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3D Scanner Using Arduino Nano

Ch. S. L. S. Uma Bhanu[1], G. Gnanendra Kumar[2], K. Vijaya Lakshmi[3], G. V. V. Siddi[4], B. Pavan Kumar[5], E. Manenna[6]

[12345]UG Students,[6]Assistant Professor, Department of ECE

N.S. Raju Institute of Technology, Sontyam, Visakhapatnam, A.P, India

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ABSTRACT

This project presents the design, implementation, and evaluation of a low-cost 3D scanner utilizing Arduino Nano microcontroller technology. The proposed 3D scanner aims to provide an accessible and affordable solution for capturing three-dimensional objects with reasonable accuracy. The system employs structured light methodology, where a structured pattern is projected onto the target object, and the resulting deformations are analyzed to reconstruct the object's geometry. The hardware architecture revolves around the Arduino Nano, a compact and versatile microcontroller, which interfaces with a camera module and a laser module for structured light projection. The Arduino Nano efficiently controls the synchronization of the structured light pattern and the image capture process. Additionally, an open-source computer vision library is utilized for image processing and depth map generation. The software pipeline involves the calibration of the system for optimal performance and accuracy. The structured light pattern is projected onto the object, and images are captured by the camera. The captured images are processed to extract depth information, enabling the reconstruction of the object's 3D model. The resulting point cloud data can be further refined for improved accuracy .The performance of the 3D scanner is evaluated through experimentation with various objects of different shapes and sizes. The accuracy, resolution, and scanning speed of the system are analyzed to assess its practical usability. The developed 3D scanner demonstrates its capability to generate detailed and accurate 3D models, making it suitable for applications such as rapid prototyping, reverse engineering, and educational purposes .In conclusion, this paper presents a cost-effective 3D scanning solution using the Arduino Nano, making 3D scanning technology more accessible to a wider audience. The system's affordability, coupled with its ease of use, positions it as a valuable tool for hobbyists, educators, and small-scale industries seeking an entry-level 3D scanning solution.

Keywords: Arduino Nano, Sharp IR Sensor, SD card Module, Stepper Motors, 3D Printed Constructed Frame.

I. Introduction

The scanner device used to store geometry of the physical object as memory in digital format. 3D printer which converts the digital memory file into physical object. This 3D scanner used to converts physical object into digital files. For example it can be utilized in museum to preserve the historical monuments digitally, in medicines like dentist can make 3D of an intricate shape facilely and in factories for documentation. To predict the degree of visual discomfort that is felt when viewing stereoscopic 3D. There are withal applications in marketing. The scanner abstracts the dimensions of the person and recommends matching habiliments sizes or engender visualizations – conclusively end with endeavouring on. Extracting 3D using high-speed stereo capture is also possible. Motion correction can be used for the moving objects . Scanners can be used in various fields such as forest field data collection . This project is about designing and implementing 3-D scanner system with edge based technique. This system is aimed at performing following objectives:

A. To calculate the depth information for n images

B. To transform the data in Cartesian co-ordinate system.

C. To group the data of n images in multidimensional array.

D. To reconstruct the 3-D object

E. To analyze the mismatch between real world and reconstructed world.

II. LITERATURE REVIEW

[1]. Infrared sensor based 3D image construction 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 project 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.

[3]. 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.

[4]. Describes about performing PSSRT systems a precise 3D digital model can be achieved in the submillimeter 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.

[5]. This project 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.

[6]. Siti Asmah Daud 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.

[7]. 3D printing starts with the creation of a 3D model in a computer. This digital design plays the key role. A 3D model is either created from the ground up with 3D modelling software or based on data generated with a 3D scanner by means of rendering. With a 3D scanner you’re able to create a digital copy of an object.Erald Piperi used a passive system, such as photogrammetry to acquire 3D geometries, with the use of one DSLR camera, a kit lens and close up lenses the results carried out for three benchmarked small objects (from 15 to 22mm) from photogrammetric 3D scan to 3D printing.

[8]. Athira K R worked on a low cost prototype of 3D scanner using low cost IR sensors and receivers and PIC microcontroller which can scan the object from every angle which transmits the signal reflected and back after striking the obstacle, the received light signal 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 .

[9]. Morteza Daneshmand provided an overview of 3D scanning methodologies and technologies proposed in the existing scientific and industrial literature. Various types of the related techniques are reviewed, which consist, mainly, of closerange, aerial, structure-from-motion and terrestrial photogrammetry.

