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Design & Development of A 3D Scanner based on a Distance Sensor to Scan Real-life Objects & Implementing in Digital Reality

Md. Rezwanur Rahman, Md. Ariful Islam, S M Jaoyad Dipto & Asim Moin Saad

Abstract

This research aims to scan a real-world 3D object, reconstruct its digital model with internal hollow space data (volume, area), and blend it into augmented reality. When it comes to rebuilding a body, precision is a significant necessity. To scan a three-dimensional object, numerous methods are available. Most of which can only determine the outside dimensions of the entity being scanned. They barely provide any information regarding the hollow surface of the body. And to ensure accuracy, expenses may spike. To reconstruct a 3D object, the distance (e.g., Lidar, GP2Y0A41SK0F, Ultrasonic, etc.) sensor-based 3d scanner comes into play. The proposed system also includes a feature that can measure the hollow space inside the object. The distance sensor bounces laser light, infrared rays, or ultrasound to gauge distance and depth to form a 3D scan. The sensor sends that data to the microcontroller, and then the microcontroller brings that cartesian coordinate data to computer software to build the mesh. For detecting internal hollow space, gamma resonance is used. Furthermore, after scanning an object, Stereolithography or Film box files may be used for various purposes, including integrating with augmented reality, generating 3D prints, creating a video game or CGI avatars, etc. This project can create 3D scanned mesh quickly and accurately of real-world items. The 3D scan data regenerated by the proposed system can merge with augmented reality to simulate the metaverse. Scanning a three-dimensional body can be useful in our everyday lives as well as for research and experimental purposes. This proposed system provides an unbiassed novel strategy for reconstructing 3D internal hollow space with significant accuracy. This research addresses the hypothetical subject of what impact real-world objects portrayed in the digital world will have on mankind's new cyber world.

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1. Introduction

The fusion of physical and digital realms is essential to innovation in the fast-paced world of technology. A 3D scanner is a specialized instrument created to capture real-life things' precise shapes and visual characteristics, transforming them into three-dimensional digital representations (Javaid et al., 2021). 3D scanning uses various technologies such as laser, structured light, and photogrammetry. The scanner captures the spatial coordinates of points on the item's surface, generating a precise mesh or point cloud that faithfully represents the object's form and characteristics. Designing and developing a distance sensor-based 3D scanner is a pioneering effort. There are two types of different scanning systems. One is a contact-type scanning system, and the other is a non-contact-type one. The contact type scanning system is ancient, cannot be used for sensitive objects, and cannot give the proper shape of the object for implementation in augmented reality. This paper establishes the non-contact type scanning system between the two types of scanning systems. Though the project is prepared using the IR sensor, it can also utilize the LiDAR sensor for better results in (Neto et al., 2021). LiDAR and 3D scanners find broad uses in manufacturing, architecture, cultural heritage protection, and reverse engineering industries. Their capacity to provide exact and all-encompassing geographical data substantially contributes to disciplines that want precise measurements and intricate digital models. Besides, two types of LiDAR sensors are compared for low cost and personal use in (Panjvani et al., 2019). The cost of the LiDAR sensor is far too much than the IR sensor. That is one of the main reasons for choosing the distance sensor. Besides, this sensor is far more available than the LiDAR sensor. The technology of this type will be developed in this project in a better way (Straub et al., 2015). LiDAR produces an abundance of data points by emitting and receiving laser pulses quickly, allowing for the generation of detailed and three-dimensional maps. This technique is widely used in geology, forestry, urban planning, and autonomous cars for accurate environmental modeling. This project uses advanced technology, notably a distance sensor, to painstakingly record tangible objects in three dimensions. Its dynamic and immersive experience makes the scanner promising for industrial design, healthcare, gaming, and virtual prototyping. As the natural and digital worlds intersect to provide excellent visualization, interactive simulations, and unprecedented creativity, a 3D scanner adds complexity and excitement to the project. Our scanner digitizes actual objects quickly using signal processing, feature extraction, and point cloud synthesis. This technology improves industrial measures and changes virtual reality. This paper will explain our 3D scanner's design and development's technical details, theoretical underpinnings, and practical applications. Our ideas, problems, and triumphs aim to illuminate the developing synergy between physical reality and digital innovation's limitless potential. Join us as we create a powerful 3D scanner to digitize the physical environment using a distance sensor.

2. Literature review

For the literature review, the LiDAR sensor-based works are described in Neto et al. (2021) and Panjvani et al. (2019). This project is mainly based on the paper with some modifications. There are many previous works on LiDAR-based 3d scanning. Different works have different criteria. Some of them wanted to develop a system for precise scanning of a 3d object, others wanted to lower the cost of the 3d scanning system and many others tried to implement their systems in different spheres of our day-to-day life. In article (Panjvani et al., 2019), it is shown the scanning process can be done at a lower cost using a reconstruction algorithm. The SimTwo simulation software is used for creating the simulation environment in (Panjvani et al., 2019). The reconstruction was visualized by the MeshLab software. After getting the data provided by the LiDAR sensor, an STL file was generated from the cloud point. Then the cloud points were reconstructed and a final result was shown in MeshLab software. Two types of scanners were made using two different types of LiDAR sensors and were compared from many points of view. The two LiDAR sensors used in (Panjvani et al., 2019) are, LMS400-2000 and LiDARPheno. The cost in LiDARPheno is less but the accuracy is higher in LMS400. The Raspberry Pi and also the Arduino Uno are mentioned for use in (Panjvani et al., 2019). The data capture process was done using the publicly available library from ROS and Python programming language for the LMS400. On the other hand, the data was captured for the LiDARPheno using the Wi-Fi process available in Raspberry Pi. There are also many other benefits of using LiDAR sensors as there are many uses in us. Not only LiDAR-based, but also simple laser-based old 3d scanner is introduced in (Borghese et al., 1998). The beginning of the 3d scanning system history can be observed.

