3D-KORN
Software Engineering
Unicorns

CONTENT

- Introduction
- Project Management
- High level design
- Acquisition
- 3D Registration
- Point Cloud Operations
- Graphical User Interface
- Demo

Introduction

- Main Objective
  - Build a home-made acquisition and processing software that does not depend on proprietary softwares
- Other goals
  - Improve the level of programming of all the students in the group
  - Robust design
  - User friendly system

Project Management

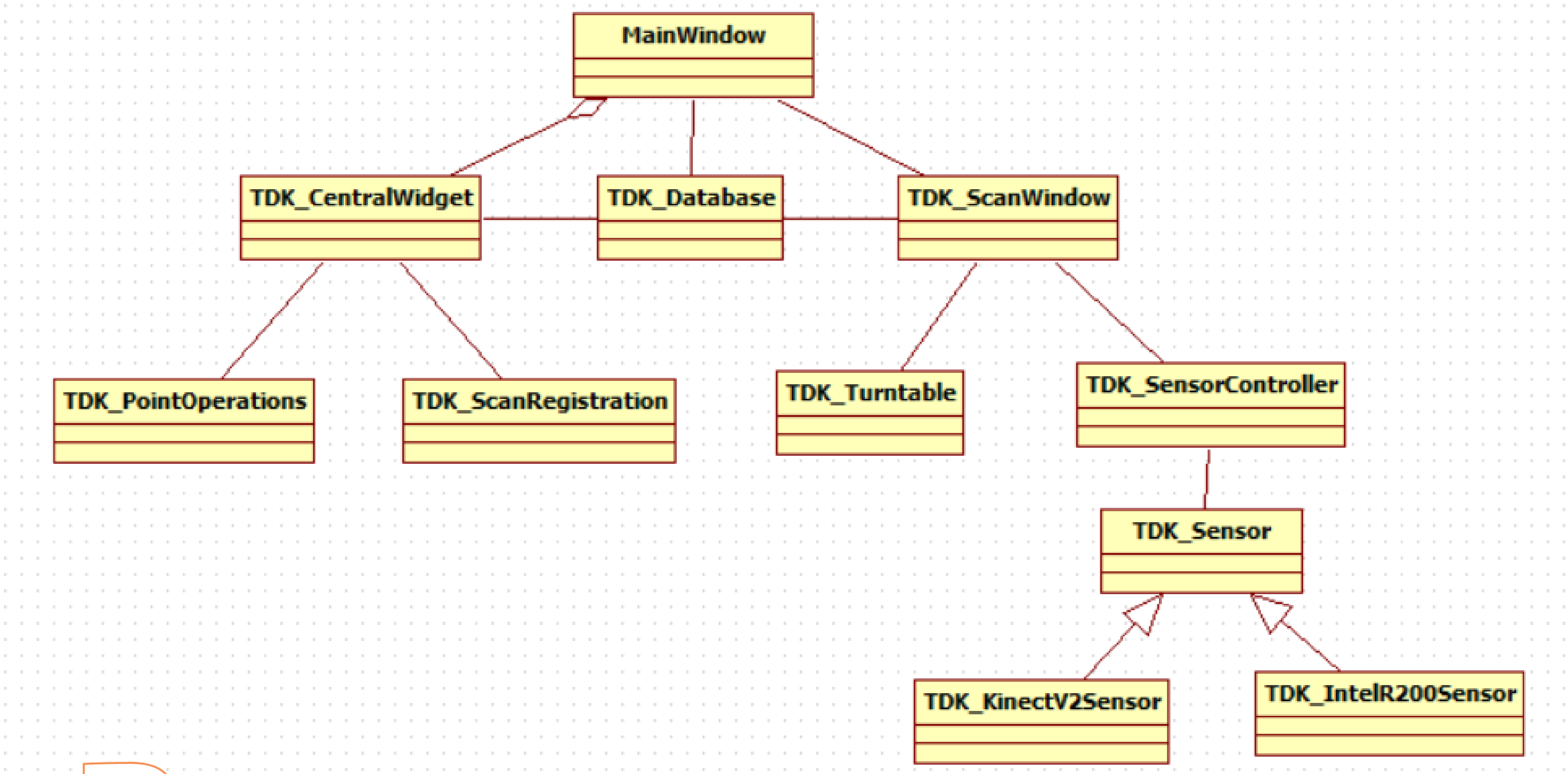
Project Management

- 11 members, different nationalities and languages
  - Collaboration platform
    - Trello - https://trello.com/b/inpECRpD/unicorns-main
    - Github repository - https://github.com/umaatgithub/3D-KORN
    - Google docs
    - Facebook group
- Divided into 4 teams after initial research
    - Acquisition team
    - 3D Registration team
    - Point cloud operations team
    - Graphical User Interface (GUI) team
  -

