Object Replica using 3D Scanner

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Abstract- *This paper explains the concept of 3D scanner built in the 3D Printer using sharp proximity sensor with low implementation cost. 3D scanner is a device that analyse a real world object to collect data on its shape. Then collected data can be used to construct digital 3D Models. It gives complete idea about 3D image construction using Atmega Microcontroller as a gateway between Sensor and MATLAB software .The sharp proximity sensor gives distance information to the microcontroller at every section of time. Microcontroller converts the analog output of sensor into digital and stores it to the SD card for further process in MATLAB software on the PC. Microcontroller controls the motors in the structure of 3D scanner. The reconstruction of 3 dimensional image of the object can be done using rendering tools.*

Keywords- 3D scanner, Matlab, Data Acquisition, Slic3r, Arduino Pro Mini

I. INTRODUCTION

A 3D scanner is a device that analyse a real world object or environment to collect data on its shape & possibly its appearance (i.e. colour). The collected data can then be used to construct digital 3D models. Many different technologies can be used to build these 3D scanning device, each technology comes with its own limitation, advantages and costs 3D modellers were united in their quest for scanner which was i)accurate ii)fast iii)Truly 3D capable of capturing colour surface iv)realistically period. A well-established classification is divided into two types: 1) contact and 2) non-contact 3D scanners. Non-contact 3D scanners can be further divided into two main categories.1) active and 2) passive. There are varieties of technologies that fall under each of these categories.

1) Contact techniques:-
Techniques used: - Traditional Co-ordinate Measuring Machine (CMM). This scanner probes the subject to physical touch. This device is used for measuring the physical, geometrical characteristics of an object. It is used mostly in manufacturing and can be very precise.

Disadvantages: - it required contact loop the object begin scan. Thus the act of scanning the object might modify or damage it. This fact is very significant when scanning delicate or valuable objects such as historical artifacts.
2) Non-contact techniques:-

Non-contact techniques 3D scanners do not make physical contact with an object surface. The end result is highly accurate cloud of point that can be used for reverse engineering, virtual assembly engineering analysis, feature and surface inspection or rapid prototyping.

a) Non-contact active:

Active scanner emits Some kind of radiation or light and detect its reflection in order to produce an object or environment. Possible type of emission used includes light, ultrasound or x-ray.

Categorization:

1) Time of flight: It is an active scanner uses laser light to probe. At the heart of this type of scanner is time of flight range finder. Laser range finder only detects the distance of one point at the time. It can measure the distance of 10,000-100,000 points every second.

2) Phase shift: This works by comparing the phase shift in reflected the laser light to standard phase which is also captured for comparison similar to time of flight except that the phase of reflected laser light further refines the distance detection

3) Triangulation:-It is quite similar to time of flight. This technique is called triangulation because of the LASER; dot camera and laser emitter from a triangle it uses a Pythagoras theorem.

a) Non-contact active scanner

1) Conoscopic holography
2) Structured light
3) Modulated light
4) Volumetric technique

b) Non-contact passive scanner: - This scanner does not emit any kind of radiation but instead relay on detecting reflected ambient radiation. They do not need particular hardware but

simple digital cameras. 1) Video scanner 2) Photometric 3) Image based modelling scanner

3D scanner is very analogues to camera. While camera collects colour information about surface within its field of view, a 3D scanner collects distance information about surface within a field. Here we are using non-contact active scanning for the subject:-'**Analysis of object using 3D scanner and replication of an object, using 3D scanner and printer**'. Here we are using IR sensor instead of laser to measure the distance. From 3 optical technology viz. Point, area, strip we are using point optical technology.

II. LITERATURE SURVEY

3D scanning is the technology used to scan the real world objects to obtain its shape, size and other features. This is a demonstration of how to design a 3D object scanner which scans the real world objects generates highly accurate images giving information of each and every points of the object and plots it on the computer screen.

Infrared sensor based 3D image construction [1] proposed by Athira K R, Aiswarya S Nair, Haritha S, Krishnapriya S Nair, Riji Mary Thomas, and Priyalakshmi S. The sensors are controlled using a PIC micro controller which obtains the data measured using sensors and will transmit it to the PC serially for plotting the 3D image of the object using MATLAB software. The data acquired by the IR sensor should be accurate to obtain the correct data and for that the distance is set to 5 cm. The data obtained are transmitted and plotted without any delay. The paper aims at developing a low-cost prototype of a 3 dimensional scanner, which can scan real world objects and plot it on a computer screen. This kind of scanners will be of useful in the research, design, manufacturing fields.
[2] Explains that at accurate estimation of the pose of a close-range 3-D modelling device in real-time, at high-rate, and solely from its own images. In doing so, we replace external positioning systems that constrain the system in size, mobility, accuracy, and cost. At close range, accurate pose tracking from image features is hard because feature projections do not only drift in the face of rotation but also in the face of translation. Large, unknown feature drifts may impede real-time feature tracking and subsequent pose estimation.

