SANGAM PROJECT BROCHURE:

Real-Time 3D Object Reconstruction using Kinect

By:

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Introduction

In a year where astronauts in the ISS have succeeded in doing 3D printing, one has hardly considered proceeding the other way around. The study and analysis of real-world objects, taking into account its shape and color, is called 3D scanning.

In modern technology, 3D scanning can be performed in various methods. These include contact, ambient light visual triangulation and structured light methods.

3-D scanning is generally a rather costly affair with pricing going up to 48,000 rupees (Makerbot's 3-D scanner). With the depth sensing technology of the Kinect and the wide array of software available, we trim the cost to about 15,000 rupees.

Project Goal-

- To construct a 3D volumetric scanner using the Microsoft Kinect by abstracting, manipulating and meshing acquired co-ordinate data.
- To further attempt to automate the entire process and store the acquired 3D file for digital manipulation purposes.
- To compare the original object with a 3-d print of its scan.

Requirements-

Hardware:

- **Arduino Uno**

  The Arduino Uno is a microcontroller board based on Atmel's Atmega328. It is meant for easy integration of electronic functionalities using user instruction. Code can be burnt using C/C++ or by using IDE's such as Arduino.

- **Kinect Sensor for Windows**

  The sensor comprises of an RGB camera and depth sensor that utilizes infrared light projection. The CMOS sensor picks up the IR speckle pattern from the surroundings and comprehends it as distance. A multi-array microphone performs well in noisy conditions, with acoustic noise suppression. In addition there is a central servo controlling tilt and a three-axis accelerometer.

- **DC Motor (10 RPM)**

- **Plastic gears**
  Three numbers, in the ratio of 1:6

- **Multi-turn potentiometer with shaft**

- **Acrylic circular sheet**

- **Screws and bolts of various dimensions.**

Software Required-

- **Processing**

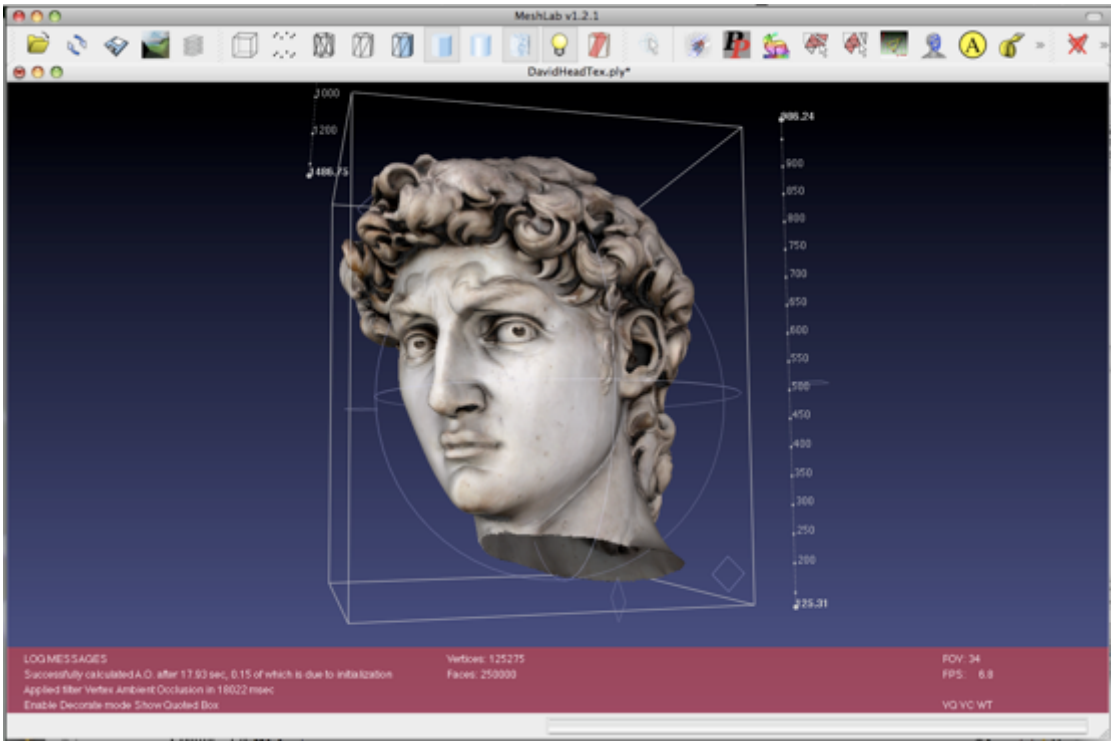
  Processing is a Java-based, open source IDE and language. It is used for graphical manipulation of data and with the help of add-on libraries you can program external peripheral.

