Jurnal E-Komtek
Vol. 8, No. 1 (2024) pp. 177-184
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Prototype of an Arduino-Based 3D Scanner Printed Using 3D Printing

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https://doi.org/10.37339/e-komtek.v8i1.1829

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
22-06-2024
Revised:
27-06-2024
Accepted:
28-06-2024
Online first :
28-06-2024

Abstract

Three-dimensional (3D) scanning technology is pivotal in manufacturing, product design, and architecture, enabling precise digital reconstructions of real-world objects. However, existing 3D scanners are often costly and complex, hindering accessibility. To address this, our study presents a cost-effective 3D scanning system using Arduino technology. A cost-effective 3D scanning system with Arduino technology is presented in this study as a solution to this problem. Utilizing an Arduino Nano, GP2Y0A21YK0F IR Sensor, stepper motors, motor drivers, and an SD card module, our system offers a simple solution for scanning small objects and creating 3D models. The scanner measures object distance, rotates a work table, and captures scan data, processed with MeshLab software. Successful scanning demonstrates affordability and automation. Future work will focus on optimizing accuracy and scanning speed.

Keywords: *3D Scanner; Arduino; 3D Printing*

Abstrak

Teknologi pemindaian tiga dimensi (3D) sangat penting dalam bidang manufaktur, desain produk, dan arsitektur, memungkinkan rekonstruksi digital objek dunia nyata secara presisi. Namun, pemindai 3D yang ada seringkali mahal dan rumit, sehingga menghambat aksesibilitas. Sistem pemindaian 3D yang hemat biaya dengan teknologi Arduino disajikan dalam penelitian ini sebagai solusi atas masalah tersebut. Memanfaatkan Arduino Nano, Sensor IR GP2Y0A21YK0F, motor stepper, driver motor, dan modul kartu SD, sistem kami menawarkan solusi sederhana untuk memindai objek kecil dan membuat model 3D. Pemindai mengukur jarak objek, memutar meja kerja, dan menangkap data pemindaian, diproses dengan perangkat lunak MeshLab. Pemindaian yang berhasil menunjukkan keterjangkauan dan otomatisasi. Pekerjaan di masa depan akan fokus pada optimalisasi akurasi dan kecepatan pemindaian.

Kata-kata kunci*: 3D Scanner; Arduino; 3D Printing*

1. Introduction

Three-dimensional (3D) scanning is an increasingly important technology widely used in various industries, such as manufacturing, product design, and architecture. 3D scanning could be an innovation that checks genuine objects to decide their shape, measure, and other characteristics [1]. In addition, it is a progressed estimation strategy that permits advanced recreation of surface geography with high exactness and precision. Such estimation procedures can offer assistance in creating conventional fabricating forms into brilliantly fabricating standards that can ensure item quality through programmed discovery and control [2]. Progress in 3D checking innovation has revolutionized different businesses in the fields of fabricating, architecture, and entertainment [3]. 3D scanning could be a preparation commonly utilized to get numerical information that speaks to the shape of genuine physical objects [4].

Numerous distinctive advances can be utilized to construct these 3D filtering gadgets; each innovation comes with its claim impediments, focal points, and costs. 3D scanners can be isolated into contact 3D scanners and non-contact 3D scanners. Among them, non-contact 3D scanners are divided into raster scanners and laser 3D scanners (too known as 3D photo trackers) [5]. Non-contact 3D scanners primarily incorporate triangulation, computer tomography, phase-shifting scanners, etc. [6]. 3D scanning spares cash and time at each point of the fabricating handle, anywhere from plan to generation. These days, noncontact-based 3D detecting is the foremost prevalent approach embraced in 3D information acquirement [7].

However, most 3D scanners are expensive, making them difficult to access for those on a limited budget. Moreover, industrial-grade 3D scanners are particularly costly to acquire [8]. The standards of commercial 3D scanners are basically based on triangulation, time of flight, and organized light, which are costly [6]. Additionally, some of the more affordable 3D scanners often require programming or in-depth technical knowledge to operate, making them challenging for beginners or non-technical users.