Table-01: Comparison of Key Features and Performance Metrics for Various other research papers

Author, year	High Accuracy and Precision	Low cost	Augmented Reality Implementation	Reconstruction Algorithm	Medical Sector Usage	Industrial Application
Neto et al., 2021	√	×	√	√	√	×
Haleem et al., 2021	√	×	×	×	√	√
Panjvani et al., 2019	√	√	×	√	√	×
Acosta et al., 2006	×	√	×	×	√	×
Lv et al., 2012	×	√	×	×	×	√
Yu et al., 2003	√	×	×	×	√	×
Tang et al. 2017	×	√	×	×	√	√
Xie et al., 2020	√	×	×	×	×	√
Straub et al. 2015	√	√	×	×	√	×
Borghese et al., 1998	×	×	×	×	√	×
Current Project	√	√	√	√	√	√

Table-01 provides a comprehensive comparison of different methods utilized in this project, highlighting their key features and aspects. This comparison study provides a comprehensive knowledge of previous researches regarding 3D scanning method and their strengths and limitations. This will put forward a clear idea about the 3D scanner and it's features and research regarding this project mentioned in this paper.

The prediction of (Borghese et al., 1998) that there will be software that can be used for reconstruction is used today commonly. This is a very simple laser-based sensor used in the article. The setup is also very simple with a laser pointer, some video cameras, and image processing sensors. This auto-scan system is very old-fashioned and also low quality. The establishment of augmented reality cannot be done in (Borghese et al., 1998). The other method of 3d scanning system is introduced in the (Acosta et al., 2006) which is known as laser triangulation. In the process, a laser beam is reflected onto an object and then the reflected beams are captured using an optic sensor. Only the shape of the object can be acquired and no total captured image can be obtained. Then, (Lv and Zhiyi, 2012) described the 3d scanning system using the laser system in a different way called binocular stereo vision. A laser and two cameras are the main part of the scanning system.

3. Methodology

Figure-01 shows the flow chart. After initialization of scanning, serial ports are activated and start SPI communication with the SD card which is inserted (Lv and Zhiyi, 2012). The turn table motor and carriage shaft motor start to rotate, turn table which is containing the object rotates in 1 step, and in every step, it moves 1.8 degrees, and in every step, the sensor measures the distance value and converts it into cm (Acosta et al., 2006). And also write the sensed distance to the SD card for storage. It automatically creates a file named "SCN000.txt", where it calculates the x, y, and z coordinate value and save it so that this coordinate data can be used as a point-cloud value for MeshLab software or MATLAB (Acosta et al., 2006). After 200 steps of turning the table motor, it completes 1 rotation, and in two hundred steps SD card stores 200 values. So, as long as the turn table completes 1 rotation the shaft motor moves 20 steps and raises the carriage 1 mm which contains the sensor (Haleem et al., 2021) (Zhang et al., 2012). And repeats the same process until the carriage reaches the top endpoint. If the carriage reaches the top the program stops the SPI communication and all the motors and returns the carriage to the home position (Acosta et al., 2006). The SD card should be inserted into the computer and input the point cloud data into MeshLab and it automatically forms the 3D figure of the real object (Yu et al., 2003). There are plenty of Android, iOS, or Windows applications that can visualize the 3D object in augmented reality (Yu et al., 2003.) By using those apps this Meshlab-generated 3D object can be visualized in AR. If this is an object of an animal it can be rigidify using Blender software and also can use as an avatar of Metaverse (Panjvani et al., 2019).