- **Open NI**

  Open NI is an industry-led natural user interface to communicate with middleware devices, such as the Microsoft Kinect,

- **Meshlab**

  It is an advanced 3D mesh processing software. It is used in scanning and printing.



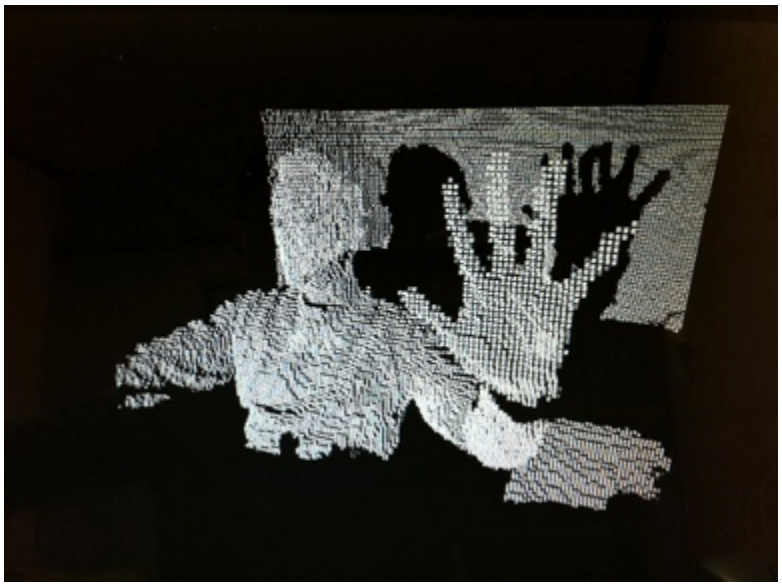
Software libraries and drivers-

- KinectOrbit
- Simple Open NI
- Open GL
- Primesense Drivers
- Kinect SDK

How does the Kinect Work?

The Kinect module covers its environment with a structure infrared speckle pattern. Structured light analysis works on the concept of parallax, with transmitter and sensor placed at different locations.

