Embedded Photographic Tomography

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Abstract— **Tomographic imaging is a technique for reconnaissance of a cross-section of an inspected object without destruction and taken at a prior-known angle. Input data that were known as the projection are gathered by repeatedly capturing image through the object in a number of viewpoints. In this paper, we designed the embedded photographic tomography that can be used for a basic purpose. A number of digital cameras are attached on the rotating to capture a series of images around the object. This mimics a cone-beam projection. Here, its application is focused on the 3D modeling. In order to design the embedded system, Raspberry Pi is used as the main microcontroller that use for digital image processing in acquisition system. The Processing system will use projection data for reconstruction and 3D modeling process.**

Keywords— Image Reconstruction, 3D Rendering, Photographic Tomography

I. Introduction

Shape extraction is the first step of many 3D applications, including a 3D modeling, object recognition, and so on. To satisfy these applications, it requires an appropriate shape extraction method. Nowadays, several shape extraction systems are proposed, and each one is suitable for the limited range of applications. Some of those, including stereoscopy, laser range finder, structured-light projection, and shape from shading, will be reviewed here concisely. In the tomographic process, by directly replacing the projections of an object with the silhouetted photographs from sufficient viewpoints, one can acquire the pseudo cross-sections of an object, which means that only the outlines are correct, regardless to the internal regions [15]. Therefore, the photographic tomography could be inferred as the one of a shape extraction system capable of reconstructing the volumetric data of an object from the sequence of photographs taken around the object to provide the 3D model. Recently, there are many attempts to the design and construction of simulated small-sized tomographic system [9-11]. In this paper, we present the embedded photographic tomography system that mimics the medical computed tomography. The camera is installed on the rotating gantry to capture a series of image of the object. The advantage of the purposed is can be applied to 3D modeling of living small animal.

II. Cone-Beam Reconstruction Algorithm

The x-ray cone-beam process can be modified for 3D modeling. Rather than using the x-ray source, a light source is used instead. The reconstruction object is then the object 3D surface. In general, image reconstruction algorithm can also be classified based on the geometry of the beam into parallel-beam, fan-beam and cone-beam tomography. While the projection data for the parallel-beam tomography is a 1D vector, the projection data for the cone-beam tomography is a 2D array. The well-known algorithm for cone-beam tomography is called Feldkamp cone-beam tomography [13, 14]. The Feldkamp algorithm based on 3D filtered back projection. The generalized cone beam image reconstruction is expressed as follows:

$$f(x,y,z) = \frac{1}{2}\int_0^{2\pi} \frac{D_{SO}^2}{(D_{SO}-s)^2} R_\beta\left(\frac{D_{SO}t}{D_{SO}-s}, \frac{D_{SO}\tilde{z}}{D_{SO}-s}\right) d\beta \quad (2.1)$$

where $f(x, y, z)$ is a reconstructed volumetric data, R_β is the two- dimensional silhouetted projection, β is the rotational angle, D_{SO} is the cone distance from source to origin, (t, s) are the coordinates which are rotated from (x,y) by angle β.

III. Shape Extraction Process

Shape extraction process from series of photographs is important for reconstruct. This process begins with the capturing of images that we consider. This method responsibility for only outline of objects. Thus, segmentation process, thresholding, and others are brought up to change captured to binary image. Eventually, volumetric data can be using for 3D modeling. The process is shown in Fig. 1.

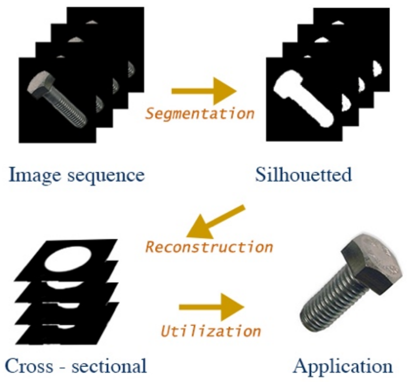

Fig. 1. The process diagram of the photographic tomography

IV. ACQUISITION SYSTEM

In acquisition system of embedded photographic tomography, we use 4 of cameras installed on the rotating gantry. The captured image of each camera will transmit to Raspberry Pi for use in digital image processing that includes of thresholding and segmentation before uploading to a cloud server. The image that uploaded will be download later for reconstruction and 3D modeling process. Rotation gantry camera will be controlled by Arduino microcontroller. When Arduino receives the command from Raspberry Pi that work with wireless, it will drive the mother to rotate one step. This system is shown in Fig. 2. The schematic diagram is shown in Fig. 3.

