International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 03 | Mar 2024 www.irjet.net p-ISSN: 2395-0072

DESIGN AND FABRICATION OF METROLOGICAL 3D SCANNER

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Abstract - *There have been several studies done to improve the technology of 3D scanning, like the source used to scan or the scanned 3D model, which undergoes several rectification procedures before being made into a complete error free model, but there are very few projects that automate the 3D scanning process. Here, we use the Arduino NANO along with a distance sensor to automate the 3D scanner on a small scale. This can be used in many industries to reduce the time consumed to re-design a product or to create a 3D model of an existing object. With this project, we can reduce or increase the time needed to scan based on the number of details needed.*

Key Words: *3D Scanning, Design, Point cloud*

1.INTRODUCTION

The current market for 3D scanning in India is growing, with various types of 3D scanners on the market. But the only issue with them is that they require human labour, and their cost is high. This 3D scanner project uses an Arduino NANO and an IR distance sensor to digitalize physical objects. It uses triangulation principles and mesh software. The open-source nature and affordable components of the project exemplify innovation with purpose, demonstrating the potential of 3D scanning in the Indian context.

2. WORKING

The 3D scanner has a simple working mechanism that comprises an Arduino Nano, an IR distance sensor, an SD card module, and a stepper motor. The Arduino Nano is uploaded with the program, which is used to coordinate the hardware components in the 3D scanner. The stepper motor serves as the scanning mechanism, with the Arduino controlling the movement across the area of activity. The stepper motor movement is controlled by delivering a certain pulse sequence that causes it to rotate progressively. This enables fine angular control, allowing the scanner to collect detailed data about the object's surface geometry. The stepper motor is controlled by the Arduino to increase in small increments during the scanning process. The IR distance sensor gathers the information by reflecting on the form and contours of the item and measuring the distance between the sensor and the object.

The data is recorded along with the stepper motor on the SD card, which is inserted in the SD card module. The scanning mechanism is performed well to get the objects precise distance measurements through the scanning region. The main control unit of the project is the Arduino Nano, which directs the movement of the starter motor and organises the data collected on the SD card. The data is collected as a 3D point cloud, which is then uploaded to the mesh LAB using it to reconstruct it as a 3D model.

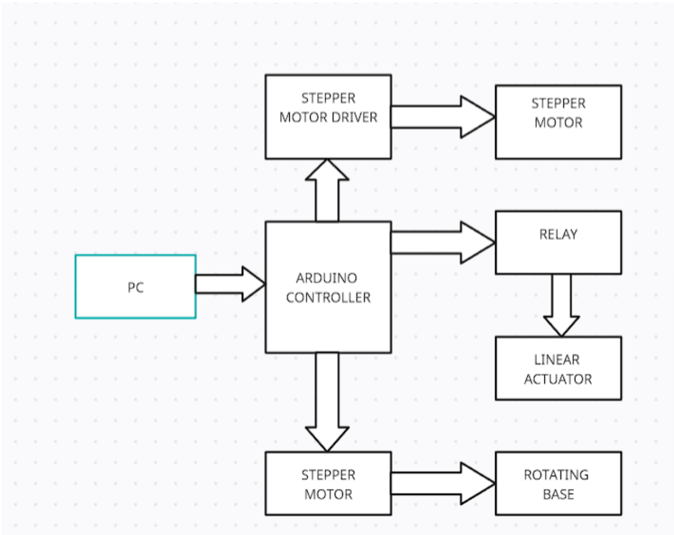

Fig -1: Working block diagram

3. METHODOLGY

We faced difficulties throughout our project, especially in the sensor's calibration phase and the last steps of achieving the design. We had trouble during the sensor calibration stage since the sensor was positioned incorrectly, which resulted in warped 3D point models. We verified the accuracy of our scanned data by contrasting the reconstructed 3D model with the actual object in order to reduce such mistakes. We enhanced the scanning performance and fidelity by repeatedly adjusting the calibration and design settings, guaranteeing more accurate outcomes.