In this work, the authors propose a simple and cost-effective 3D scanning system using Arduino. This approach allows scanning small objects to create 3D models. Most of the connecting parts are manufactured using 3D printing. This is similar to other research where the standards of commercial 3D scanners are mainly based on triangulation, time of flight, and organized light, which are costly [9]. Furthermore, the resulting 3D images from the 3D scanner can be used for additive manufacturing (3D printing) or other machining purposes.

2. Method

This research was conducted in several stages, beginning with the literature review, followed by preparation, design, and manufacture, and concluding with completion. Figure 1 shows a flowchart for this study.

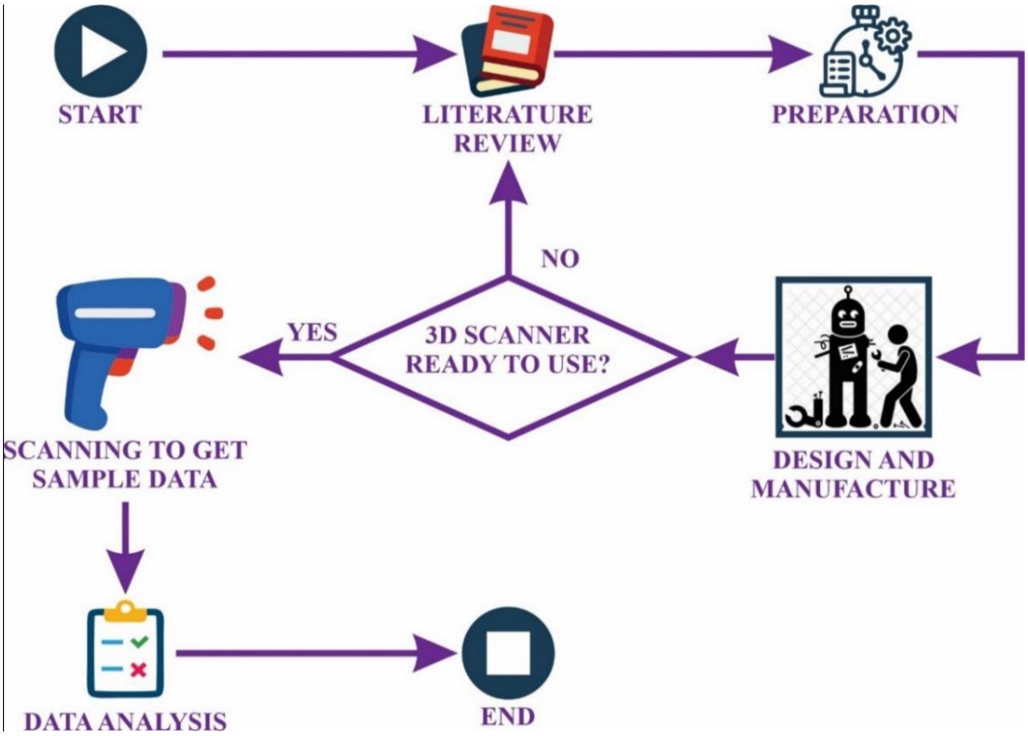


Figure 1. Flowchart for This Study

The main components needed:

1. Arduino Nano

   The Arduino was chosen because it is relatively inexpensive, can be reprogrammed, and is open-source [10]. The Arduino Nano could be a small, total, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x). It has the same usefulness as the Arduino Duemilanove but in a distinctive bundle. It needs a DC power jack and works with a Mini-B USB cable rather than a standard one [11].