Siti Asmah Daud [9] proposed an infrared sensor rig in detecting shapes which measure the distance. Between the sensors and the object placed at the centre of the plate. The data received will be fully controlled by Arduino microcontroller and then sensors send to the MATLAB software to reconstruct the image of the object based on the values obtained. The proposed system uses a set of five sensors which is installed in the shape of a pentagon. The movement of the sensors will be controlled by the Arduino microcontroller and the data obtained will be stored .It is then used to plot the images in the MATLAB software. Another 3D geometry using IR sensors proposed by Tar [3] uses IR sensors and IR emitters to measure the distance and creates 3D mono-graphic geometry of the sensed objects in this system the LEDs and photo- transistors are used. The resolution of the object's heights, orientation and distance will be very low but have a large sensing area of about 1m and it can be increased depending on the application.

G.Benet [4] proposed a system using IR sensors for distance measurement. Here the amplitude response of the sensors depends on reflected ray‟s amplitude and reflectance characteristics of the object .In this system the IR sensors are used in mobile robots which will be very attractive for enhancing real time operation .Here Benet also describes about the intensity of the back scattered light from objects and it is capable of measuring distances up to 1 m. [5] proposed system from 3D scanning to 3D printing in fashion industry. For acquiring a high level of details (LOD), firstly the procedure used is to have 36 photos by rotating the platform of 10 degree, while maintaining the full object in focus at any viewing angle. Then having as much as possible close up photos depending on the geometry of the object. The texture image generated by the reconstruction algorithm of Agisoft™, is used as displacement map for transforming the 3D model into a high resolution geometry detail as accurately as possible printing. It is possible to export directly the file in STL format if the desired results are achieved by the scanning, but in most of the cases it needs to be processed for advance modification and preparation of file. For these purpose ZBrush™ software was used even for the modification of the file and for applying the displacement map. Exported the 3D jewellery model as .STL file, enables the slicing software CURA™ for 3D printing. Fused deposition modelling (FDM) is used as prototyping technology to produce the replica of the object. [6] describes about performing PSSRT systems a precise 3D digital model can be achieved in the sub-millimeter feature. The digitized and the produced data indicate that the use of close-up lenses, light setup scene and appropriate hardware can give outstanding achievement of small object digitalization. The use of FDM technique gives the possibility to create scaled object and replicating for different needs. Achieving more details during the scanning process, efforts need to be done to improve the stability of hardware by electronic micro-steeper control units for three axes. Also, the use of Stereo lithography (SLA) can print with higher resolution the scanned objects. [7] this paper explains proposed algorithm for object detection using image processing and manipulation of the output pin state of Arduino board with Atmega 8 controller by tracking the motion of the detected objects. The object detection algorithm has been developed on Matlab

platform by the combinations of several image processing algorithms. [8] presented new techniques for passive ranging with a dualband IR search and track IRST sensor aboard a ship. Three distance estimation methods are described: the atmospheric propagation model, the apparent surface of the target, and target motion analysis ıTMA. These methods are tested on the sensor output of real data during cold water trials ıCWTs. They are evaluated by comparing with simultaneously obtained radar reference data at the test site. Results of these three passive ranging and three fusion processes, combining the preceding methods, are presented.

III. SYSTEM MODEL

The 3D object scanner consist of basically two parts (i) the embedded part and (ii) MATLAB part. The embedded part consists of the hardware components which are used for three dimensional scanning. This embedded part consists of microcontroller, stepper motor along with turntable and threaded rod to move the object to be scanned and the sensor for effective scanning of the object in three dimensions, stepper motor driver, distance sensor. The microcontroller will act as the overall brain of the system which controls the motor controller for the proper working of the motor. Micro controller also receives the distance measured by the distance sensor as analog voltage; the analog to digital pins of the micro controller converts the analog data values to digital data. The converted digital data is then transferred to the PC for plotting a three dimensional image of the object using MATLAB. Distance sensor used here is a reflective type sensor, which transmits the signal were it reflect back after striking the obstacle, the received light or sound is measured in terms of voltage and this analog voltage is then converted to digital voltage and then transferred to the PC for plotting 3D graph. Motor Controller used has to carrier board or breakout board for Allegro's A4988 DMOS micro stepping driver with Translator and Overcurrent protection. A stepper motor is used to rotate the turn table in steps so that the object is rotated in 360 degree and threaded rod vertically from the bottom to top of the object..

IV. WORKING

The concept of the Object Replica 3D scanner is to measure the distance of different parts of the object to be scanned from a scanner sensor. The mechanical structure is built to the platform of a 3D Printer. In this structure it consists of a turn table, which can rotate 360 degrees and replaces the heat bed of 3D Printer, on which the object to be scanned will be placed. The hot end module is replaced by the scanner sensor GP2Y0A21YK0F on the 3D printer. There are two main sections for the system- the embedded system section and the PC section. The embedded system section is built around an Atmega32U4 microcontroller. The sharp scanner sensor GP2Y0A21YK0F is connected to the microcontroller, which gives the distance between the sensor and any obstacle facing it.