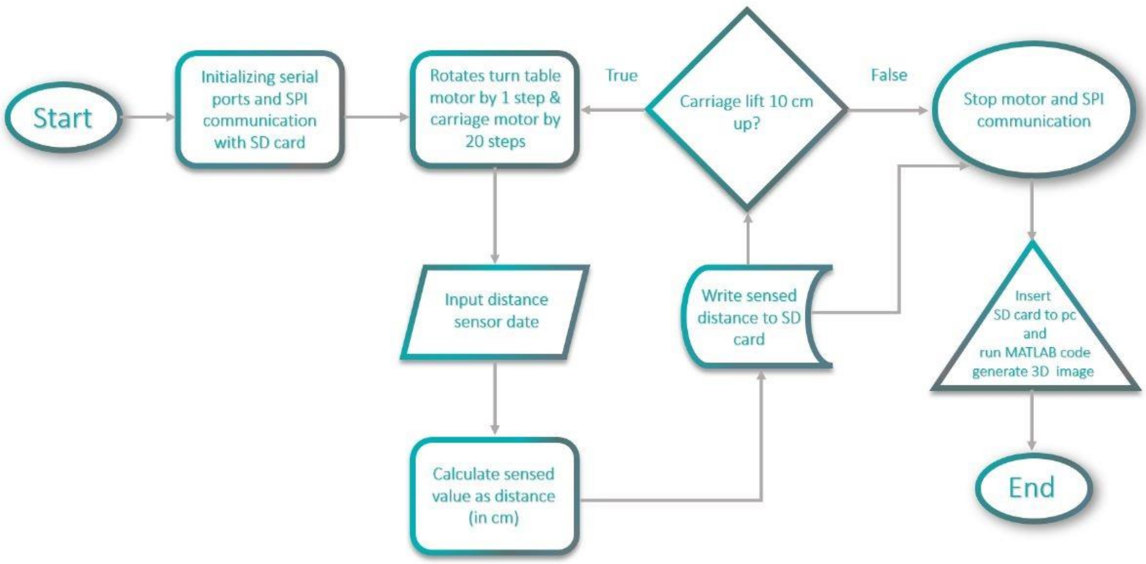


Figure-01: System flowchart of the project

4. Calculation

Figure-02 shows the complete visual calculation. NEMA 17 stepper motor is used in this project. A motor moves 1.8o for every step. That is 200 steps needed to complete 1 revolution or 360^{o}. Let our object is 10 cm tall so the carriage needs to climb 10 cm. By analyzing the shaft, we get linear motion for the z-axis motor is 1cm/rev. That is 200 steps/rev. Or 200 steps/ 1 cm. Or 200 steps/ 10 mm. so, 10 / 200 = 0.05 mm linear displacement per step. 20 steps push carriage 0.05x20 = 1mm. The steps required for turn-table-motor to complete a full rotation are the accounts = 200. The total desired z-axis travel is 10 cm, so vertDistance= 10. The number of z steps per rotation of the z-axis-motor is 20, So noZsteps = 20. Calculating the z-axis-motor's rotation number,

$$\text{steps\_z\_height} = \frac{200 \times \text{vertDistance}}{\text{noZsteps}} = \frac{200 \times 10}{20} = 100.$$

That means the z-axis-motor has to be rotated 100 times (every time 20 steps together) to raise the carriage 10 cm. For every 1mm raise sensor resets itself and counts the reading from the beginning. Every time the z-axis motor or carriage climbs 1 mm and it waits for the turn table to complete 1 rotation or 200 steps. In every step of the turntable motor, the sensor read 40 samples and calculates the average, which is not a distance value.

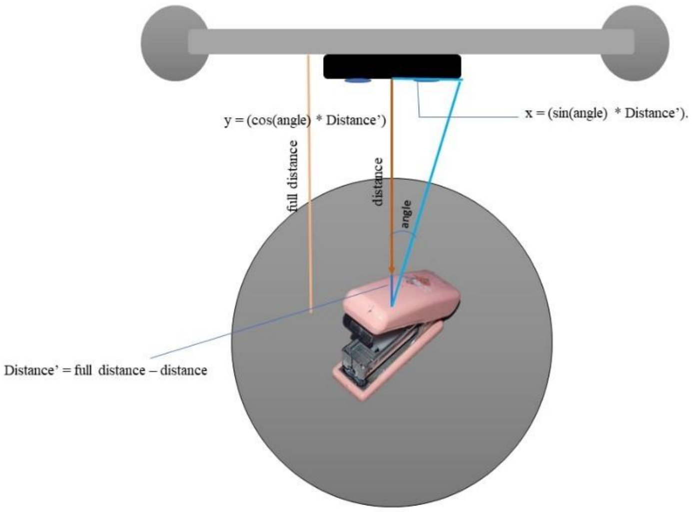


Figure-02: Visualization of the calculation

Sensor reading is converted into a voltage between 0v to 5v using a function: (Balali-Mood et al., 2006) (Eizadi-Mood et al., 2011)

$$\text{voltval} = \frac{(x - \text{in}_{\text{min}})(\text{out}_{\text{max}} - \text{out}_{\text{min}})}{(\text{in}_{\text{max}} - \text{in}_{\text{min}})} + \text{out}_{\text{min}}$$

x= sensor reading
in_{min}= minimum sensor reading (0)
in_{max}= maximum sensor reading (1023)
out_{min}= minimum voltage draw
out_{max}= maximum voltage draw
Convert voltage value to distance in cm via a cubic fit of sharp distance sensor datasheet calibration:
SenceDistance = - 5.402(voltval)^3 + 28.48 (voltval)^2 – 49.71(voltval) + 31.344
This is the sensed distance and finally, the mesh is built in MatLab/MeshLab using this sensed data.
<u>Calculating angle:</u>
RADIANS = (3.141592÷180.0) × (360÷200)
RADIANS = (3.141592÷180.0) × (360÷200) 200 steps per rotation for the motor (turn table motor). If we want to raise the carriage by 8 cm then, steps_z_height = (0.5×200×8) ÷10.
We let the initial angle 0, then we calculate,
angle = angle + RADIANS.
Distance' = Total distance – distance.
This distance is the distance from the sensor to the center of the object.
y coordinate value:

y = (cos(angle) × Distance')
x coordinate value:
x = (sin(angle) × Distance')

5. Experimental setup

Components are designed in CAD software; in this case, it is Solid Works as shown in Figure-03.