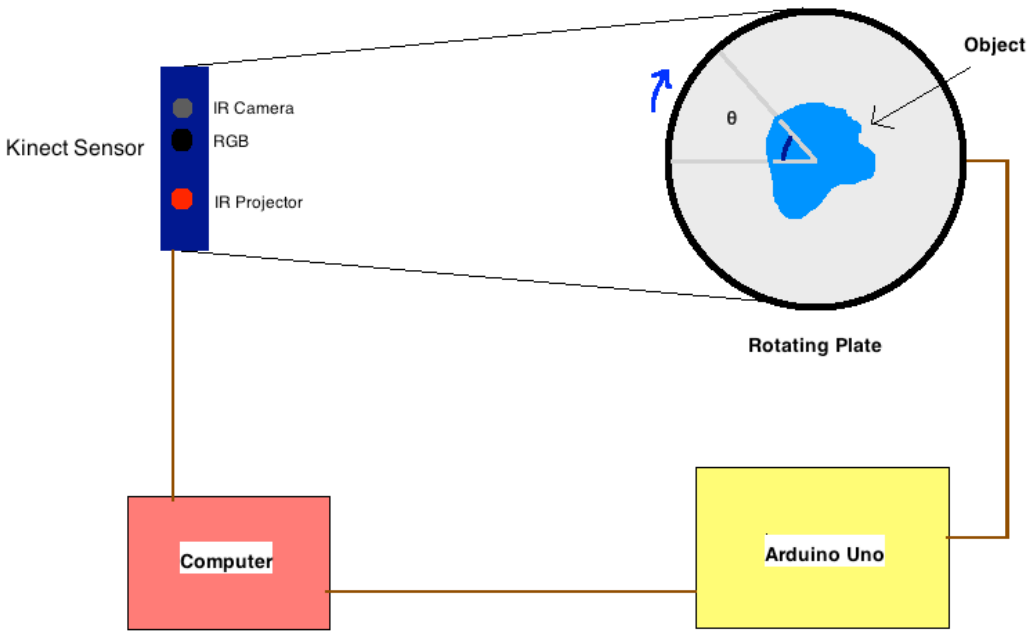
There is a POV difference between the IR transmitter and the CMOS sensor, leading to a difference between the expected and actual position of the IR dots. This difference, along with trigonometric considerations, is used to calculate depth of the pixels. This depth can further be attributed to the respective RGB pixel entities.



Modus Operandi-

Setup-

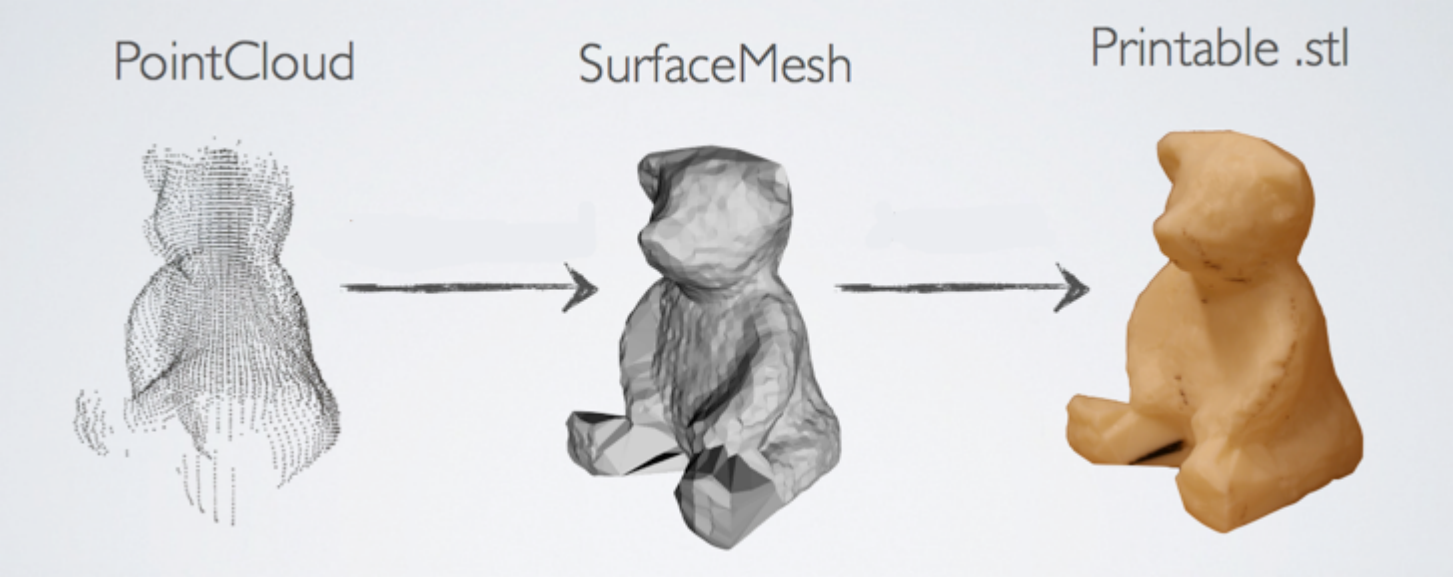
The rotating plate is integrated with the Arduino and placed in line with the Kinect device. The object to be scanned is placed on the turntable, and should fit the expected dimensions. The setup must be placed in an area of good ambient lighting and minimal background interference.