Initially, the sensor will be facing the bottom edge of the object. The distance sensor gives the distance information to the microcontroller, which stores this data to the SD card. Then SD card connects to PC and run the MATLAB application in the PC for plotting the data graphically. As rotation starts, distance measurement is done and plotting is done accordingly at every step of rotation. After one complete rotation, the vertical rod rotates to move the distance sensor upward. The entire process is repeated, till the top end of the object under scanning is reached. Now the PC will be having the Three Dimensional information of the object and this will be plotted by MATLAB, using 3D rendering toolkits. The microcontroller and SD card is used as gateway to the PC from sensor. The microcontroller is programmed in embedded c and the controller is programmed for controlling the motor controller and to obtain the data sensed by the IR sensors at each point of time. The obtained data from sensors is in the form of analog values which is converted into digital values by the microcontroller. Then data is storing it into ASCII values and stored in the SD card. To reconstruct the 3D image of the object, we filter edges in MATLAB software. MATLAB software is used to store the data which is serially transmitted by the microcontroller as a matrix and are plotted using 3D rendering tools. This process takes place without any delay as the data is transmitted continuously and image is constructed as soon as the data is received by the MATLAB software. Thus, if any interruption occurs in between if have to restart the scanning process. The stepper motor rotates at a fixed angle and rotates till 360 degree for each n degree rotation the sensors obtain distance variation and sends continuously to the microcontroller and on the other hand both the sensors will also initiate movement to obtain various points of the image and thus to make the plotted image accurate and relevant.

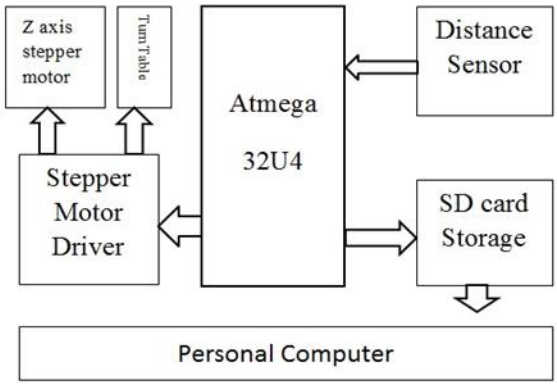

Fig.1. Block Diagram of Hardware Part

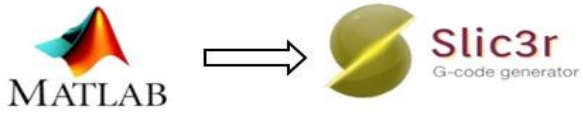

Fig.2. Block Diagram of Software Part

Hardware Part

Arduino Pro Micro

Microcontroller Used: Atmega32U4
Maximum Current for Chip: 200mA
High Speed PWM with programmable resolution from 2- 11 bits.
As it requires low input power, power consumption is less. We require microcontroller only for scanning purpose and controlling stepper motors.

A3967SLB stepper motor driver

It is designed to operate bipolar stepper motors in full-, half-, quarter-, and eighth-step modes, with output drive capability of 30 V and ±750 mA. The A3967SLB includes a fixed off-time current regulator that has the ability to operate in slow, fast, or mixed current-decay modes. This current-decay control scheme results in reduced audible motor noise, increased step accuracy, and reduced power dissipation.

GP2Y0A02YK0F sharp sensor

The variety of the reflectivity of the object, the environmental temperature and the operating duration are not influenced easily to the distance detection because of adopting the triangulation method. This device outputs the voltage corresponding to the detection distance. So this sensor can also be used as a proximity sensor.
Features:
1. Distance measuring range : 20 to 150 cm
2. Analog output type
3. Consumption current : Typ. 33 mA
4. Supply voltage : 4.5 to 5.5 V

TF card shield

It allows us to add mass storage and data logging to our project. This module uses the standard SPI interface for communication, which involve SPI buses, MISO, MOSI, SCK, and a CS signal pin. through programming, the data can easily be read and wrote into SD Card by using the Arduino or other microcontrollers.

Software

MATLAB R2013a

Matlab is for post processing on analog values taken by the sensor. This is to filter the regenerated 3D model.

Slic3r

The 3D model generated by Matlab is in the form of stl format (Stereo lithographic format). For 3D printing we need gcode file. For conversion from stl to gcode file we use this software.

V. APPLICATIONS

1) Construction industry and civil engineering
- Quality control
- Quantity surveys
- Documentation of historical sites

2) Design process
- Increasing accuracy working with complex parts and shapes
- Coordinating product design using parts from multiple sources.

3) Entertainment
- 3D scanners are used by the entertainment industry to create digital 3D models for movies, video games and leisure purposes.

4) Law enforcement
- 3D Models are used for on-site documentation of Crime scenes
- Accident reconstruction
- Bombings
- Plane crashes

5) Reverse engineering
- Reverse engineering of a mechanical component requires a precise digital model of the objects to be reproduced.

6) Cultural heritage.
- Scanning of historical sites and artifacts both for documentation and analysis purposes.

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