A MOBILE 3D SCANNER INTERFACE FOR INDOOR SCENE UNDERSTANDING

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ABSTRACT: *Scene reconstruction has been proven to be beneficial in assisting various applications such as in 3D as-built development for Building Information Modelling (BIM), crime scene understanding and mapping of an environment for a mobile robot. With the availability of various 3D scanners in the market recently, the task of data gathering representing a scene has become straightforward. However, the accompanying interfacing may not be adequate to allow users to understand the scene, furthermore, not all software are capable to open and process the data obtained from a 3D scanner, and some requires a lengthy programming to be performed. This project concentrates on the development of an interface to complement a mobile 3D scanner in understanding indoor scenes. The developed interface is capable to show the real scene with its respective depth information, in addition to perform basic measurements needed in scene understanding. Upon validating the results with real measurements from a laser range finder, the depth model shown high accuracy readings. Thus, it is hope that the interfacing could be used in accompanying any 3D scanner for indoor scene understanding.*

Index Terms: 3D scanner interface, mobile , 3D scanner, indoor scene understanding, Structure sensor**.**

I. INTRODUCTION

3D scene understanding and reconstruction has been a dynamic research area for quite a few years. Compared to 2D data representation, 3D modelling and interpretation is preferred as it provides clearer visualization [1]. Various approaches, apart from the usage of specialized 3D sensor, can be utilized in gathering data to develop 3D scene. Methods such as stereo images and photogrammetry could also be adapted, however they might have limitations in handling occlusions and clutter [2]. Due to the advancement in sensor technology, various sensors are now capable to gather depth and 3D information like a laser-based and light-based scanner [3].

3D reconstruction is useful in various applications such as for BIM, AEC/FM (Architectural, Engineering, Construction / Facility Management), mobile robotics, forensic investigations, mining, geology and archaeology [4], [5]. Nevertheless, due to its nature of data in 3D, not all software are capable to process it, therefore there is a need to have a suitable software interfacing that able to process and display the data, especially in understanding and reconstructing 3D scene.

This paper concentrates on the development of a computer interfacing to display and process 3D indoor scene data. This is crucial especially when to convey respective information regarding the scene to the people who were not at the scene themselves. It focuses on the usage of a hand-held 3D scanner called Structure sensor to capture and documenting the information representing the scene. Although the sensor comes with its own application called Scanner, it only allows viewing the collected data and doing instant basic processing on its grayscale-depth data and thus, this may not be enough for scene understanding and to produce higher accuracy scene modelling.

This paper is organized as follows – Section II will focus on the 3D scanner and Section III highlights on the developed interfacing. Section IV covers some analysis on the results and will conclude in Section V.

II. 3D SCANNER

Scene reconstruction is one of the most highly complex activities where the development of the techniques and methods should have the capability to reconstruct missing elements, to get measurement in all dimensions, and easily generated images which can be interpreted by the third party people (people who do not have access towards the scene). Thus, an appropriate 3D scanner should be used to gather the information representing the scene.

The advantages of 3D scanning over conventional photography include the potential to generate accurate, reproducible measurements from the 3D data and the ability to reconstruct missing elements [6]. Scanner works either using laser to precisely capture 3D shape using triangulation or using structured light [3]. This project concentrates on the usage of a structure light-based scanner called Structure sensor. It is known as a mobile Structure Light System (SLS) that utilizes infrared sensor to capture 3D details of an object. Figure 1 shows a Structure sensor and Table 1 summarizes the sensor’s technical specification.

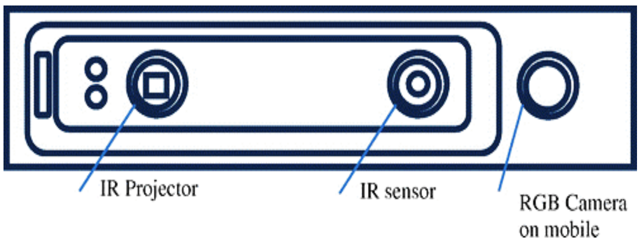


Figure 1: Structure sensor configuration [7]

Table 1: Technical specification of Structure sensor [8]

Dimension	119.2mm x 27.9mm x 29mm
Weight	95g
Resolution	VGA (640 x 480), QVGA (320 x 240)
Framerate	30 / 60 frames per second
Field of view	58 degrees (horizontal), 45 degrees (vertical)
Range	3.5m+ (maximum), 40cm (minimum)
Precision	0.5mm at 40cm (0.15%), 30mm at 3m (1%)

III. METHODOLOGY

In order to develop a suitable interfacing for the sensor, several steps are taken to ensure appropriate, suitable outcome. MATLAB software is utilized to develop the interfacing as it could read 3D data.