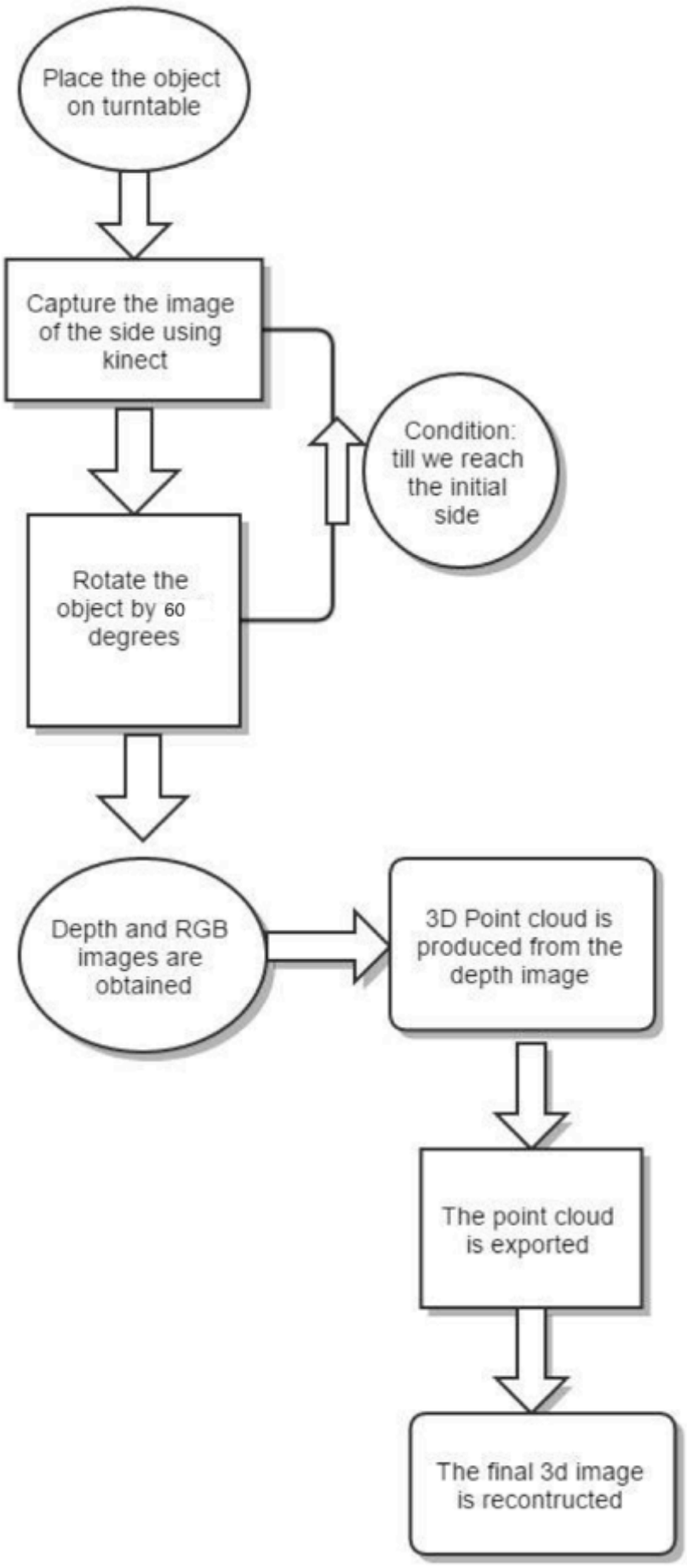
Algorithm-

- The object to be scanned is place on the turntable, in any orientation.
- We run the processing sketch, integrated with the Kinect software, to create the depth map and color data.
- Rotation takes place through 120 degrees with the help of the 10 RPM DC Motor. Potentiometric feedback plays a vital role in positioning the turntable.
- A second scan is taken at the new position, and the point cloud is stored.
- The above steps are repeated for a third time.
- The points are transformed to fall in line with the original axis using trigonometric relations.