[10]. Aman Sharma explained advanced technology of 3D printing, their implementation in the respective fields and its significant contribution in the global world of science and medical. In this project we will deal with the term Additive Manufacturing or 3D Printing and a little bit of its history. Its various applications along with the type of materials used in the 3-D are also described and numerous opportunities provided by this emerging technology as well as the risks and challenges related to it.

III. WORKING PRINCIPLE

In trigonometry and geometry, triangulation is the process of determining the location of a point by forming triangles to the point from known points.

Cartesian coordinates, also called rectangular coordinates, system of describing the position of points in space using perpendicular axis lines that meet at a point called the origin. Any given point's position can be described based on its distance from the origin along each axis.

The x-axis is the horizontal line along which the wall to your left and the floor intersect Cartesian coordinates of three-dimensional space.The y-axis is the horizontal line along which the wall to your right and the floor intersect. The z-axis is the vertical line along which the walls intersect.

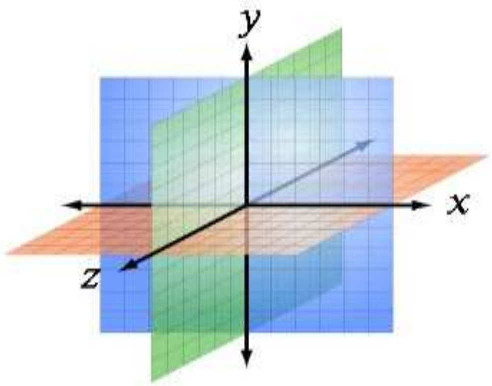

Fig.no.1: Representation of x,y,z planes

IV. BLOCK DIAGRAM

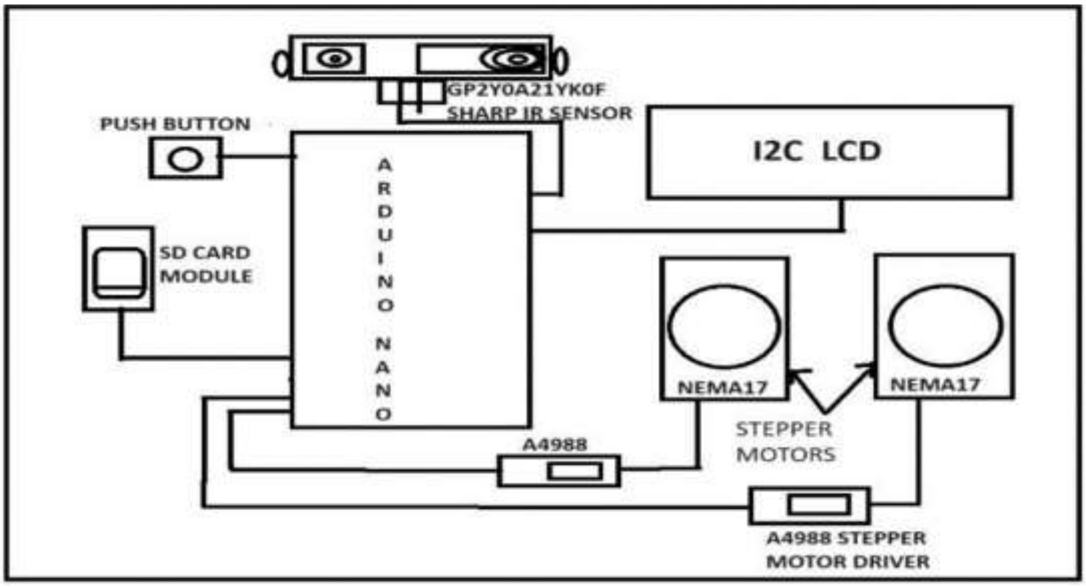

Fig.no.2: Block Diagram

V. COMPONENTS

1. Arduino Nano
2. GP2Y0A21YK0F IR Sensor
3. Stepper Motor
4. Motor Drivers
5. I2C LCD
6. SD Card Module
7. SD Card
8. Push Button Start Switch