A. Data Collection

The 3D data representing indoor scenes are first captured using Structure sensor. The sensor is mounted to an iPad using a special bracket developed by the manufacturer for a secure attachment (refer to Figure 2 for more details). By using its SDK application (Scanner), a variety of scenes were collected, including small room, meeting room, and bigger room like a laboratory. This will ensure that the interface will be able to display and process the data later on. Figure 3 shows the sample of data collection process.

Figure 2: Structure Sensor attached with an iPad which is ready to be used (Source: Structure by Occipital, https://structure.io)

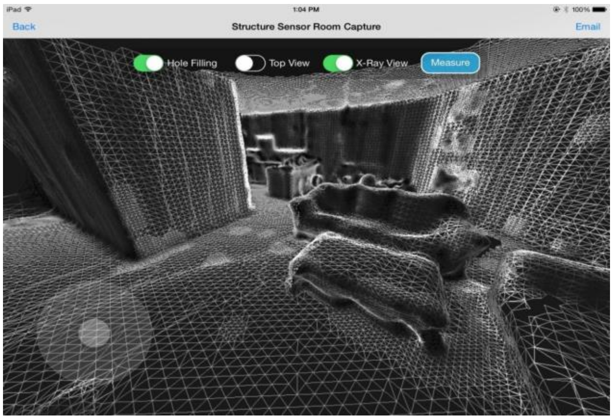


Figure 3: A sample of data collection process – application only allows instant processing (Source: Structure by Occipital, https://structure.io)

B. Data Processing

The Structure sensor produces 3D data and scene textures in .obj and .mtl files, as well as accompanying .jpg file. Upon further investigation, several processing are needed to be performed before the correct model can be displayed. Figure 4 shows the block chart of the overall processes done.

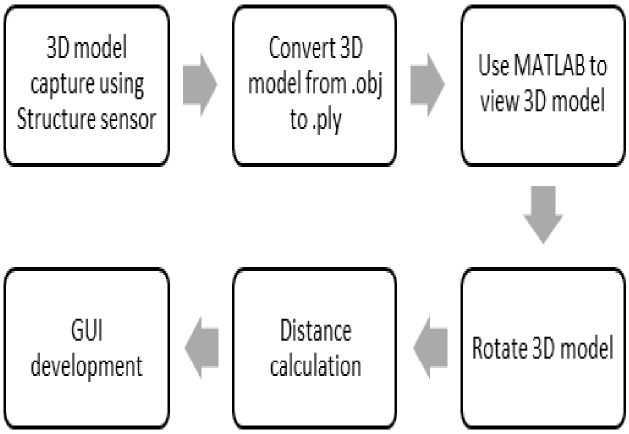
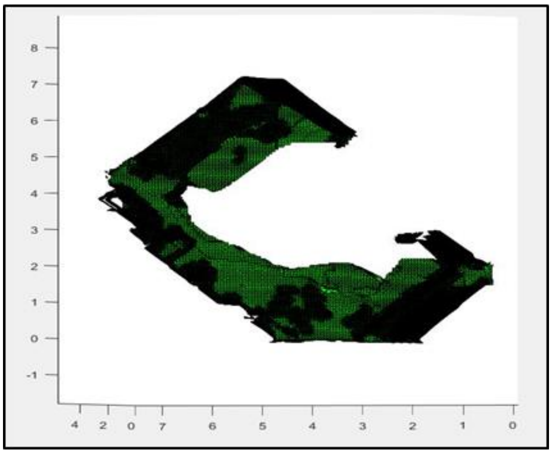


Figure 4: Process in developing the interface from Structure Sensor indoor scene data

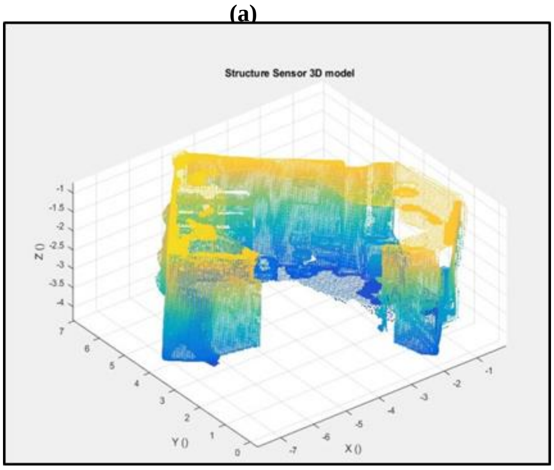
After the scene has been captured, the .obj file needs to be converted into .ply as the original results did not show any significant information representing the scene. Figure 5 shows a sample of .obj plot as well as its respective .ply plot. It could be seen from here that the .ply plot could display more information. Then, the data needs to be rotated correctly as current view of the data is upside down. This is due to an orientation issue during data collection using the iPad [9]. Then, suitable processing like distance calculation can be embedded to make the interfacing more beneficial. In here, Euclidean distance equation as in (1) is used to perform the measurement:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (1)$$

where: d = Euclidean distance
x_1, x_2 = points between two objects for x-axis
y_1, y_2 = points between two objects for y-axis



(a)



(b)

Figure 5: (a) An .obj plot of an indoor scene and its .ply plot shown in (b), which is clearer and ready to be processed

C. The Developed Software Interface

Figure 6 shows the final developed interface with its respective results. To make it more user friendly, load buttons are allocated to allow users to choose the appropriate data to be displayed and processed. As can be seen from here, the 3D model and its original scene in image were displayed side-by-side as a comparison to develop more understanding towards the scene. Basic operations like rotating and zooming can be performed towards the model and image. Processing like measurements of respective items can be done by allowing user to click on the respective points and the interface will calculate and display the distance. Figure 7 shows a sample of measurement that has been done using the developed interface.