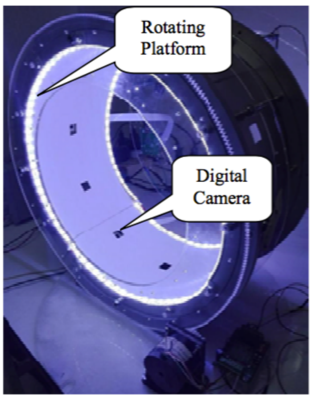

Fig. 2. Acquisition system of embedded photographic tomography

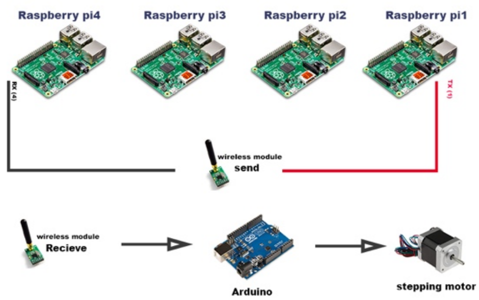

Fig. 3. A schematic of the system

V. EXPERIMENTAL AND RESULTS

An important factor for cone-beam reconstruction is the orientation of cameras toward objects plane. Ideal configuration of the 3D scanner is that the object image plane must be perpendicular to camera plane. To determine the orientation of the camera, we use a direct linear transformation [12] by taking a picture around a chessboard placed on an object plan where the center is in the middle of the scanner. The result of this orientation is defined from 0-90 degree rotation as shown in Fig. 4.

To test the embedded photographic tomography, we place the interested objects in the middle of rotating gantry. The rotation gantry is installed with 4 cameras. The objects then were captured from 4 cameras with an interval of one degree from 0 to 90. The sample of captured image was shown in Fig. 5 after performing image thresholding. After that, the image will be cropped to a size of 256 pixels that was reconstructed using cone-beam reconstruction program. The sample of cross-sectional images of the 3D volumetric data was shown in Fig. 6. Surface rendering technic is then performed in the volumetric data. The results are shown in Fig. 7.

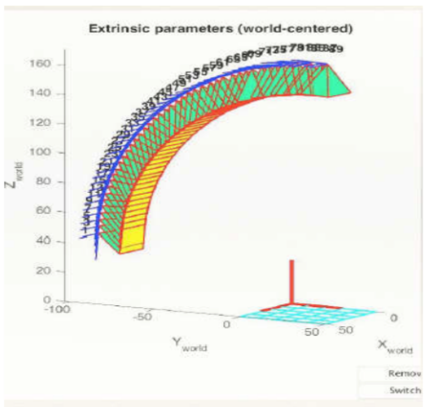

Fig. 4. Alignment of camera

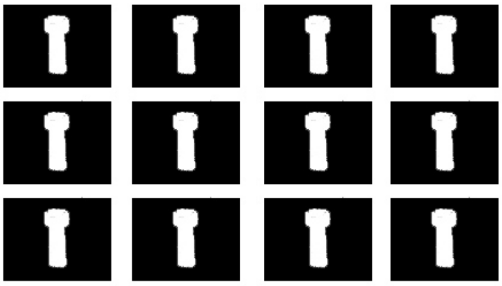

Fig. 5. 30 degrees sample of projection data of screw

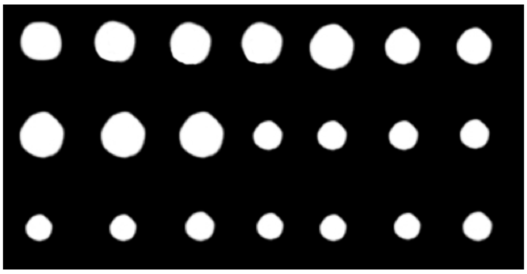

Fig. 6. Cross-sectional Image of screw

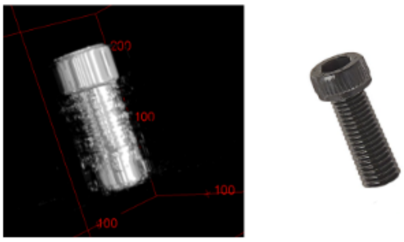

Fig. 7. Reconstruction Screw

VI. CONCLUSIONS

Embedded photographic tomography which shown in this paper. The main idea of the method is that the tomographic imaging is used to reconstruct the stack of pseudo cross-sectional images from a series of photographs taken around the object. The shape of the stack can closely resemble the shape of the original object. The system consists mainly of the rotating gantry that is installed with four digital cameras. The captured image of each camera will transmit to Raspberry Pi for digital image processing including segmentation and thresholding before uploading to a cloud server. The image will be later downloaded to a personal computer for reconstruction and 3D modeling process. This technique is a very satisfying technique for shaping images of objects that purpose in this paper is interested in.

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