- When 3 scans are completed, Processing is instructed to combine all three point-clouds into a single 3d space. The color of each point is also stored likewise.
- The obtained point-cloud is stored as a .obj file.
- This file is opened in mesh lab to be edited.
- Any inconsistencies in the structure are manually removed.

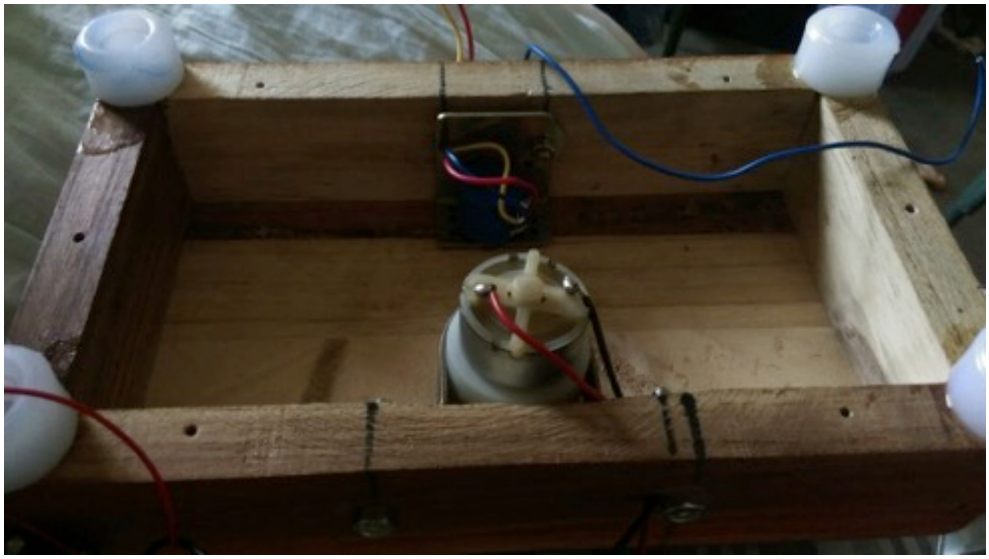
- The surface normals are marked and Poisson reconstruction is performed.
- Color is represented in the remainder of the created points, giving the image credibility.
- This gives you a finished 3D file that can be saved and sent for digital use as well as 3D printing.