Project Management

- Skill set analysis chart
- Built group with a mix of skill set
- Task allocation chart
- Project specific coding standards
- 3 months
    - 1 month -> Requirement analysis & Proof of Concept
        - Output - High level design
    - 2 months -> Coding and Testing
        - Output - Final code, report, presentation

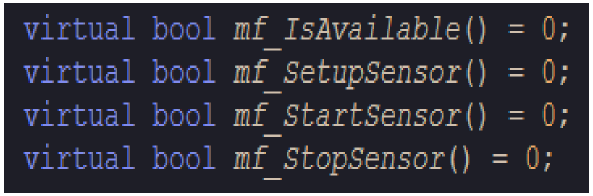
High Level Design



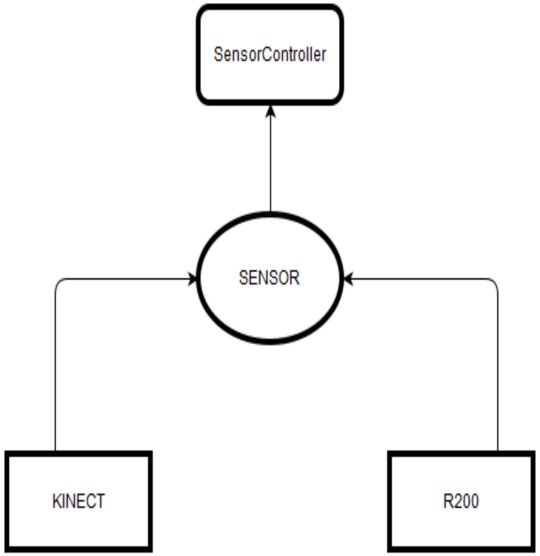
Acquisition

Tdk_sensor

- Abstract class:

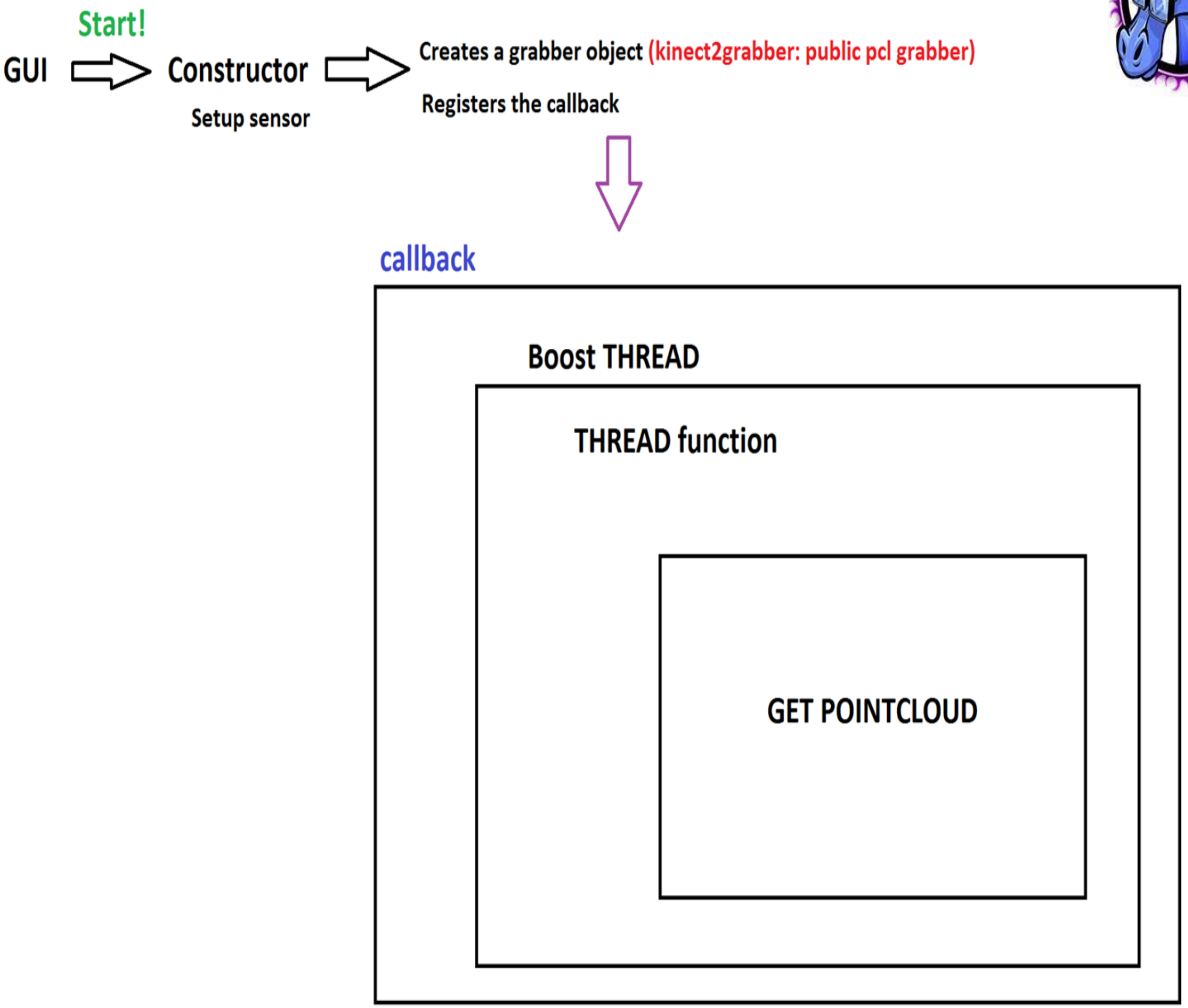


```
virtual bool mf_IsAvailable() = 0;
virtual bool mf_SetupSensor() = 0;
virtual bool mf_StartSensor() = 0;
virtual bool mf_StopSensor() = 0;
```



- Core functionalities:
  - Get pcl<pointXYZRGB> pointcloud from the sensor
    - Register a callback that uses a separate <boost>thread
      - Updates the Pointcloud every time a new valid Pointcloud is available
  - Get/set parameters from/of the sensor
    - Filter box
    - Sensor status

Wc



GUI

Start!

Constructor

Setup sensor

Creates a grabber object (kinect2grabber: public pcl grabber)