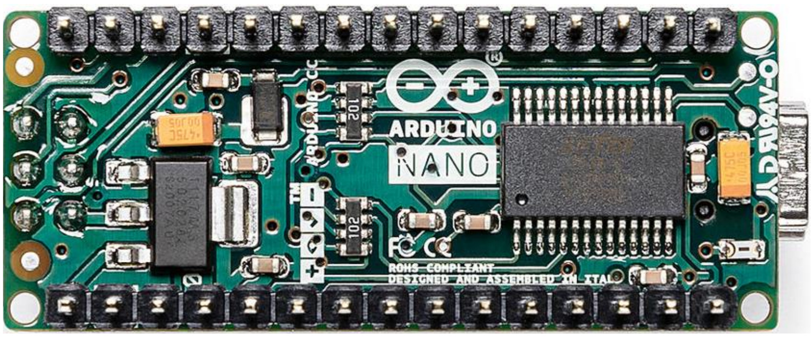


Figure 2. Arduino Nano [11]

Table 1. Tech Specs **[11]**

Specification	Value
Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Input Voltage	7-12V
Digital I/O Pins	22 (6 of which are PWM)
PWM Output	6
Analog IN Pins	8
DC Current per I/O Pins	20 mA (I/O Pins)
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Power Consumption	19 mA
PCB Size	18 × 45 mm
Weight	7 g
Product Code	A000005

2. GP2Y0A21YK0F IR Sensor

The GP2Y0A21YK0F could be a separate measuring sensor unit comprising a coordinates combination of an IRED (Infrared Radiating Diode), a PSD (Position Touchy Finder), and a signal processing circuit. When identifying distance, this sensor is not effectively influenced by varieties within the object's reflectivity, natural temperature, or working length. The device outputs a voltage compared to the identified separate, allowing it to function as a proximity sensor. Physical form of GP2Y0A21YK0F is presented in Figure 3.

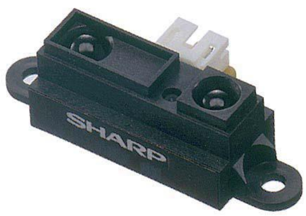


Figure 3. GP2Y0A21YK0F IR Sensor [12]

3. Stepper Motor

This study consists of two stepper motors. One stepper motor controls a rotary table, while the other drives the Z axis (vertical translation movement for the 3D scanner).

4. Motor Drivers

The motor driver functions as a link between the control circuit and the motor. The motor requires a lot of current, while the control circuit works on a low-current signal. Therefore, the role of the motor driver is to convert the low-current control signal into a high-current signal that can drive the motor.

5. SD Card Module

   This component helps with the SD card interface process. The scan data is spared to an SD card utilizing an SD card module.

6. SD Card

   This is a data storage card for a 3D scanner.

In addition, the connecting parts are manufactured using 3D printing. Before this process, the parts must be designed in CAD to create a 3D solid model. Following this, the parts can be sliced using a slicing application and then manufactured using 3D printing. Figure 4 illustrates the design of the 3D scanner.

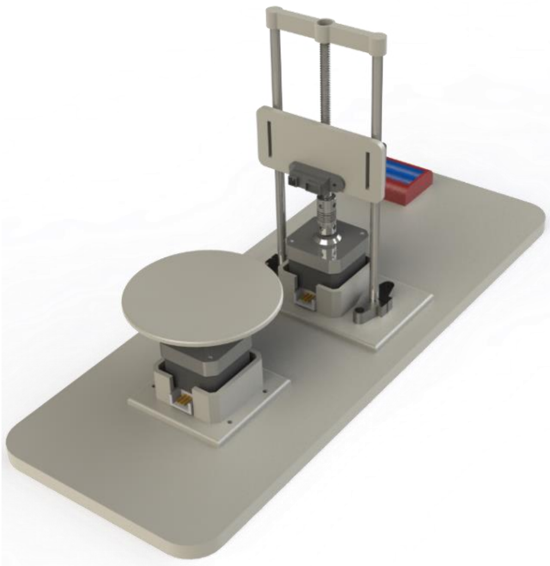


Figure 4. Design of 3D scanner

3. Results and Discussion

Figure 5 depicts the operation of the 3D scanner. The scanning process begins by measuring the distance to the object and then calculating and saving the object's position. This is done by rotating the worktable 360 degrees using a stepper motor. After that, the table moves up one step. This process continues until the object is completely scanned. If no object is detected, the scanning process is considered complete, and the data is processed using MeshLab software. Flowchart for the Working of 3D Scanner is presented in Figure 5.