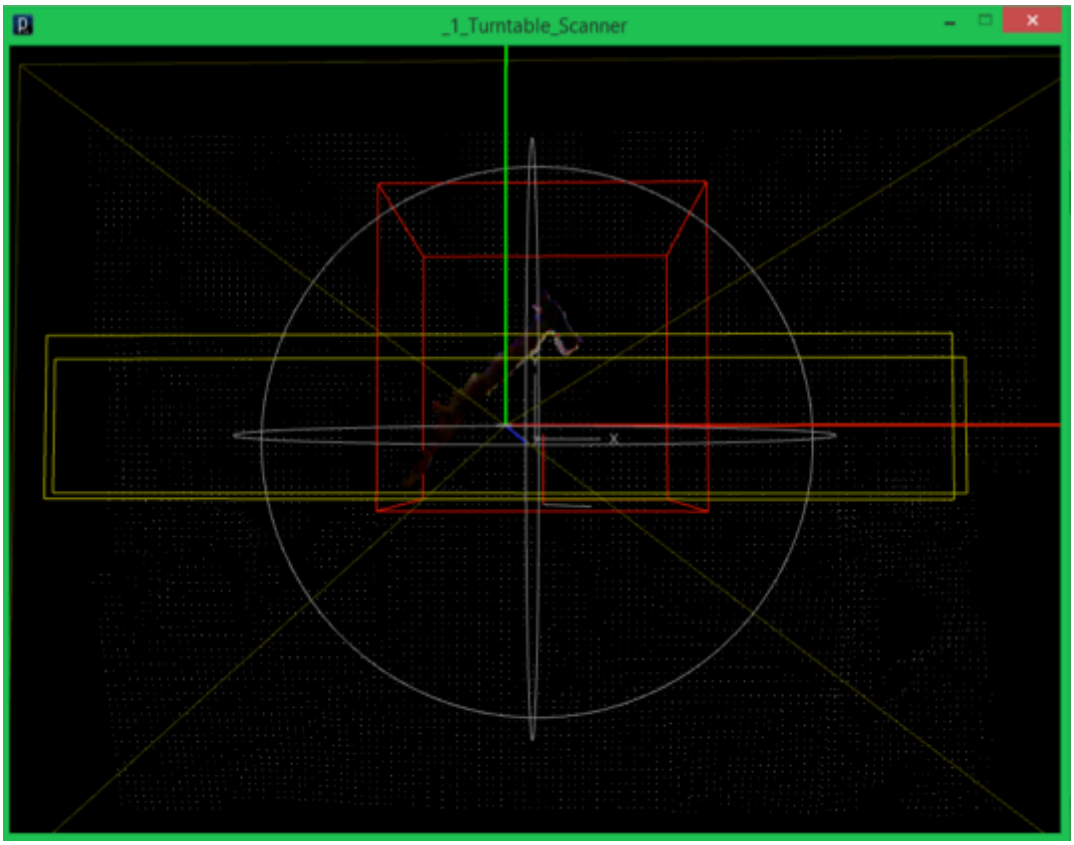
Flowchart-

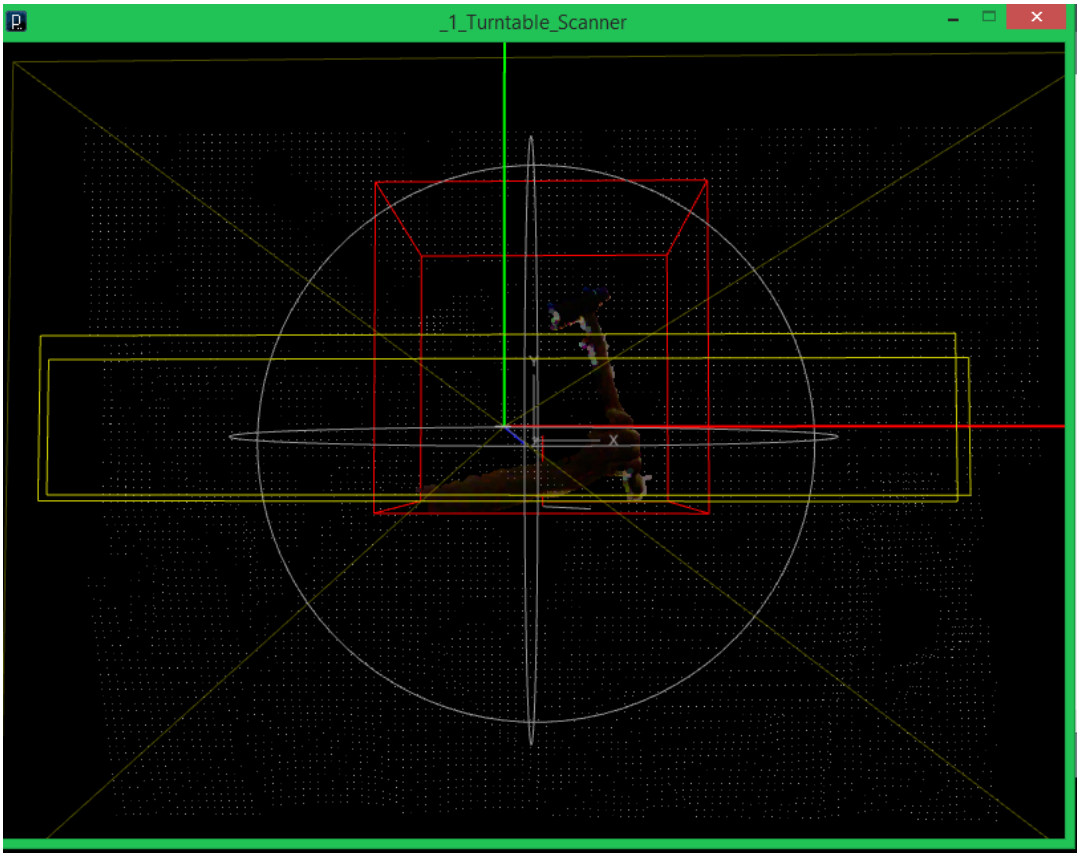

Place the object on turntable
Capture the image of the side using kinect
Condition: till we reach the initial side
Rotate the object by 60 degrees
Depth and RGB images are obtained
3D Point cloud is produced from the depth image
The point cloud is exported
The final 3d image is recontructed