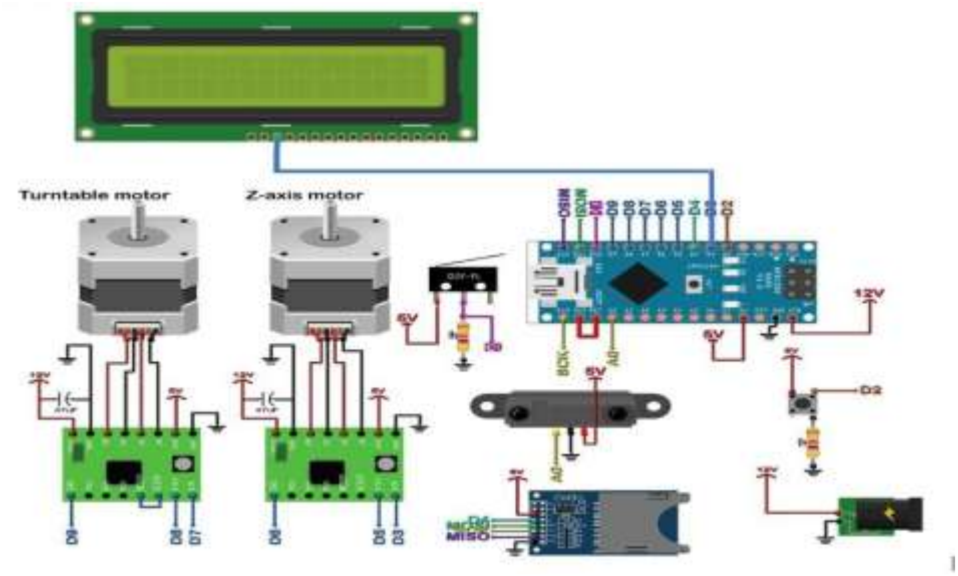

Fig.no.3:Components used in the project.

VI. IMPLEMENTATION OF SCANNER

The system hardware consist of micro-controller,2 stepper motors, sharp distance IR sensor , 2 Motor drivers, SD card module, I2C Display, Push Button. On the software side it uses Microsoft operating system, C programming language and IDE Software. It uses libraries such as according to the sensor interfaced ,from tools we can include the sensors libraries from the IDE software itself. C is a general purpose programming language.

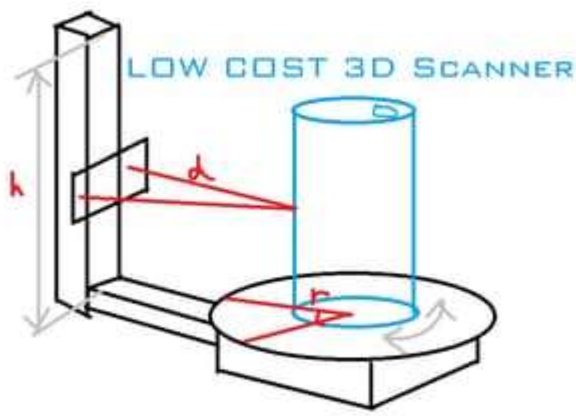

Fig.no.4:System Setup

VII. WORKING OF 3D SCANNER

The system uses 2 stepper motors for the machine. We use a stepper motor with a model platform mounted to it. The platform is used to place the physical models to be scanned. The motor rotates at gradual intervals so that the scanner can get 360-degree scans of the model.

The second stepper motor is mounted at the bottom of a screw-based arrangement that is used to mount the Sharp IR Distance Sensor. The scanner can move in a vertical direction using this second motor. Both the motors are operated in coordination to achieve a 3D scan of the model. Arduino controller is used to control the movement of both motors along with the scanner sensor to achieve the scan.

The IR sensor will send the infrared rays or beam towards the object and the rays are reflected back to the sensor in a particular time i.e, the object reflects the beam towards the sensor ,such as the ray bounce back to sensor, and it is noted as a point. All the infrared rays passed towards the object are reflected back to the sensors as different points at different time intervals and also based upon the object surface distance to the sensor.

By this process the points collected at different time intervals by the IR sensor it stores the points and collect all the points known as point cloud format i.e, collection of all point clouds of the object , this is known as scanning in simple words. The points of the object are sequentially stored from one after another i.e, from the base of the object ,the IR sensor starts producing the rays and it will detect and stop producing the rays when no longer reflected rays is obtained to the sensor for at 30 seconds.

So that the object is totally scanned from bottom to top by the sharp distance IR sensor.

