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Design and Construction of a Device for Free Form Surfaces 3D Reconstruction Using Microsoft Kinect

Dr. Tahseen F. Abbas[1], Dr. Ali Abbar. Khleif[2], Dr. Hameed S. Ismael[3]
*[1]Production and Metallurgy Engineering. Department, University of Technology-Iraq, Baghdad Iraq
[2]Production and Metallurgy Engineering Department, University of Technology-Iraq, Baghdad Iraq
[3]Civil Engineering Department, University of Technology-Iraq, Baghdad Iraq

ABSTRACT

There is an increasing need for geometric 3D reconstruction models in the Reverse engineering which is ones of computer Vision applications, reconstruction from a sequence of 2D images is much cheaper than 3D scanners and coordinate measurement machine and also been able to take advantage of the developments in digital cameras and the increasing resolution and quality of images. This work aims to develop a concept of 3D free form surface reconstruction rig and generate the dimension of the surface depending on proposed image processing technique. Through the results obtained is observed that. The overall of calibration accuracy the Root mean square (RMS) value of the point was produced the residuals value in the image space was (0.2830 mm) in the IR images.

Keywords : Range Camera, IR Sensor, Stepper Motor, Imaging, Arduino and Matlab

I. INTRODUCTION

Reverse Engineering (RE) plays a fundamental role in industrial Computer Aided Engineering systems (CAE). With RE, objects can be digitized, three dimensional (3D) reconstructed and assimilated as computerized models. Digitizing systems in RE are founded on three major technologies

a) Coordinate measuring machines (CMMs).
b) 3D laser scanners.
c) Digital photogrammetry systems.

A. A contact measuring instrument such as plumb-line is used. Since this method is adequately strong and accurate, it is generally used to sample points as part of the RE process. However, its advantages are highly diminished by the slow rate of data taking. In increased, the object's surfaces may be superfine or adaptable and require non-contact measurement . Figure (1-1) illustrate a coordinate measuring machine..

Figure 1: CMM [1]

B. Laser-based range sensors are non-contact sensors and therefore are very rapid. The scanned data give straightforward 3D points from that a 3D model can be reconstructed. However, the 3D data generated by 3D laser scanners is not appropriate for direct integration in CAD systems: the scanned data is irregular and sprinkled and requires heavy processing in order to rebuild the surface of the object. Laser scanner systems provide a massive amount of digitized point data, therefore requiring a time- exhaustion data lowering process. In order to get better 3D reconstruction processing, some scanned systems provide range image instead of scattered points. A sampled surface (z) function of (xy) is represented as a 3D image where each pixel contains a height [1,2]. Figure (1-2) illustrate a laser scanning.

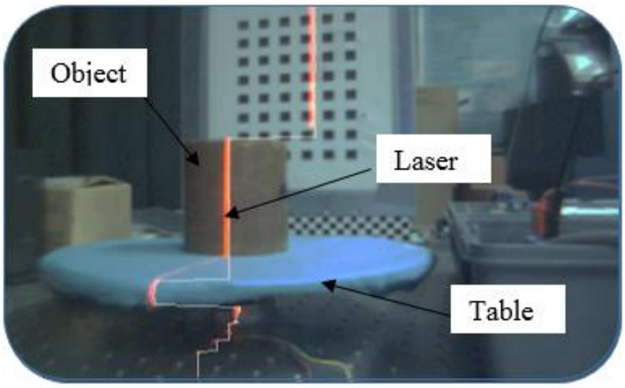

Figure 2: Laser scanner [2]

C. Digital Photogrammetry Systems

3D models are reconstructed from an arrangement of 2D pictures. Utilizing a triangulation strategy, the scope of focuses in the scene can be figured by applying a coordinating procedure. This procedure, in any case, is tedious and experiences merging issues. The data is not finished since a few focuses are not "seen" in both pictures. In addition, when different pictures are utilized, camera adjustment is expected to rectifying geometric mistakes and to representing the camera parameters. PC vision procedures can be connected to range of images alone to gather geometric and topological structure, yet precision issues happen on the limits [1,4].

II. EXPERIMENTAL WORK

In this proposed 3D reconstruction technique the shape and dimension of the lasted object are captured and separated with a specific end goal to get duplicate of the same objects and creating information that can be utilized for several engineering applications.