The final design acquisition process was less of an issue we had to deal with head-on and more of an approach. We were now finished with all the required steps. However, we were given the choice between two software programmes for turning the point cloud file into a 3D model: MATLAB and MeshLab. Compared to MATLAB, MeshLab has a more user-friendly interface and is open-source, which made it a better choice for our project's requirements. This choice allowed for more efficient data processing and workflow optimization, which eventually helped us finish our 3D scanning project successfully.

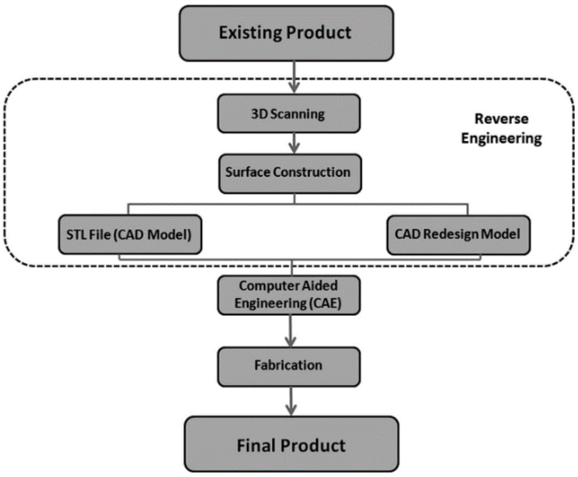

Fig -2: Work flow block diagram

3. HARDWARE

The hardware needed for this project is readily available and reasonably priced. The open-source Arduino NANO controller, which is used in a variety of projects ranging from entry-level to highly complex, is the one used in this project. This controller level allows us to control up to 13 motors in a single direction and up to 6 motors in addition to direction control. Next, we employed the Nema 17 for the primary moving parts. Its 3.2 kg holding torque and 1.8 degree minimum step angle allow it to be used to improve point cloud file precision, which in turn improves 3D model completion. The A4988 microstepping motor driver, which is utilised to operate the motor one step at a time from user input pulses, has been integrated with it. It is among the stepper motor's best-optimized motor drivers.

The source of the scanner is one of the project's main elements. An infrared 3D scanner is the one employed in this project. It is utilised since it is among the most affordable and has a high degree of precision, which improves the object's point cloud finishing. It operates on the triangulation principle, which uses trigonometry to pinpoint a fixed point's location given the knowledge of a triangle's two angles and one side.

Additionally, an SD card module is utilised to enable data store and retrieval operations by facilitating communication between an Arduino microcontroller and an SD card. It makes use of the SPI protocol, which enables quick data transfer between the SD card and Arduino. It functions as an external storage device that is utilised to save the point cloud straight out of the scanner, deliver it to the computer, and turn it into a workable 3D model.

Fig -3: Components

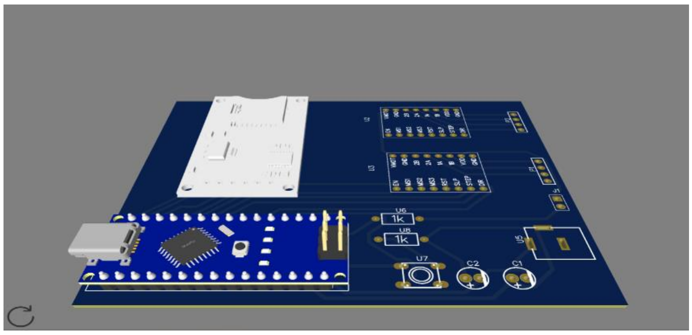

Fig -4: PCB board for scanner

4. SOFTWARE

We employed more recent software in the project. In order to create the 3D structural sections that needed to be more accurate at the beginning of the project, we utilized CAD software. In particular, we selected Fusion 360 software because of its many benefits, which include integrated workflow, cloud-based collaboration, simulation, and analysis. All things considered, Fusion 360 offers a strong and adaptable product design, engineering, and manufacturing solution that enables users to develop, work together, and successfully realize their ideas.