The scan data is saved to an SD card using an SD card module. The scan data can then be transferred to a PC to convert it and get 3D model files of the same.

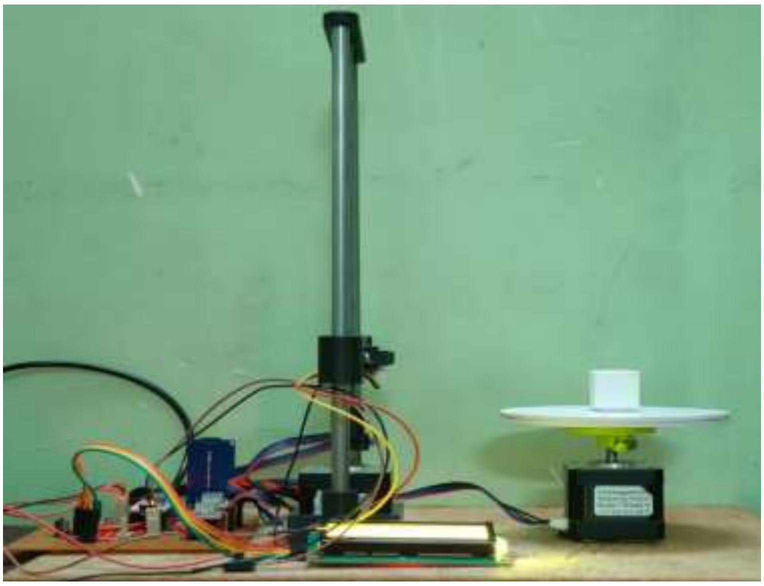

Fig.no.5:Hardware Implementation

VIII. ALGORITHM

Input: Capture object images in 360 degrees

Output: 3-D reconstruction

Method Begins:

Step 1: Initialize the serial communication between pc and controller with the appropriate baud rate.

Step 2: By method for a serial communication, processor gets commands from a system written in the processing unit and platform pivots by a fore drained angle.

Step 3: Project infrared rays from Sharp IR Distance Sensor (GP2Y0A21YK0F) on object to be scanned and trigger or collect the bounced ray by the object.

Step 4: Process the step 3 and fit an object into the area of interest.

Step 5: IR sensor starts producing rays towards the object.

Step 6: Segment it using appropriate threshold.

Step 7: Calculate centroid of the segmented object.

Step 8: Produce the contour points.

Step 9: Using trigonometric functions, transform the distance (x, y, theta) into 3D Cartesian co-ordinate system as (x,y,z).

Step 10: Read the data from multi-dimensional array and plot the 3D object, by collecting all the points together as a point cloud format.

IX. FLOW CHART

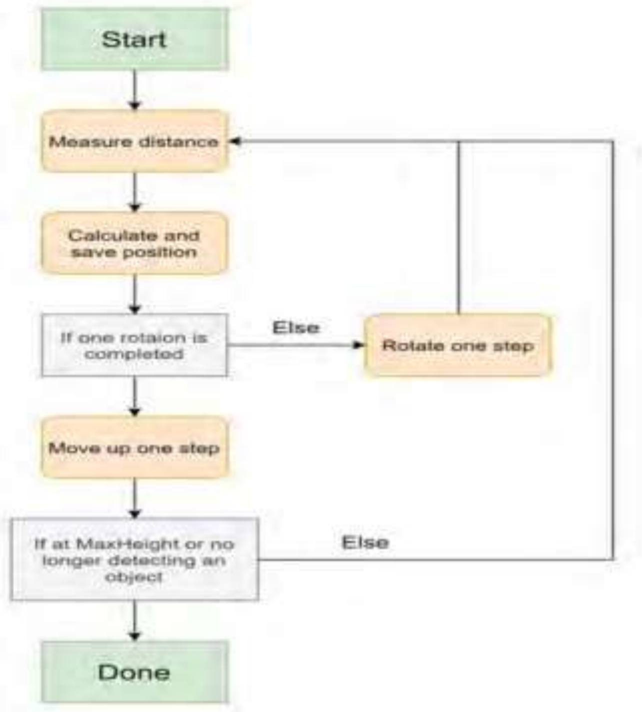

Fig.no.6:flow chart for the working of project

X. OUTPUT

MESHLAB Software:

MeshLab is an open-source, advanced 3D mesh processing software that provides a wide range of tools for visualization, editing, and processing of 3D models and point clouds. The interface of MeshLab is designed to be user-friendly while offering a powerful set of features for users working with 3D data. Below is a brief explanation of the main components of the MeshLab interface:

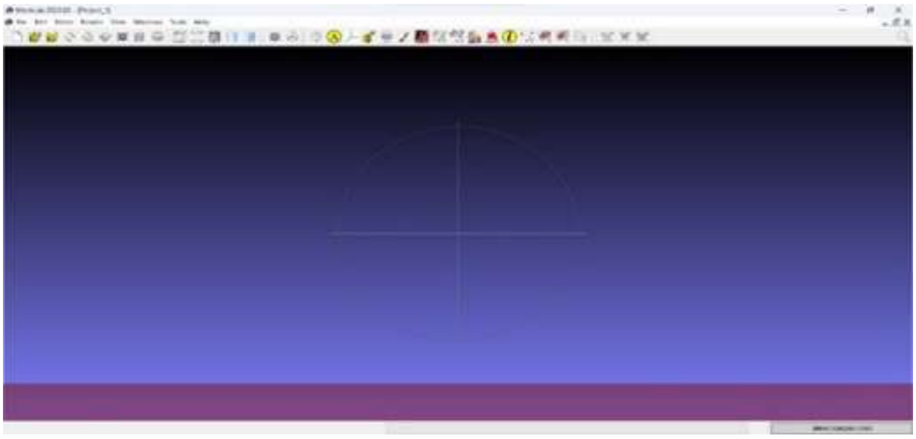

Fig.no.7:Interface of Meshlab Software

STL Format:

Converting a point cloud to an STL (Stereolithography) file using MeshLab involves a series of steps to create a 3D mesh representation from the point cloud data. MeshLab is a free and open-source software for processing and editing 3D triangular meshes.

Open MeshLab and import your point cloud data. Point cloud data is essentially a set of coordinates in 3D space that represent the surface of an object.

In the subsequent export options dialog box, you can adjust parameters such as the format version, binary/ASCII encoding, and unit of measurement. Modify these settings as needed for your specific requirements.

MeshLab will then generate the STL file and save it to the designated location.

