Object Mapping with LiDAR

Introduction

The idea for converting LiDAR data into an STL file for 3D printing emerged as a response to several project ideas that failed to meet budget and availability constraints. Originally, the goal was to create an autonomous boat that would feature a sonar array taking depth measurements. These soundings would then be stitched together to create a depth chart for any given body of water. However, underwater sonar sensors proved to be unavailable, extremely pricey, and bulky; as a result, the team decided that a potential project idea would be to build our own sonar sensor instead. Once again, adding an aquatic element to the project made the task too complicated and expensive to pursue. Thus, it seemed natural to transition to an alternative form of measurement: LiDAR. The team found that LiDAR sensors had superior range, lighter weights, positive availability, and cheaper prices than sonar alternatives. Based on these findings, the group decided that constructing a project from this technology would prove to be significantly more fruitful.

Problem Description

Corporations spend millions of dollars designing products and then ensuring that manufactured results are up to the original design specifications. Using CAD software, nearly any part or product can be digitally modeled. However, this can often be a time consuming process and there is no guarantee that the engineer doing the modeling will complete his task perfectly. If even one dimension is off, the model will need to be updated and any parts already sent to the printer will need to be scrapped. Thus, if there is already a prototype of a part and a company or individual would simply like to replicate it in CAD they must undergo a time consuming and error prone process to model it in software. Additionally, there are currently incredibly costly systems in place to ensure parts meet the standards that they were designed with. Having an individual take measurements or employing a computer vision system can be unreliable and incredibly costly. If a cost effective, simple solution to this problem could be implemented, it would increase the efficiency and accuracy of designing and manufacturing all sorts of products.

Proposed Solution

In order to solve this problem, a LiDAR scanner could be created. This scanner would employ a LiDAR array that continuously takes distance measurements. Additionally, this array will move to varying heights to record the full dimensions of a part. While the LiDAR array is moving up, the part will be placed on a 360 degree rotating tray. Because the part is rotating and the LiDAR array is moving to variable heights, this will enable measurements to be taken at every point around a part. This data can then be exported to an SD card, and an .STL file can be generated. Additionally, computation can be performed on the data points the LiDAR has recorded to determine if a part's dimension is within a preset acceptable tolerance.

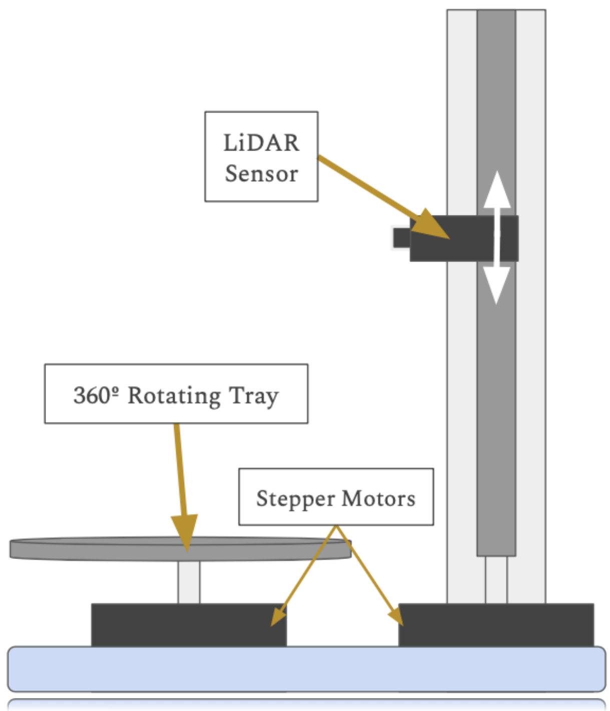

Figure 1: Proposed Design of Sensor and Motors

Demonstrated Features

- Functional Lidar
- Precise Motor Adjustment/Control
- Real-Time Preview of Model (Wireless Communication)
- Successful STL file creation
- Quality Control/ Rejection of a part based on preset dimensional criteria

Available Technologies

LiDAR Sensor - Use the Lidar sensor to capture the physical dimensions of the object we want to scan. The sensor uses an UART interface. It has a resolution of 5mm, and it only requires 5V to run making it an easy sensor to power.
https://www.sparkfun.com/products/15179

SD Card Module – The data collected from the LiDar Sensor will be stored on a SD card. The SD card module has an SPI interface driver installed and can read and write through a file system.

HiLetgo Micro SD TF Card Adapter Reader Module 6 Pin SPI Interface Driver Module

Stepper Motor - The project will use two of these motors for all of the operations. One motor will be used to rotate the object to be scanned. The second motor will be used, in conjunction with a screw, to raise and lower the LiDAR sensor.

STEPPERONLINE Nema 17 Stepper Motor Bipolar 2A 59Ncm(84oz.in) 48mm Body 4-lead W/ 1m Cable and Connector compatible with 3D Printer/CNC

EIH 3D Printing Resources - Much of the supporting infrastructure necessary for this project can be 3D printed using the EIH. The rotating platform and supports can all be designed in Solidworks. Additionally, an enclosure for the entire system could be designed and printed.

Engineering Content

- Data collection and transmission from the LiDAR sensor to the microcontroller
    - The LiDAR sensor will take measurements 360 degrees around the part and at different height intervals. This sensor can be controlled using an Arduino interface from the ESP32. The data received can be verified by taking manual measurements and verifying collected data matches.
- Data storage onto an SD Card
    - This will be accomplished using the SPI interface from the ESP32. Once the data has been stored on the SD card it can then be read into a variety of programs.
- Accurate motor control of a stepper motor
    - We will test varying amounts of adjustment with the stepper motor to see how the resolution of the data map is affected. The motors will be controlled through the ESP32. By testing various increments of steppage, we will optimize the time it takes to generate the data map and the quality of the map generated.
- Design the mechanisms of the frame to allow the LiDAR sensor to move
    - This will occur in 3D printing software (either Autodesk Inventor or Solidworks). There can be several iterations of this design (if necessary) to allow for smooth operation and movement of the sensor.
- Bluetooth transmission of data collected real-time to a web server
    - A real time transmission of the LiDAR data can be "stitched" together. A web server can be created (similar to the one in the previous individual coding assignment), where the data map can be viewed.
- Programming to convert data collected into a STL file
    - A significant amount of testing will be needed to determine if this feature is properly working. After the initial programming for this feature is finished, it can be tested by 3D printing the .STL file generated, or viewing it virtually, and comparing the print to the original object.

Conclusions

This project would consist of a LiDAR sensor that records the distance of a rotating object as the LiDAR array is moved vertically. By doing this, a 3D object of a model can be created which can be used to generate a .STL file and verify certain dimensions for quality assurance.

This design could be used for several purposes. First, if there is a part that an individual or a corporation would like modeled, there is no need to spend valuable time making a CAD model. Instead, the part can simply be placed on a scanning tray and a 3D model with 0.5 cm resolution will be generated. Due to cost constraints, a LiDAR sensor with greater resolution cannot be implemented for this project; however, in a corporate setting with increased funds, resolution could be greatly improved.

Additionally, the model generated from the LiDAR can be used for quality control purposes. By setting a specific tolerance between two data points, this system could accept or reject parts. Thus, this LiDAR scanner can serve multiple purposes and could be outfitted with several different sensors depending on the resolution required.