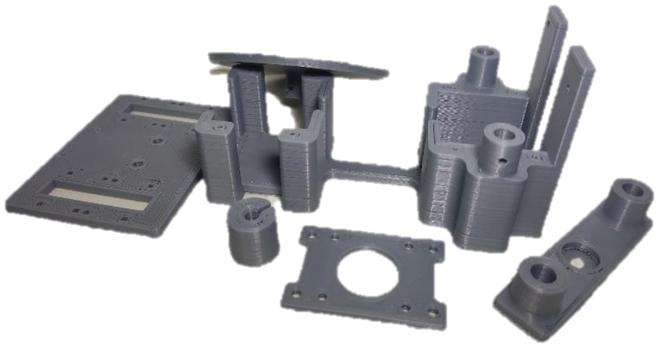


Figure-03: 3D printed body parts

The basic circuit was sketched in software named 'Fritzing' to develop a more professional circuit diagram, shown in the Figure-04.

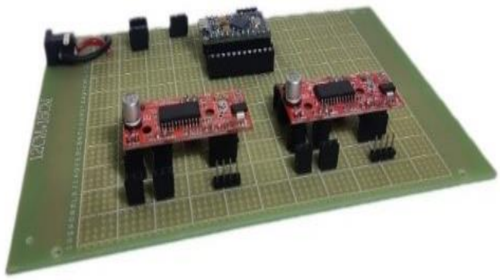


Figure-04: Circuit board

6. Results

After the whole scanning process was done, a 3D scan file of the object used is generated in MATLAB or MeshLab. After scanning, we get some coordinate values recorded in the memory card which is called point cloud. This point cloud is analyzed in MatLab or MeshLab more precise 3D mode. The results are in Figure-05, Figure-07 and .txt data of figure-05 in Figure-06. Now this image file can be converted into different types of files for further use such as 3D printing, merging with Augmented reality-based applications, and so on. The most important aspect of this scanner from another previous 3D scanner is it can scan the hollow surface of the object being scanned. Many other scanners are not able to scan hollow grooves and those parameters efficiently. Some fundamental differences between this 3D scanner and the previously designed 3D scanner are that the preceding scanner was mostly used in the industrial sector but this scanner can be used for academic research and personal work.

Because of industrial usage, the previous scanner was very costly on the other hand 3D scanner mentioned in this paper is very much affordable. These features will make this scanner preferable for the mass.

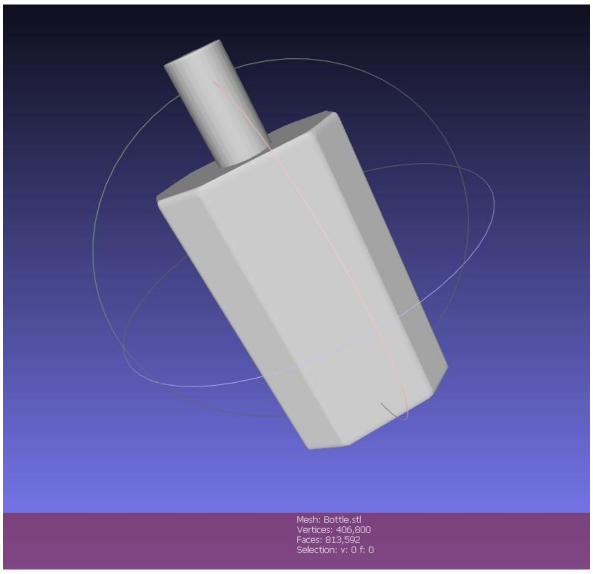
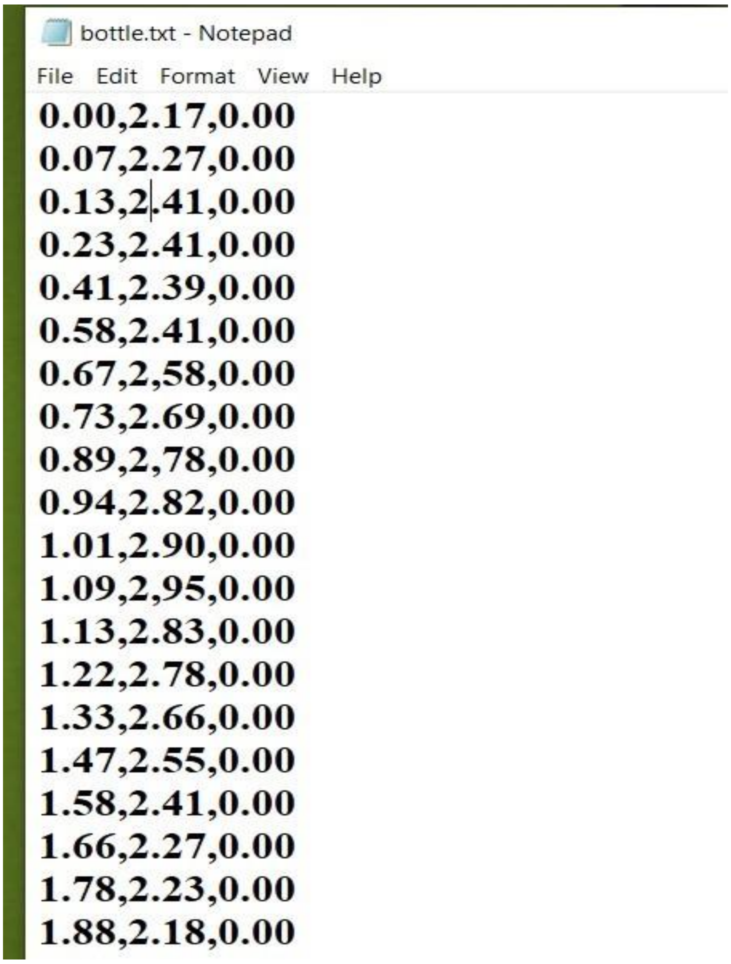