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Additionally, we programmed the microcontroller utilized in the project using the Arduino IDE as it offers a flexible and easy-to-use platform for programming Arduino boards, allowing programmers of all experience levels to develop interactive projects and prototypes. Electronics amateurs and experts alike favor it because of its open-source nature, ease of use, and simplicity.

Finally, we utilize software to scan the output and create a 3D model for the project. Generally speaking, there are other programs like Leica Cyclone, Point Cloud Processing Software, ESRI ArcGIS, QGIS, Autodesk AutoCAD Map 3D, Global Mapper, FARO SCENE, and more. We choose to utilize meshlab software since it is a portable, adaptable, open-source platform for handling and modifying unstructured 3D triangle meshes. It offers a large selection of tools for 3D mesh model processing, cleaning, editing, and rendering. In summary, MeshLab is an effective and multipurpose tool that can be used for a variety of 3D modeling and visualization tasks. It has an extensive feature set. In the realm of digital 3D processing and editing, its open-source design, cross-platform compatibility, and vibrant community render it an invaluable tool.

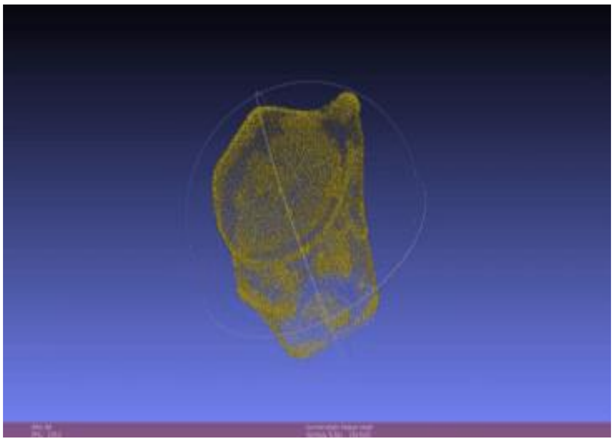

Fig -5: Point Cloud

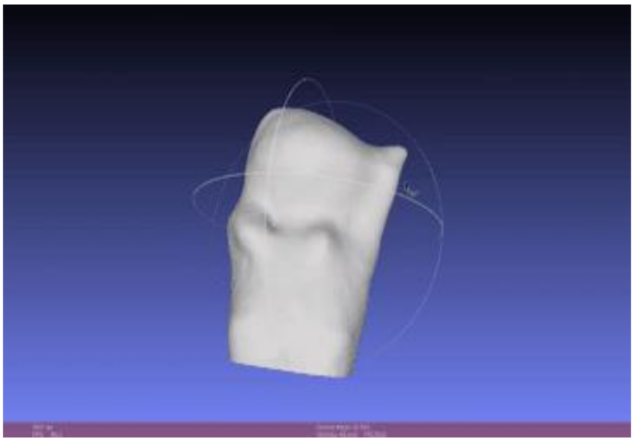

Fig -6: Completed 3D model

5. CONCLUSION

To sum up, the creation of an automated 3D scanner with an IR distance sensor and an Arduino NANO is a major advancement in the field of 3D scanning technology. With the addition of automation, affordability, and adaptability, this idea overcomes the drawbacks of the current 3D scanning techniques. This project shows that a practical and affordable 3D scanning solution can be created by integrating widely accessible and moderately priced hardware components, such as the IR distance sensor, Nema 17 stepper motor, and Arduino NANO controller. Accessibility and versatility are further improved by the use of open-source software tools, such as MeshLab for mesh processing and the Arduino IDE for programming. In order to guarantee precise and dependable scanning findings, the project's methodology included iterative calibration and optimization procedures. Careful testing and parameter adjustments allowed us to overcome obstacles that arose during the sensor calibration process and the final design acquisition.

Overall, this project's automated 3D scanner offers a practical, affordable, and approachable way to digitize actual things and produce precise 3D models. It is a major leap in 3D scanning technology. As this technology is further developed and optimized, it has the potential to be widely used and integrated into a wide range of applications, which will improve the field of digital 3D processing and editing.

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