. With the use of novel web-based 3D graphics technologies: WebGL, the scanned 3D products can be displayed with latest web browsers seamlessly. In the following of this paper, we will introduce the whole workflow from the creation of 3D model using a self-developed low-cost 3D scanner, to the display and browsing of 3D product on a web-based C2C platform.

2. Related Works

2.1. Low-cost 3D Scanning using Kinect

There are a number of attempts to use Kinect as a depth camera for 3D object scanning and reconstruction, even though Kinect is initially designed to track human bodies and objects for games. ReconstructMe [1] is a user-friendly system that used for real-time 3D reconstruction and it also released related SDK for developers. However, the reconstructed scene does not contain any colour information as shown in Figure 1a. KinectFusion [2] is developed by Microsoft Research for building 3D scenes in real-time (see Figure 1b). It is similar to ReconstructME, while it depends heavily on GPU processing which is a demanding requirement for a web-based application. 3D scan 2.0 [3] provided a Linux based solution including three main libraries (libfreenect, OpenSceneGraph, ARToolKit) for developers to build their 3D scanner program (see Figure 1c).

Figure 1. Previous works of 3D scanning using Kinect. (a) ReconstructME, (b) Kinect Fusion, and (c) 3D Scan 2.0.

(a) (b) (c)

2.2. C2C E-commerce Web-sites

In current e-commerce market, the most of popular online auction website in the world is EBay; while Taobao is famous in Hong Kong and China. Existing system allows sellers to post their auction and related information forms of text or images alone. To promote the product, sellers usually have to acquire several pictures for their product so as to allow potential buyers to understand better the condition of the goods as shown in Figure 2. Our system, therefore, targets to evolve the way of presenting products with the latest 3D technologies.

Figure 2. Many pictures have to be taken from different views of the product when placing an auction.

3. Appoarch

Our system is divided into two main parts, one is for the creation of 3D model, and another is for the visualization of the 3D product on the web-based environment.

3.1. 3D Model Creation

Our system uses Kinect as the capturing device, which will output a set of point cloud from each view. However, to compose a full object, post-processing is necessary. As shown in Figure 3, three major steps are included in the main process: 1) model capture, 2) processing on point cloud and 3) point cloud registration.

Figure 3. Overview of steps in 3D model creation

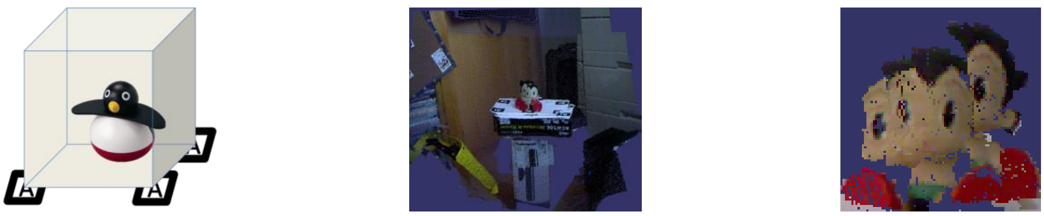
3.1.1. Model Capture

Capturing RGBD-data from Kinect is performed with the help of OpenNI SDK. Our system combines with marker-based tracking technologies brought from AR systems. As illustrated in Figure 4, markers are placed around the object to define effective region for scanning. Moreover, the markers will help in making a fast estimation of orientation of the scanned point clouds in the next step.

3.1.2. Processing on Point Cloud

A preliminary and fast processing of the point clouds will be performed based on the markers. First, we will use the markers for matching orientations of different point clouds. Therefore, we have a preliminary combined 3D object as shown in the Figure 4b. However, the result obtained contains background objects, so our next step is to remove points outside of the region enclosed by the markers. Point cloud resulted from the process can be reference to Figure 4c, which is still not well registered. Therefore, an iterative optimization is performed to obtain a more satisfactory result in next step.

Figure 4. (a) Markers are placed around the target object. **(b)** Result obtained after matching of marker orientation. **(c)** Point cloud left after background removal.



(a) **(b)** **(c)**

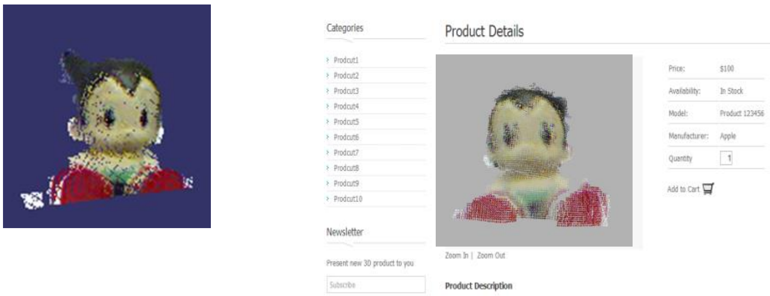
3.1.3. Point Cloud Registration

In this final step, Iterative Closest Point (ICP) [4] is used to further enhance the point cloud registration. It is an important and time-consuming process in 3D reconstruction because it has to combine thousands of points from the multiple frames into one single 3D point cloud.

As the name suggested, ICP is an iterative process to optimize the relative orientation between two point clouds. It has to start with a good initial guess in order to obtain a quality result. To improve robustness, a matching of feature points in the point clouds is first performed in order to obtain a better initial guess. Fast Point Feature Histogram is used as the feature descriptor for finding correspondence between feature key points. Furthermore, we uses RANSAC to effectively remove noise and outliners. To improve efficiency of the ICP registration, KDTree is employed to boost speed in spatial search.