The Adopted rig included implementation of measurement rig based on image processing technique to get measured data of the existing objects. The calculated circular path of specific camera and definite the distance between the engineering part who want to measure and the camera are main items to be studied to have accurate results with assume the other parameters are constant like lighting system. The measurement system was built, and some parts were manufactured in this work. After system assembly, tests and calibrations were carried out to obtain the system performance and results. Figure (1-1) illustrate the Adopted rig.

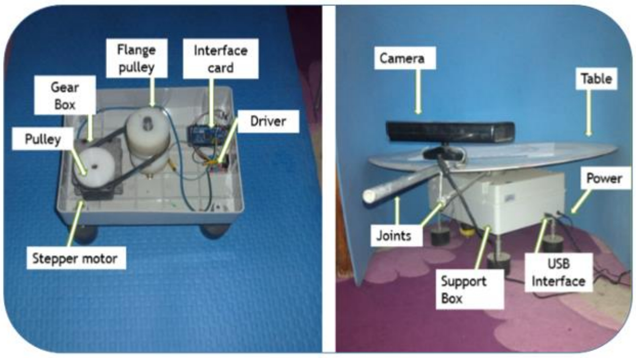

Figure 3: Adaptive System

III. IMPLEMENTED THE RIG

The adopted rig consist of asset of subsystems and there subsystems in turn consist of a set of parts as illustrated in figure (1-2).

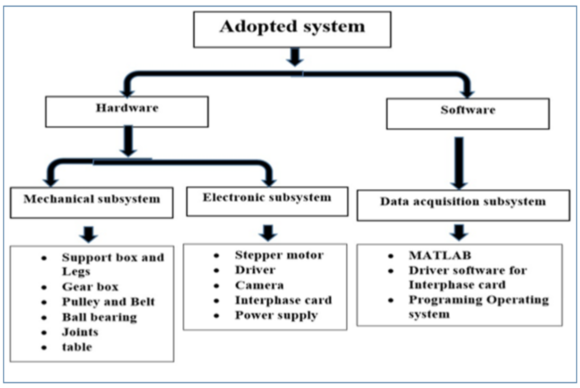

Figure 4: adopted instrument parts

A. Code for rig operation

The block diagram shown in Figure (4) illustrate the steps of programs work

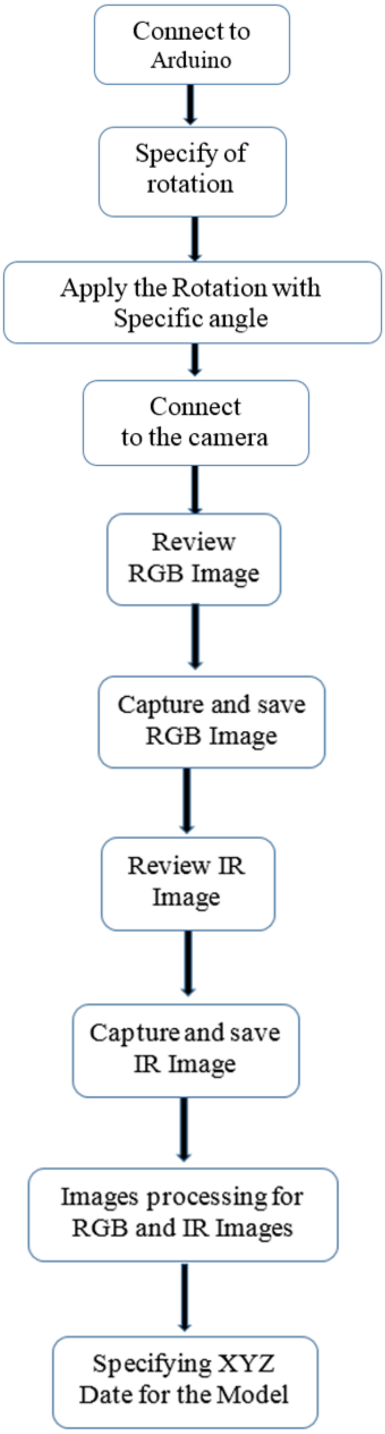

Figure 5: Flow chart

IV. RESULTS AND DISCUSSION

An accurate stepped objected has been machined using CNC milling machine with predefined dimension to be used as a tested object to calibrate the adoptive instrument . Figure (1-4) illustrated the tested object front and side view of the tested first part