Figure-05: 1st example of generated 3D file in MeshLab



0.00,2.17,0.00
0.07,2.27,0.00
0.13,2.41,0.00
0.23,2.41,0.00
0.41,2.39,0.00
0.58,2.41,0.00
0.67,2,58,0.00
0.73,2.69,0.00
0.89,2,78,0.00
0.94,2.82,0.00
1.01,2.90,0.00
1.09,2,95,0.00
1.13,2.83,0.00
1.22,2.78,0.00
1.33,2.66,0.00
1.47,2.55,0.00
1.58,2.41,0.00
1.66,2.27,0.00
1.78,2.23,0.00
1.88,2.18,0.00

Figure-06: Example of point cloud values

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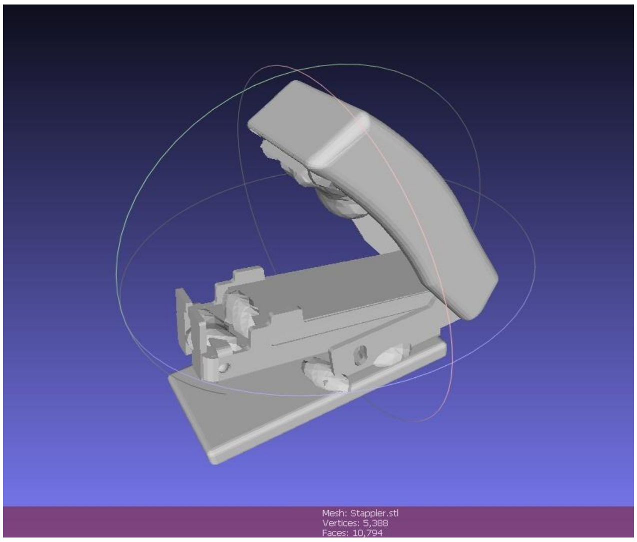

Figure-07: 2nd example of generated 3D file in MeshLab

We use the GP2Y0A41SK0F sensor module manufactured by Sharp Corp. Its range is 30cm. The voltage is very low when the distance between the sensor and the object is too low. It gradually increases for a certain distance but slowly decreases for the increasing distance between the sensor and the object.

Data collection:

G7

	A	B	C	D
1	Voltage	Distanc e	Desired volt	% of ERROR
2	0	0	0	0
3	1.2	0.5	1.3	7.692308
4	1.4	1	1.83	23.49727
5	1.6	1.5	2	20
6	2.1	2	2.2	4.545455
7	2.3	2.5	2.8	17.85714
8	2.8	3	3.2	12.5
9	3	3.5	3	0
10	3.9	4	2.78	40.2878
11	4.3	5	2.35	82.9787
12	2.4	5.5	2.2	9.09091
13	2	6	2	0
14	1.79	6.5	1.85	3.243243
15	2	7	1.75	14.2857
16	1.5	8	1.7	11.76471
17	1.3333	10	1.3	2.56154
18	1.7	12	1.1	54.5455
19	1.1	14	0.93	18.2796
20	0.8	15	0.9	11.11111
21	0.73	18	0.75	2.666667
22	0.7	20	0.55	27.2727
23	0.5	24	0.47	6.38298
24	0.39	30	0.42	7.142857
25	0.333	34	0.399	16.54135
26	0.2	40	0.31	35.48387
27				

Figure-08: GP2Y0A41SK0F Sensor Voltage for distance data and Error Calculation

Curve fitting:
Analysis and graph plotting done through MATLAB. Figure-09 shows the relationship between voltage and distance may not be linear, so you may need to use curve fitting technique.
Calibration equation:
Based on the curve-fitted data, derive an equation that relates the analog output voltage (V) to the actual distance (D). The equation might look like:
$D = a \times V^b + c$
where 'a', 'b', and 'c' are constants which are 3, 5, 1.
>> callibration
Fitted Coefficients:
1.0e+04 *
-2.9392 0.0000 2.9406
Fitted Equation:
$D = -29392.4166 * V^{0.0004} + 29405.6531$