After the point cloud registration, repeated points will remain in the overlapped regions. We have to remove those overlapped points based on the criteria that distance between repeated point pair is equal to 0. Finally, the point cloud data will be output as the pcd/asc format to save for display on the website. Figure 5a shows the registered result which is rather satisfactory for our purpose.

Figure 5. (a) Result after ICP registration. **(b)** Web interface for displaying scanned 3D product



(a) **(b)**

3.2. 3D Point Clouds and its Rendering

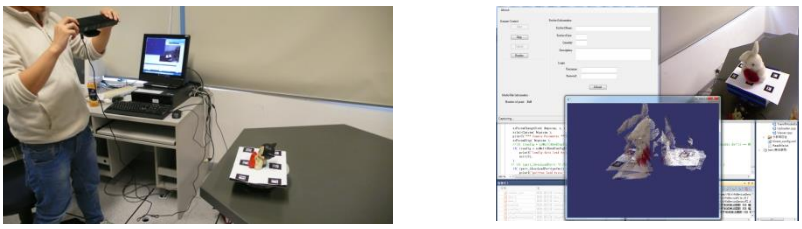
The stored point cloud can be directly used for display on the Internet. The latest WebGL technologies enable us to render 3D objects without 3rd party plug-ins. Figure 5b demonstrates the online platform visualizing the captured point cloud used in our experiment.

4. Results

4.1. Scanning System

We have built a prototype system with Intel i5-3.4GHz CPU to realize our idea. The scanning is done by manually moving the Kinect camera around the target object as shown in Figure 6a. The system will record every frame and its point cloud obtained and display on screen interactively as in Figure 6b.

Figure 6. (a) Configuration of our 3D scanning system. **(b)** User interface of the prototype system for 3D scanning



(a) (b)

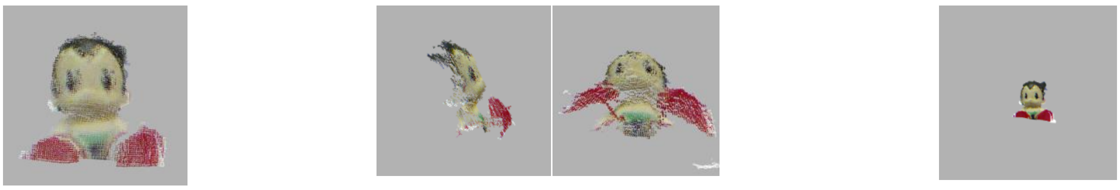
4.2. Scanned 3D Models

Three testing products are used in our experiments; they are the bunny, bottle, and Astroboy. The scanned results are list in a table in Figure 7. The post-processing time is around 1-3 minutes depending on the size of the model (the total number of points). The process can be further improved by optimizing some of the implements in the current prototype system. The scanned model can be freely rotated, zoom in and out within the web browser environment so as to view the object under different viewpoints as illustrated in Figure 8.

Figure 7. Experimental results of scanning. From left to right: bunny, bottle and Astroboy.

			
Number of total Points	98024	44560	10089
Number of frames	8	6	4
Processing Time	3mins	1.5mins	57sec
Number of Iteration	560	390	160

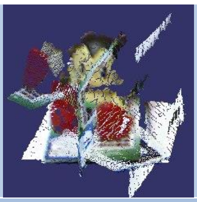
Figure 8. Control of viewing angle in the web browser.



Original Model　　Rotation　　Zoom out

The accuracy on the matched model will be affected by noise and the nature of scanned surface; therefore we tried to analyze and evaluate the accuracy under different conditions. The scanned results under three different environments are listed in the table in Figure 9. When symmetric surface exists, it can lead to incorrect matching of point clouds, because of the limitation on the curvature evaluation by PCA. When under strong light intensity, serious noise will be introduced to the infrared sensor in Kinect; so that it cannot capture enough depth data for 3D reconstruction. A better reconstructed result can be obtained when the surfaces contain clear 3D geometric features and the scanning does not suffer from noise.

Figure 9. Experimental results of scanning. From left of right: Astroboy and doll.

			
Environment	Symmetric	Strong light intensity	Non-symmetric
Minimized Error	0.003506	0.002230	0.002143

5. Conclusions

A consumer level 3D object scanning device has significant potential to evolve the current habits of e-commerce because of the portability, affordable cost and user-friendliness for C2C sellers to capture 3D geometry of goods for sale; instead of using traditional 2D images. On the other hand, low-cost 3D reconstruct techniques can be applied to other application areas such as modelling in animation production.

Conflicts of Interest

The authors declare no conflict of interest.

References and Notes

1. ReconstructMe. 2012. http://reconstructme.net/
2. S. Izadi; D. Kim; O. Hilliges; D. Molyneaux; R. Newcombe; P. Kohli; J. Shotton; S. Hodges; D. Freeman; A. Davison; and A. Fitzgibbon. 2011. “KinectFusion: real-time 3D reconstruction and interaction using a moving depth camera”. In Proceedings of the 24th ACM symposium on User interface software and technology (UIST '11), 559-568.
3. 3D Scan 2.0. 2012. http://vr.tu-freiberg.de/scivi/
4. Besl, Paul J.; N.D. McKay. 1992. "A Method for Registration of 3-D Shapes". IEEE Trans. on Pattern Analysis and Machine Intelligence (Los Alamitos, CA, USA: IEEE Computer Society) 14 (2): 239–256.