Registers the callback

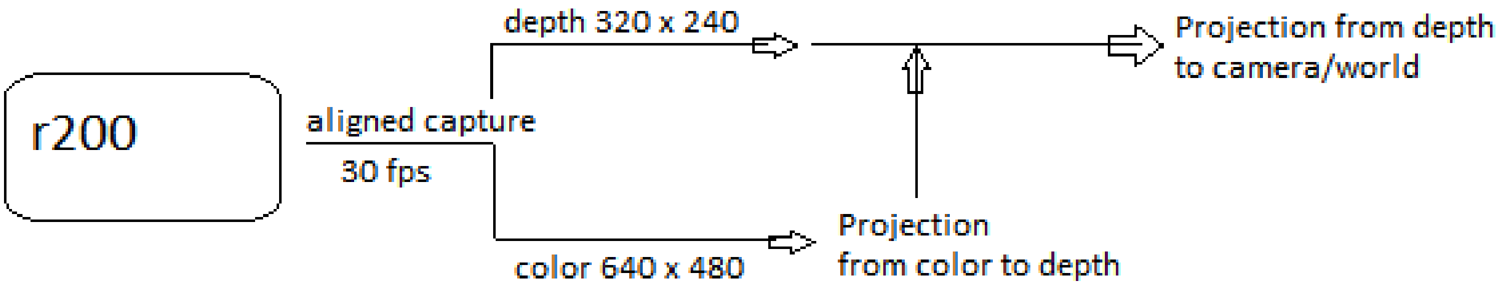
callback

Boost THREAD

THREAD function

GET POINTCLOUD

Acquisition with R200: tdk_intelr200sensor



r200

aligned capture

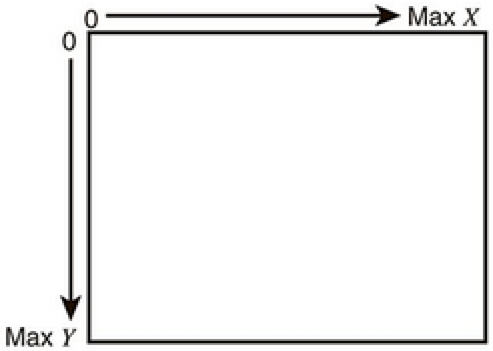
30 fps

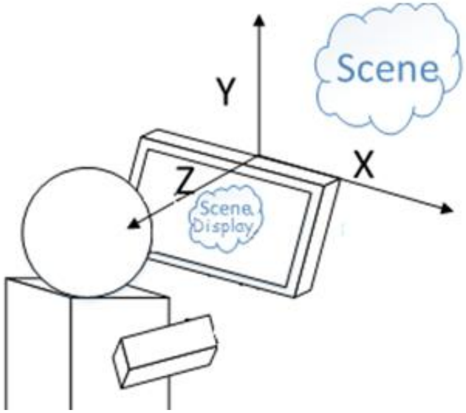
depth 320 x 240

color 640 x 480

Projection from color to depth

Projection from depth to camera/world





About the sensor:

Drawbacks:

-Noisy data (Low resolution depth image)

-Shorter working range than kinect

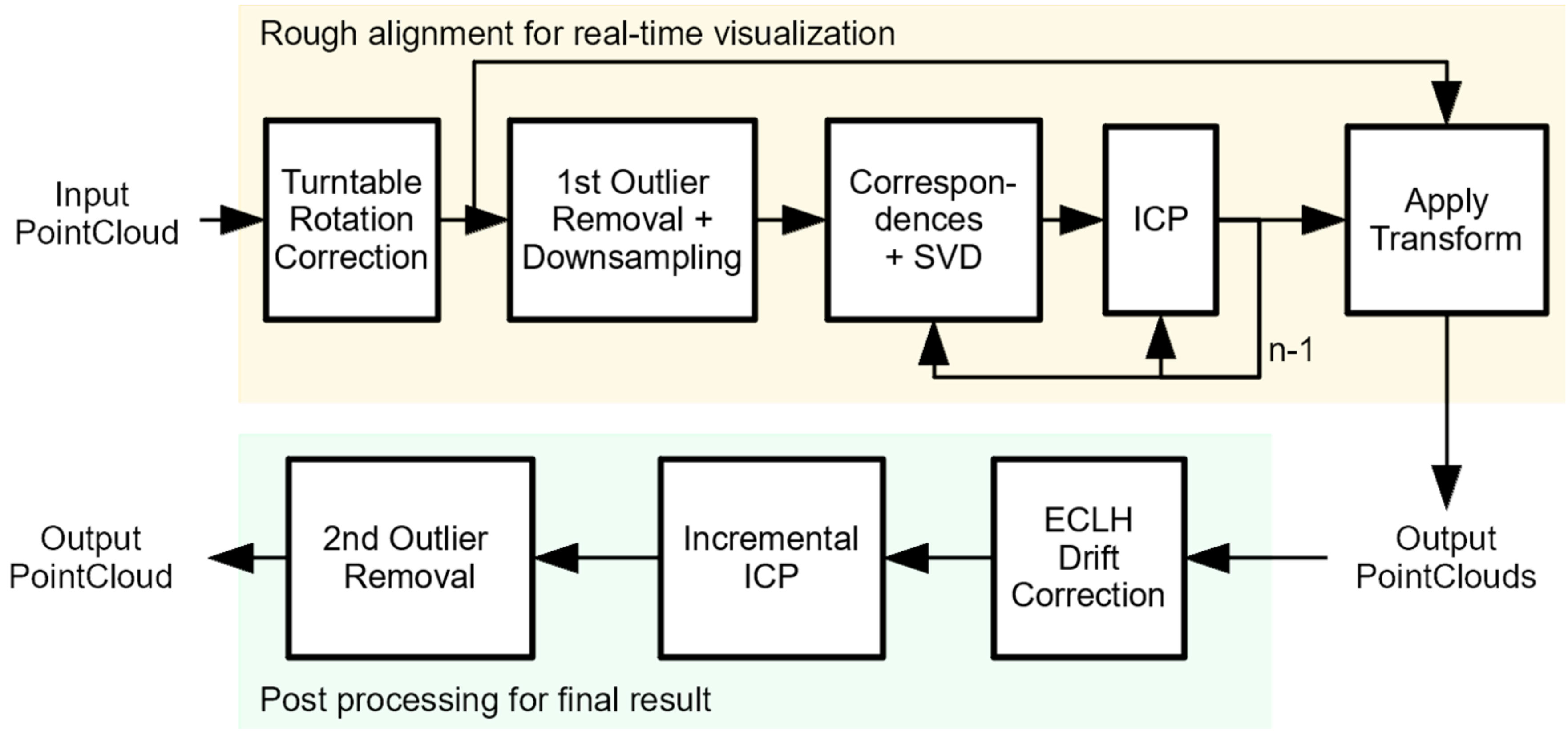
Advantages:

-Portable, small and cheap

-Good sdk (documentation)

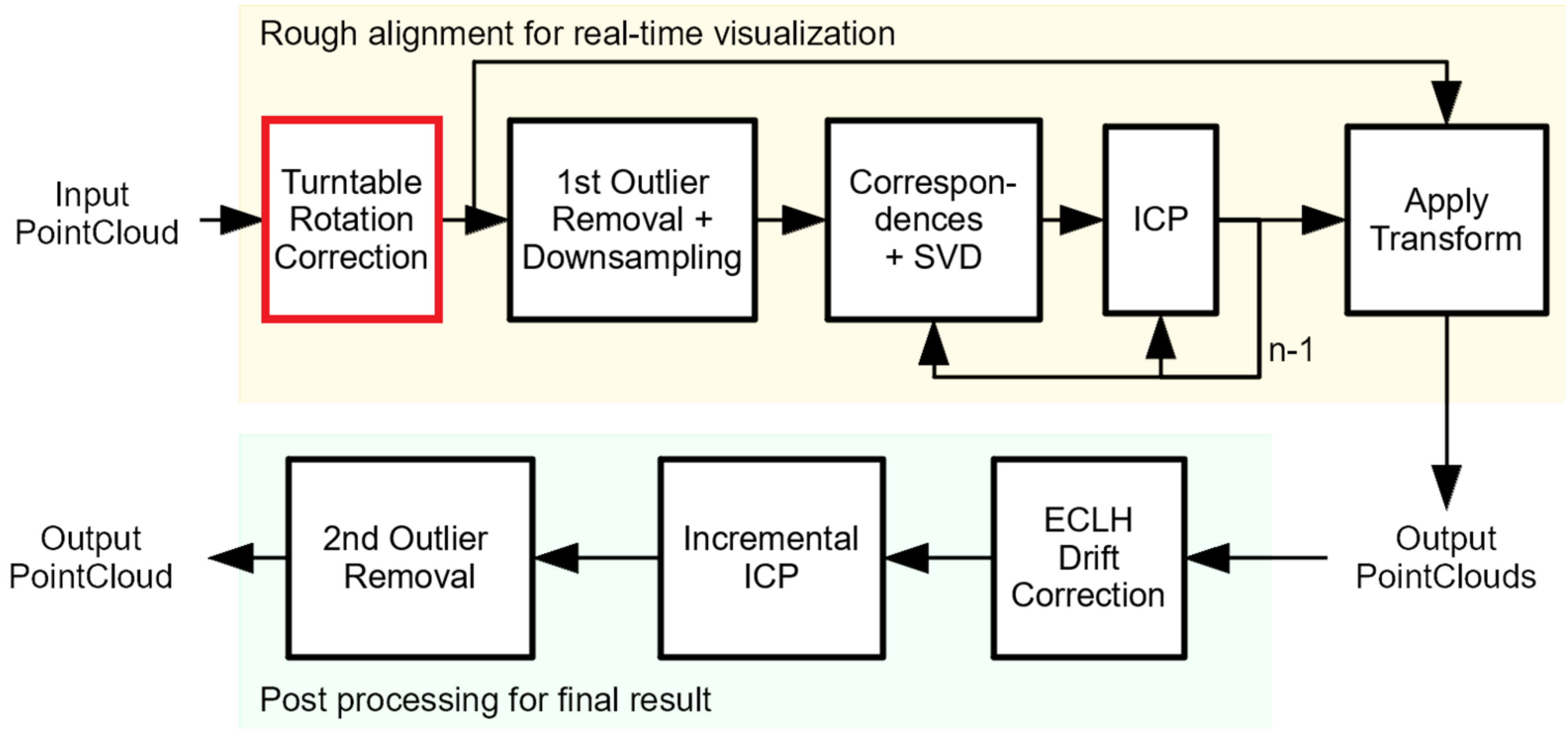
3D Registration

General Algorithm Overview.



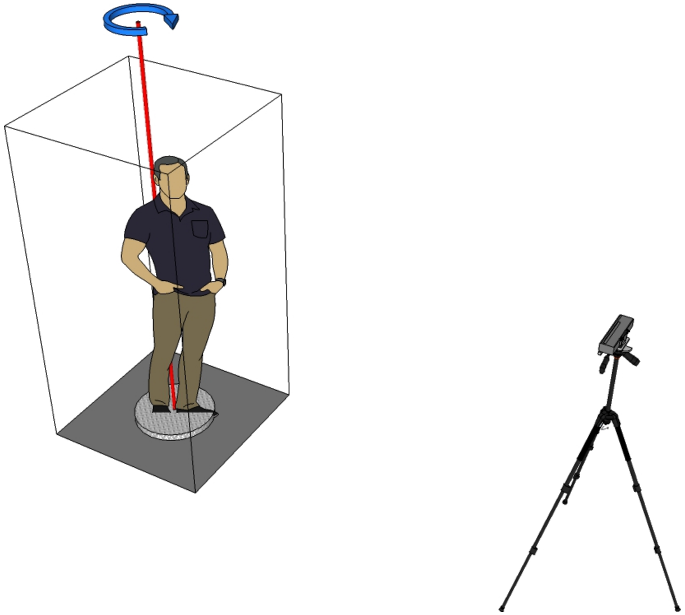
Registration chartflow. Rough and precise correction alignments (yellow and light-blue blocks respectively).