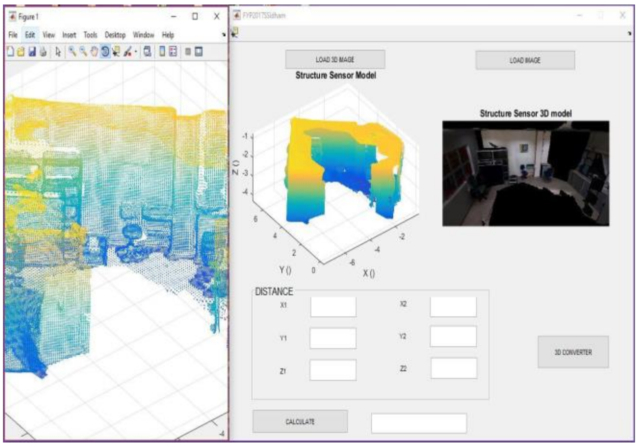
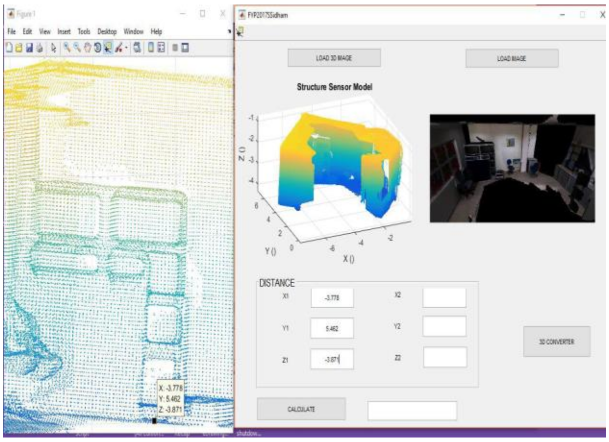
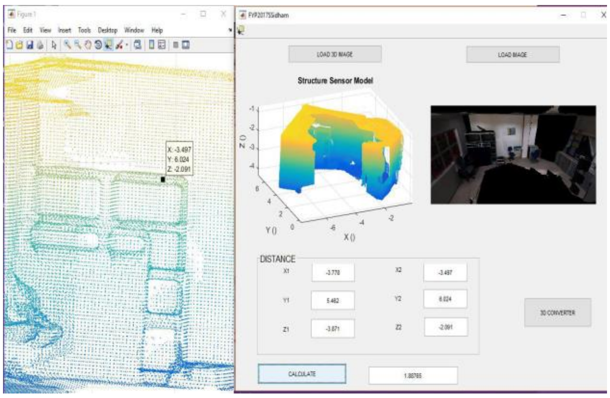


Figure 6: The developed interface



(a)



(b)

Figure 7: Using the interface to measure the height of a cabinet inside the room: (a) selection of initial / starting point, (b) location of end point, and distance is measured and shown

IV. ANALYSIS OF RESULTS

To ensure the correct measurement and modelling has been done, basic analysis is done towards the results obtained from the interface. Table 2 summarizes the measurement taken from the model and comparison with the real measurement from a digital laser measure with 2.0 mm accuracy [10]. Error is calculated using (2):

$$error = \left|\frac{actual - model}{actual}\right| \times 100 \qquad (2)$$

Table 2: Error calculations of actual and model measurements

Item	Actual dimension (m)	Model dimension (m)	Error (%)
Height of chair	0.970	1.01347	4.48
Height of cabinet	1.832	1.88765	3.04
Average of error (%)			3.76

As can be seen from Table 2, the average of error produces by the model is 3.76%. The error is most probably come during the selection of points in determining the measurement of the item. Thus, proper selection of points needs to be done to ensure correct and accurate measurement. However, the error is small compared to the dimensions and thus, the final interface and results can be accepted.

V. CONCLUSION

This project has successfully developed an interface that could process 3D data in understanding indoor scene. It has utilized the usage of Structure sensor to collect the data, and based on the characteristics, it could also be used to process similar data collected by other 3D sensors as well like Kinect. More features can be added to make it more beneficial to be used, so that related professionals can adapt this for various applications in BIM, AEC/FM and in forensic investigation, to name a few.

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