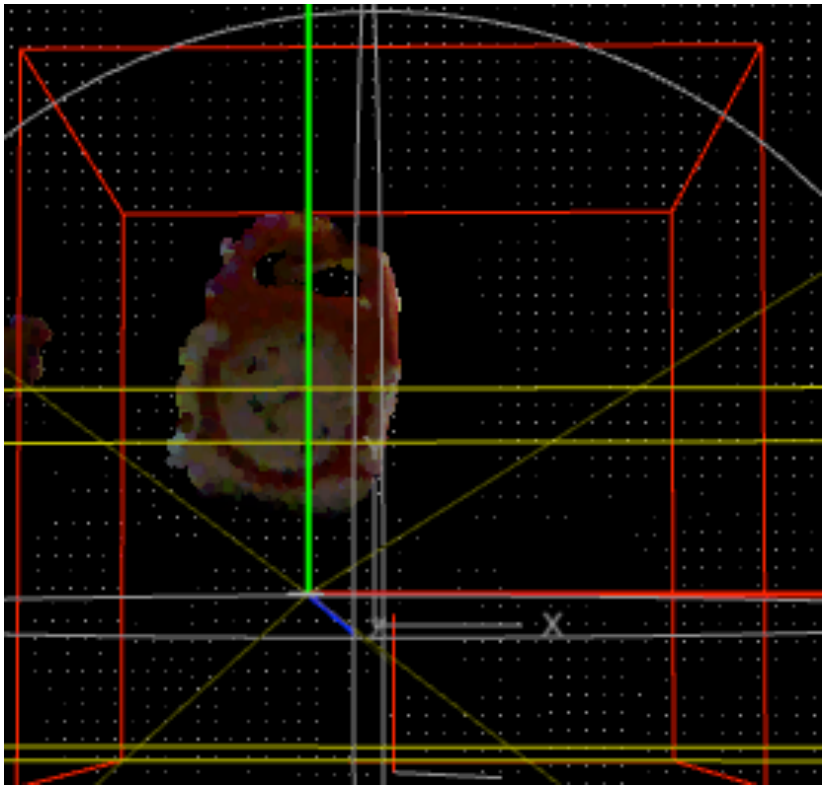
Mechanical Implementation



Processing Simulation




_1_Turntable_Scanner



Applications

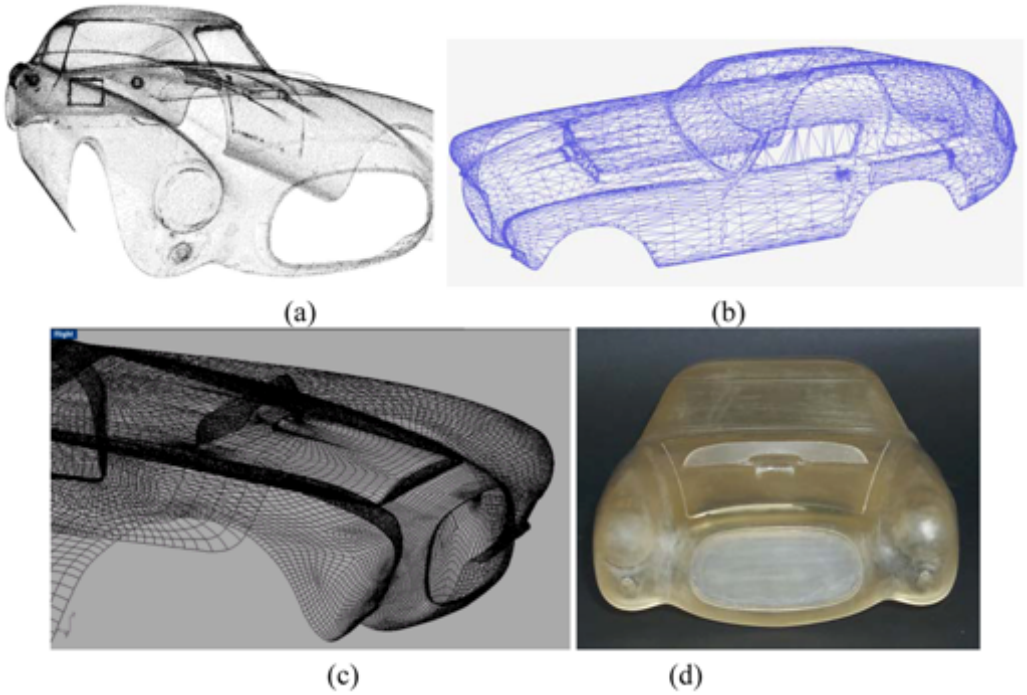
REVERSE ENGINEERING:

Reverse engineering of a mechanical component requires a precise digital model of the objects to be reproduced. The reverse-engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured using 3D scanning technologies like CMMs, laser scanners, structured light digitizers, or Industrial CT Scanning (computed tomography). The measured data alone, usually represented as a point cloud, lacks topological information and is therefore often processed and modeled into a more usable format such as a triangular-faced mesh, rather than a set of points a precise digital model can be represented by a polygon mesh, a set of flat or curved surfaces rather than a set of points therefore offering great flexibility and precision for handling both ANALYTIC and GEOMETRIC shapes, or ideally for mechanical components, a CAD solid model.

Current scenario doesn't give you flexibility of recreating from the real world, without professional help. A Kinect based scanner allows us to recreate everyday objects, such a forks and keys from existing one.

PACKAGING

In packaging design, there are two fundamental objects involved: the product and its package. Consequently, reverse engineering in the packaging industry can require dimensions from both objects. When designing a custom package for a specific product, its dimensions can be extracted and used as a reference to build the 3D CAD model of the package. After this operation, the dies or the molds can be properly fabricated with the resulting CAD model.



a. *Point cloud of a car body*
b. *Triangle Mesh*
c. *KINECT model*
d. *Scaled prototype*

Other Miscellaneous uses:

Medical Prosthetics
Quality assurance

Conclusion:

The above sections have highlighted our line of thinking and the steps needed to realize this prototype. We have also illustrated the practical applications of the same, keeping in mind the low penetration of 3D scanning in the hobbyist and enthusiast level