Turntable Rotation Compensation.

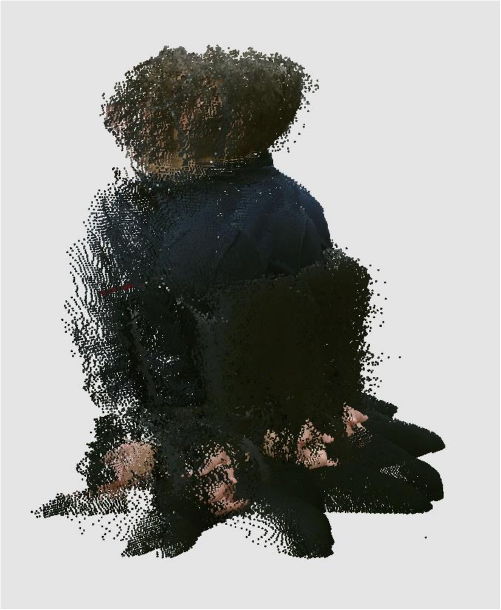


Registration chartflow. Rough and precise correction alignments (yellow and light-blue blocks respectively).

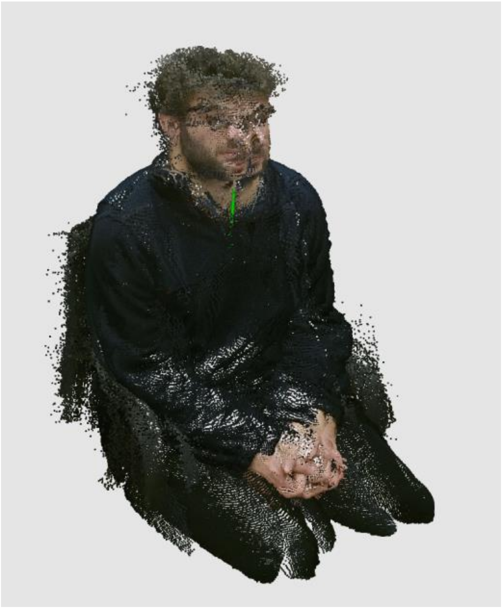
Turntable Rotation Compensation.



a) Rotation correction.