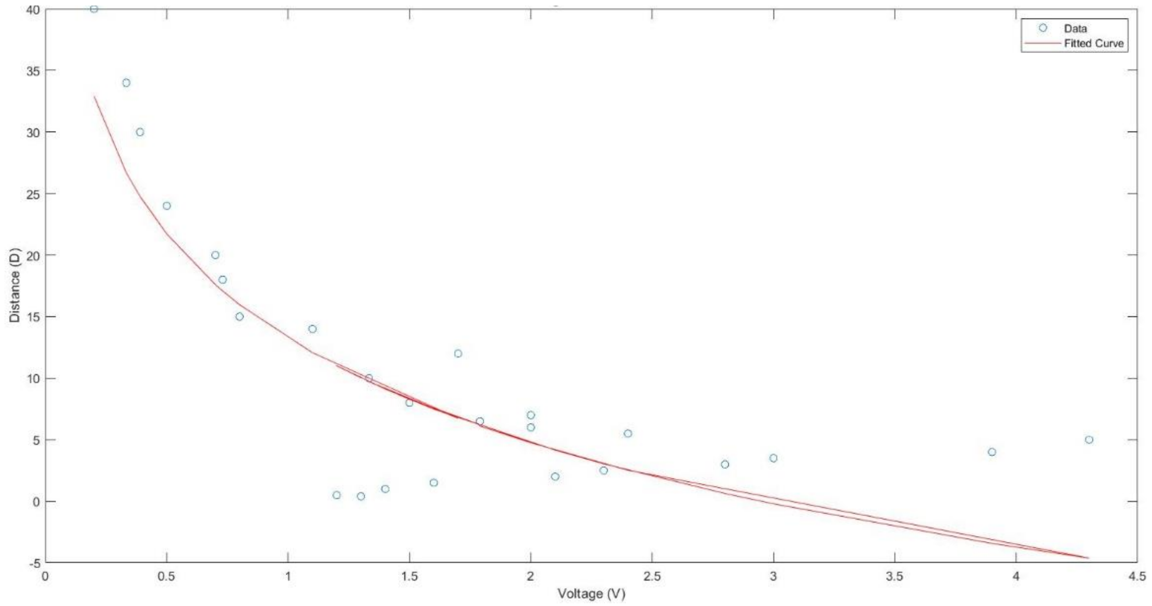

Figure-09: Curve Fitting for Sensor Calibration

Comparison between Conventional 3D scanner available in market vs current project:

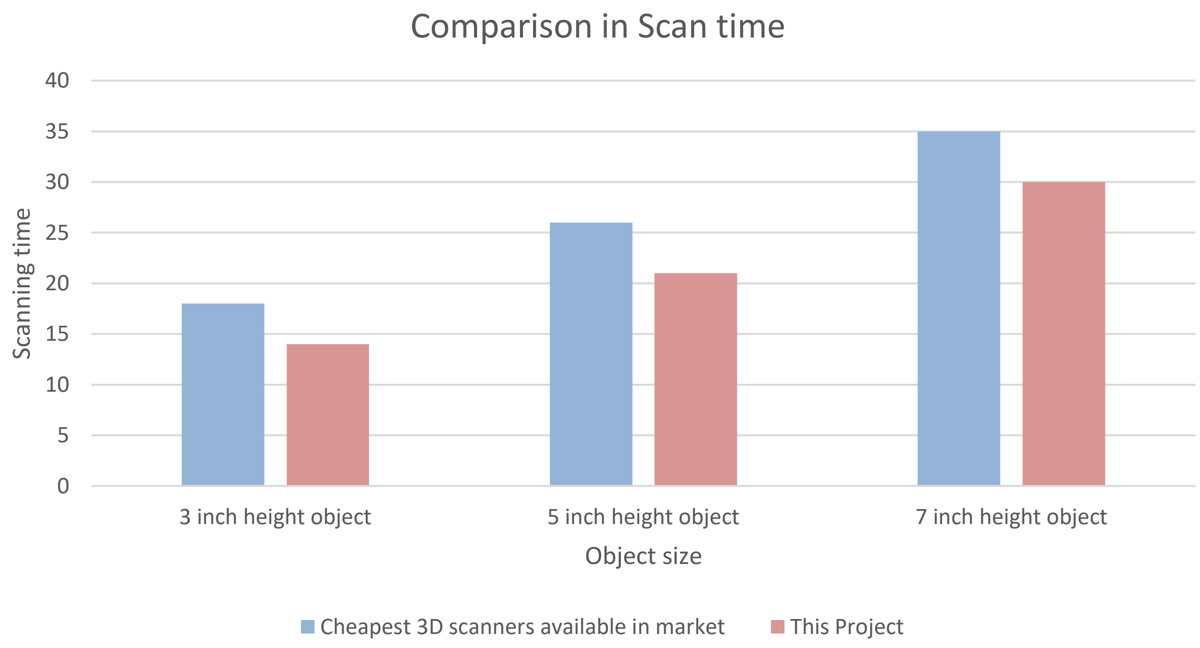

Table-02: A comparison is shown between the 3D scanners available in the marker and the scan we built in Table-02

Cheapest 3D scanner available in market	This project
Price range 180 Doller	This project cost 53 Doller
Effected by heat and temperature	System stands even in 80 to 90 degree centigrade and reads fine.
Scan accuracy depends on environment, lightings, object shape.	Nothing affects accuracy, able to scan in dark
Can carry 3 kg	Can carry 5.5 kg weight object
Cannot scan transparent object	Can scan transparent object.
Surface finishing is not perfect.	Perfect surface finishing.

The whole workflow of our 3D scanner is shown in Figure-10.