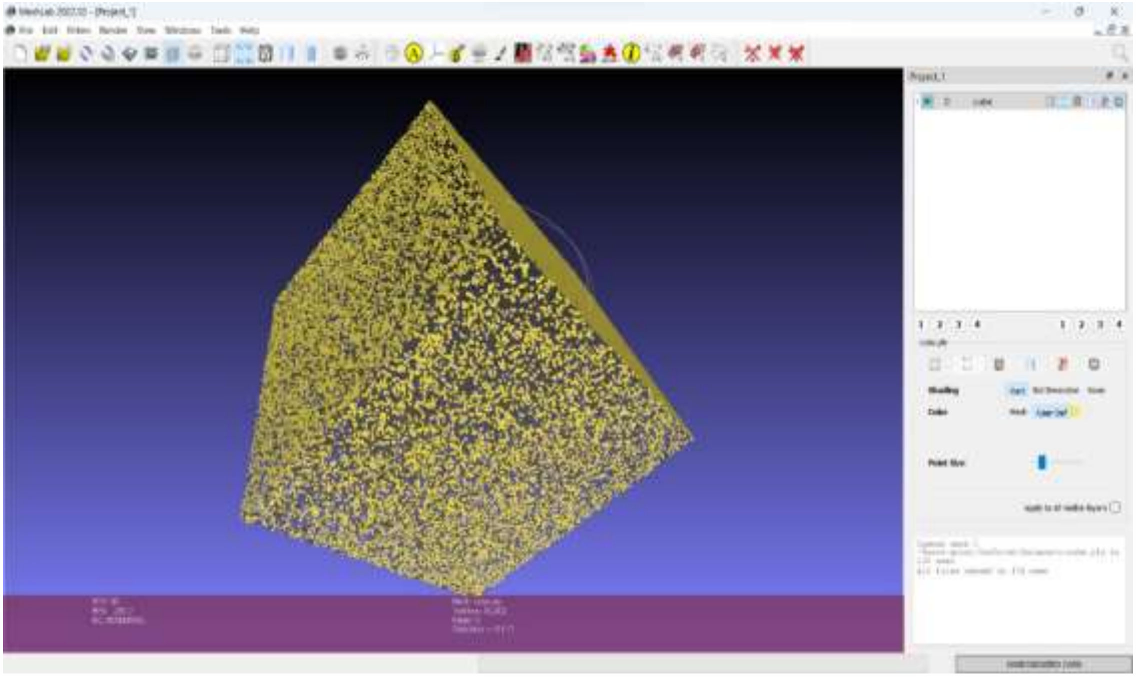

Fig.no.8:Point cloud format

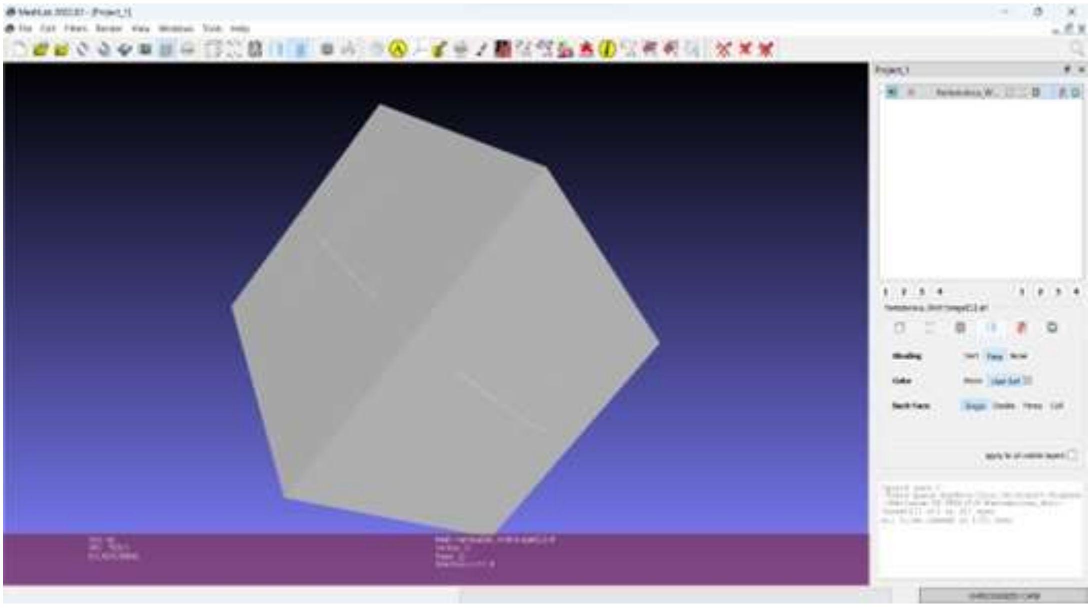

Fig.no.9:STL Format

XI. ADVANTAGES

- Accuracy: 3D scanners can capture precise details about a surface, including subtle contours and complex geometric differences.
- Speed: 3D scanners can quickly capture all of the physical measurements of any physical object.
- Quality control: 3D scanners can check the composition of the material and the volume of the object.
- Saving time in design work.
- Ensuring parts will fit together on the first try.

- Utilizing modern manufacturing on parts that were originally manufactured before CAD.
- Improved scanning accuracy.

XII. APPLICATIONS

- Making important decisions based on accurate 3D measurements.
- Capturing large amounts of surface measurements quickly and efficiently.
- Reconstructing a physical object in 3D to be visualized digitally on screen.
- Reverse engineering: 3D scanners can help reverse engineer physical products.
- Art reconstruction: 3D scanners can be used in the art reconstruction of historical and cultural moments.
- Automotive industry: 3D scanners can be used to 3D scan entire vehicles, parts, etc,.

XIII. CONCLUSION

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.

The project 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 field 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 Meshlab software to reconstruct the image of the object based on the values obtained. System using IR sensors for distance measurement. The output is obtained in STL format.

XIV. FUTURE SCOPE

Our present civilization places a great deal of importance on the task of three-dimensional scanning, which is translated by a broad field of knowledge that encompasses a variety of approaches to this task. The majority of the technologies are pricey because this process is not simple, even though even the most affordable ones are still a wise investment for the average customer. Thus, this work proposes a low-cost 3D scanning technology based on LIDAR that can reconstruct digital STL models from 3D scans of small things. Stepper motors are used to operate the system's single rotating platform and scanning arc-shaped structure.

XV. REFERENCES

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