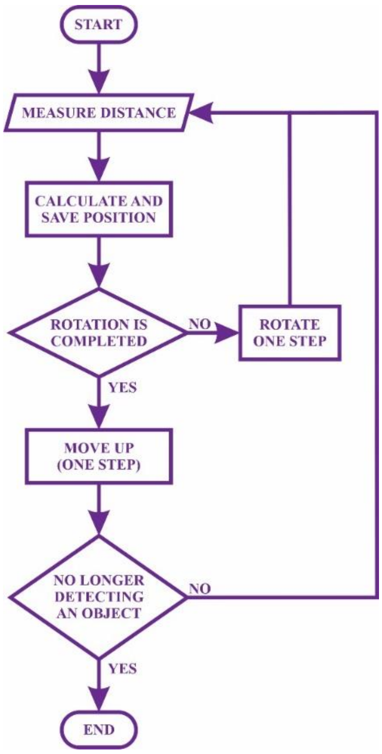


Figure 5. Flowchart for the Working of 3D Scanner

MeshLab software is an open-source platform for processing and altering 3D triangular networks. It offers a variety of instruments for assignments such as altering, cleaning, repairing, assessing, rendering, texturing, and changing over networks. Also, it incorporates highlights for taking care of crude information from 3D digitization apparatuses and planning models for cases to 3D printing. The interface of MeshLab is additionally outlined to be user-friendly, advertising an effective set of highlights for users working with 3D information. [1].

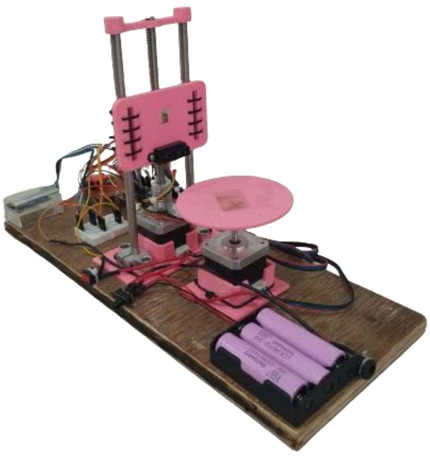
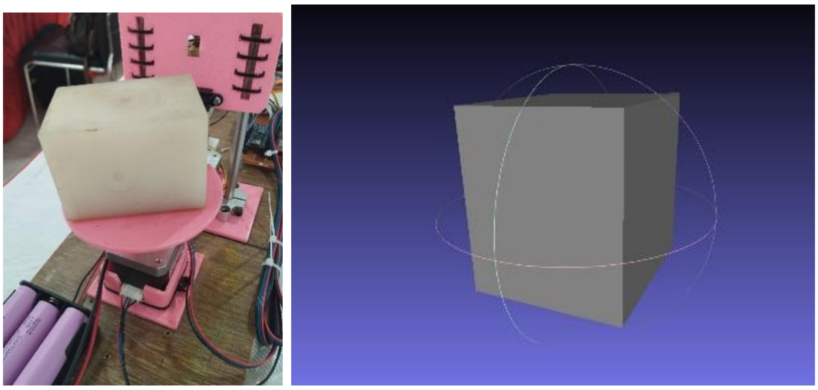


Figure 6. Assembled 3D scanner

Once assembled and programmed, the 3D scanner is ready to be tested. The test is conducted by placing the object on a rotary table. The 3D scanner operates as shown in Figure 6. The scanned data is edited and reconstructed in MeshLab, as illustrated in Figure 7. The output is obtained in STL format.



(a) (b)

Figure 7. (a) Placing the object on a rotary table; (b) Editing in MeshLab

4. Conclusion

The prototype successfully carried out three-dimensional scanning. In other words, the objective of creating an affordable portable handheld 3D scanner and an automated system for the scanning process has been accomplished. The scanned data can also be easily accessed for editing in MeshLab software. The output is obtained in STL format. Future work will include the optimization of the 3D scanner, its accuracy, and scanning speed.

5. Acknowledgement

Universitas Tidar supported this study under grant DIPA FT 2023. We thank the reviewers and proofreaders, as well as the student PKM group, for their technical assistance.

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