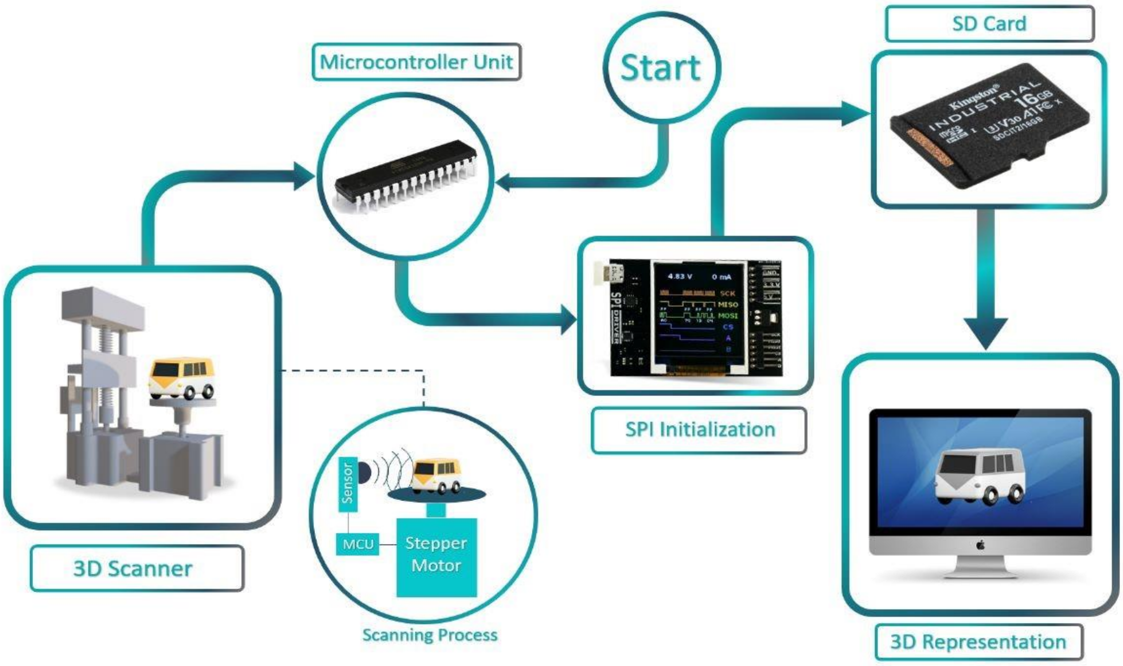

Figure-10: Work flow diagram of whole process

7. Future scopes

Medical and digital entertainment industries may benefit from 3D scanning technologies. This approach has major implications for the development and replication of complex organ structures and drugs. 3D scanning allows for precise anatomical reconstruction. This technology helps advance medical research and produce patient-specific medicines. In digital entertainment, especially video games and movies, 3D scanning is cost-effective and efficient. Reshaped china clay is used to reproduce complex things. These things are scanned with a 3D scanner and digitalized. This method creates detailed 3D objects cheaply. The technique also makes three-dimensional avatars for immersive virtual worlds easy in the fast developing metaverse. In the online furniture market, 3D scanning increases customer experience by visualizing furniture in real life. In mechanical and architectural research, 3D scanning allows experimentation and investigation, improving designs and structures. Space and interplanetary studies benefit from 3D scanning. For instance, Mars rovers use 3D scanning to get accurate surface data. Dental 3D scanning uses detailed scans to replace teeth precisely.

This technique also allows archaeologists to scan and recreate delicate uncovered relics, preserving them precisely. 3D scanning's versatility exceeds many industries, advancing science, medicine, entertainment, and more.

Figure-11 also shows some future scopes. In conclusion, the future applications of sensor-based 3D scanners have immense potential across a wide range of sectors and fields (Tang et al., 2017). These scanning machines, which are outfitted with high-resolution sensors and precise technology, have the potential to change industries such as architecture, manufacturing, healthcare, entertainment, and others. 3D scanners may enhance product design, expedite manufacturing processes, tailor healthcare solutions, and immersive virtual reality experiences, and accurately preserve cultural heritage by enabling precise and fast capture of real-world items and settings. Sensor-based 3D scanners are set to become crucial tools as technology advances, boosting innovation and revolutionizing how we interact with the physical world.