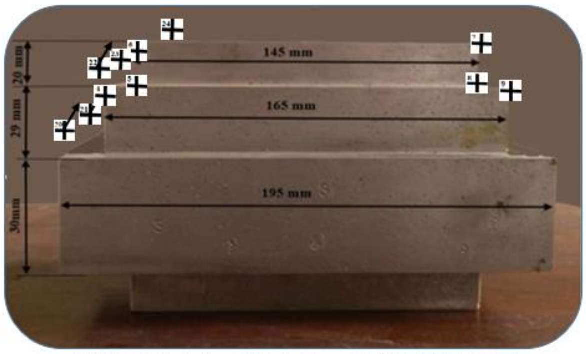

Figure 6: front view of the tested part with control point

Table 1. Control Point of the First Tested Part

CP	X(mm)	Y(mm)	Z(mm)
1.	100	100	100
2.	100	130	100
3.	115	130	115
4.	115	159	115
5.	125	159	125
6.	125	179	125
7.	170	179	125
8.	170	159	125
9.	180	159	115
10.	180	130	115
11.	295	130	100
12.	295	100	100
13.	295	100	195
14.	295	130	195
15.	180	130	180
16.	180	159	180
17.	170	159	170
18.	170	179	160
19.	100	100	195
20.	100	130	195
21.	115	130	180
22.	115	159	180
23.	125	159	170
24.	125	179	170

Table 2

listed the RMS value of each IR images of first tested part, and figure (7) indicates the residual value in all capturing IR images of the first part.

Image No.	angle (◦)	RMS (mm)
1.	0◦	0.0057
2.	45◦	0.0048
3.	90◦	0.1216
4.	135◦	0.1690
5.	180◦	0.4700
6.	225◦	0.0339
7.	270◦	0.1735
8.	315◦	0.3906

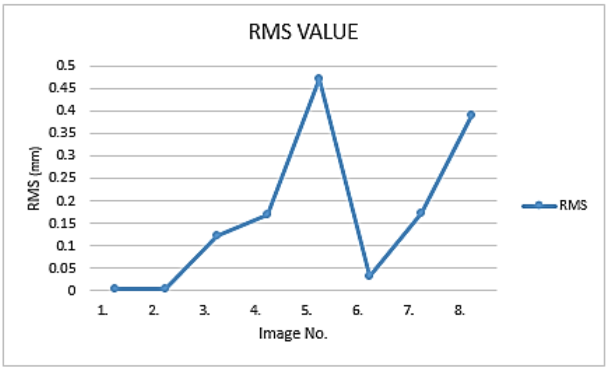

Figure 7: The Residuals value in all capturing IR images of the first tested part

Through the results obtained is observed that .The overall of calibration accuracy the Root mean square (RMS) value of the point was produced the residuals value in the image space was (0.2830 mm) in the IR images. that is mean the error in 3d reconstruction was (0.2830 mm) in total length.

V. CONCLUSION

3D models Reconstructing from existing part is a prime issue in numerous computer vision research like Pattern recognition, Reverse engineering and Industrial investigation. The automatic instrument for creating 3D models was implemented. In this 3D Reconstruction technique the shape and dimension of object are captured and separated with a specific end goal to get a duplicate of the same part in this manner creating information that can be utilized for CAD/CAM purposes.

From the results of this research the following most conclusions can be listed.

1. The adapted 3D reconstruction instrument is a low cost portable compound Comparison with not portable alternative expensive laser scanners (LS) and Coordinate measuring machines (CMMs) in 3D reconstruction and measurement application
2. The cloud point of the properly was calibrated Kinect sensor camera did not contain large systematic errors.
3. The IR camera didn't effect with how much light in room when the captured images hence the 3D reconstruction and measurement instrument work in any condition didn't required tough light condition and we could classified the images
4. The value of error of depth data measurements has been increases quadratic with increasing distance from the camera.
5. The 3d reconstruction instrument didn't effect with how much Wight of the object because the table didn't have any movement
6. There is limitation of the object size for this instrument the size should not exceed 500 mm circle diameter
7. 7. The density of extracted points would be decreases with increasing the distance to the camera. It is influencing factor of the depth image resolution.

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