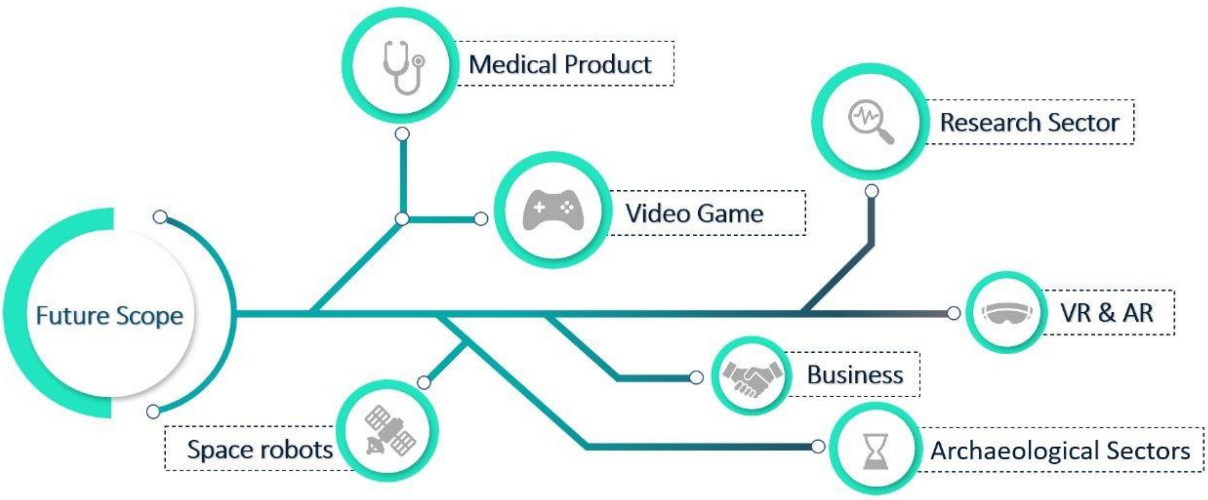

Figure-11: Various future scopes of 3D scanner

8. Conclusion

This paper presented a distance sensor-based low-cost 3D scanner that can scan small 3D objects and reconstruct their digital model shown in Figure-12. The device is economical and easy to operate. It is composed of a rotating platform and a scanning arc-shaped structure in which two stepper motor actuates both. IR Based 3d Scanners can generate high-quality 3D images while maintaining their accuracy. The IR sensor bounces the infrared light to measure the distance or depth of every point on the body to be scanned the device has to go through a time-consuming process, however considering the system's limitations with a budget investment the time consumption is acceptable. Fabricating the digital STL model isn't the sole feature of the device. It also includes a feature that can scan the inside surface if the object is hollow. Moreover, it lacks no possibility for the future. From scanning small objects to blending the digital model into augmented reality, everything could be done with this handy device, if necessary, improvements are made.

Figure 12: 3D representation of the machine

The design and development of a 3D scanner based on distance sensor technology have opened up exciting possibilities for scanning real-life objects and implementing them in augmented reality (AR). Furthermore, the successful implementation of this 3D scanner demonstrates the rapid advancement of sensor technology as well as the rising importance of augmented reality in our daily lives.

9. Reference

Neto, J. A. B., Lima, J. L., Pereira, A. I., & Costa, P. (2021, March). Low-cost 3D LIDAR-based scanning system for small objects. In 2021 22nd IEEE International Conference on Industrial Technology (ICIT) (Vol. 1, pp. 907-912). IEEE.

Panjvani, K., Dinh, A. V., & Wahid, K. A. (2019). LiDARPheno–A low-cost lidar-based 3D scanning system for leaf morphological trait extraction. Frontiers in plant science, 10, 147.

Borghese, N. A., Ferrigno, G., Baroni, G., Pedotti, A., Ferrari, S., & Savare, R. (1998). Autoscan: A flexible and portable 3D scanner. IEEE Computer Graphics and Applications, 18(3), 38-41.

Acosta, D., García, O., & Aponte, J. (2006, September). Laser triangulation for shape acquisition in a 3D scanner plus scan. In Electronics, Robotics and Automotive Mechanics Conference (CERMA'06) (Vol. 2, pp. 14-19). IEEE.

Lv, Zhihua, and Zhiyi Zhang. "Build 3D Scanner System based on Binocular Stereo Vision." J. Comput. 7.2 (2012): 702399404.

Yu, C. Y., Lo, Y. H., & Chiou, W. K. (2003). The 3D scanner for measuring body surface area: a simplified calculation in the Chinese adult. Applied ergonomics, 34(3), 273-278.

Bi, Z., & Wang, X. (2020). Computer aided design and manufacturing. John Wiley & Sons.

Planchard, D. (2017). SOLIDWORKS 2017 reference guide. Sdc Publications.

Shahrubudin, N., Lee, T. C., & Ramlan, R. J. P. M. (2019). An overview on 3D printing technology: Technological, materials, and applications. Procedia Manufacturing, 35, 1286-1296.

Su, B., & Wang, L. (2010, April). Application of Proteus virtual system modelling (VSM) in teaching of microcontroller. In 2010 International Conference on E-Health Networking Digital Ecosystems and Technologies (EDT) (Vol. 2, pp. 375-378). IEEE.

Muralikrishna, S., & Sathyamurthy, S. (2008, November). An overview of digital circuit design and PCB design guidelines-An EMC perspective. In 2008 10th International Conference on Electromagnetic Interference & Compatibility (pp. 567-573). IEEE.

BALALIMOUD, M., BALALI, M. K., & Hosseini, S. F. (2006). Recent advances in treatment of acute organophosphorous nerve agents poisoning.

Haleem, A., Gupta, P., Bahl, S., Javaid, M., & Kumar, L. (2021). 3D scanning of a carburetor body using COMET 3D scanner supported by COLIN 3D software: Issues and solutions. Materials Today: Proceedings, 39, 331-337.

Zhang, Z., & Yuan, L. (2012). Building a 3D scanner system based on monocular vision. Applied optics, 51(11), 1638-1644.

Tang, Q., Peng, X., Liu, X., & Cai, Z. (2017, February). Portable 3D scanning system based on an inertial sensor. In International Conference on Optical and Photonics Engineering (icOPEN 2016) (Vol. 10250, pp. 476-480). SPIE.

Xie, Q., Lu, D., Huang, A., Yang, J., Li, D., Zhang, Y., & Wang, J. (2020). RRCNet: Rivet region classification network for rivet flush measurement based on 3-D point cloud. IEEE Transactions on Instrumentation and Measurement, 70, 1-12.

Straub, J., Kading, B., Mohammad, A., & Kerlin, S. (2015). Characterization of a large, low-cost 3D scanner. Technologies, 3(1), 19-36.

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