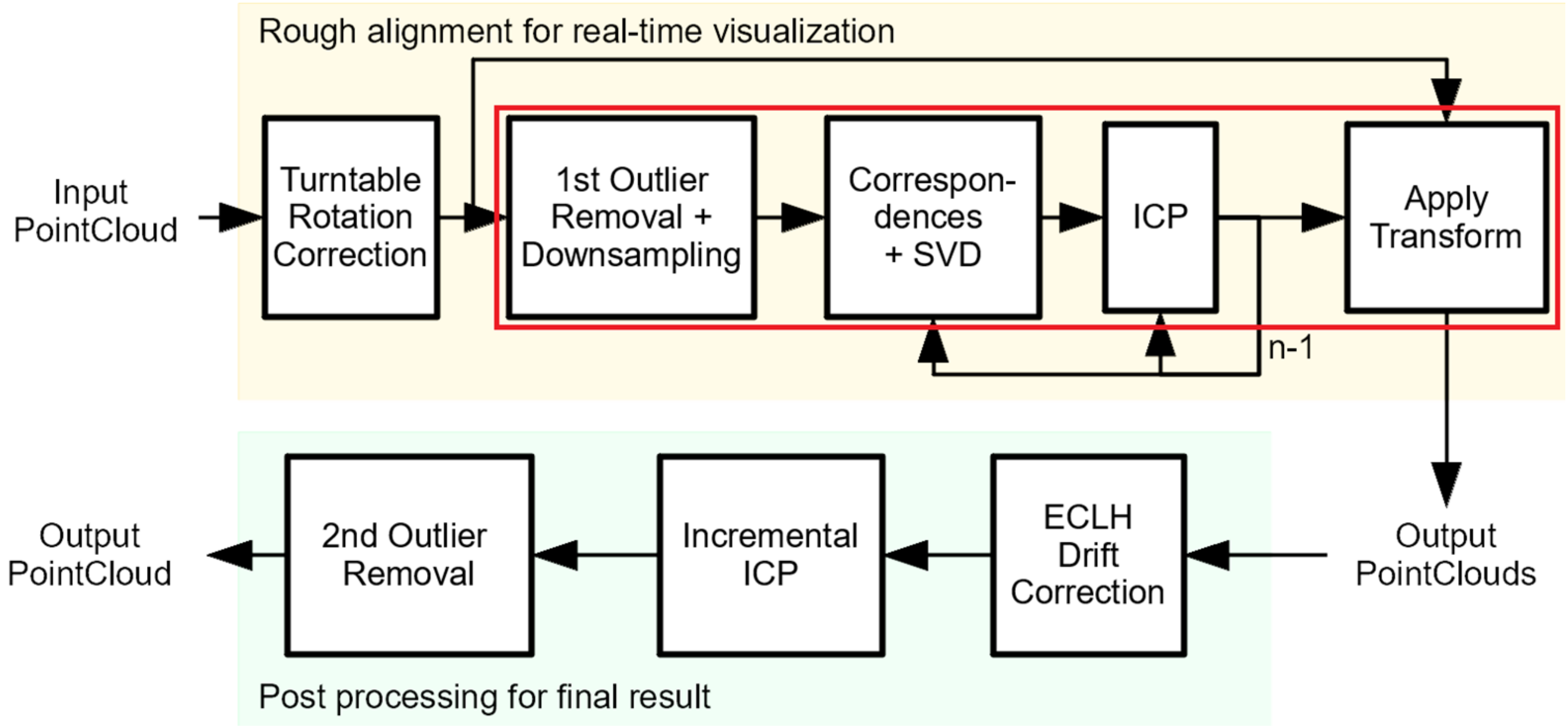
b) Raw data.



c) Pre-aligned raw data.

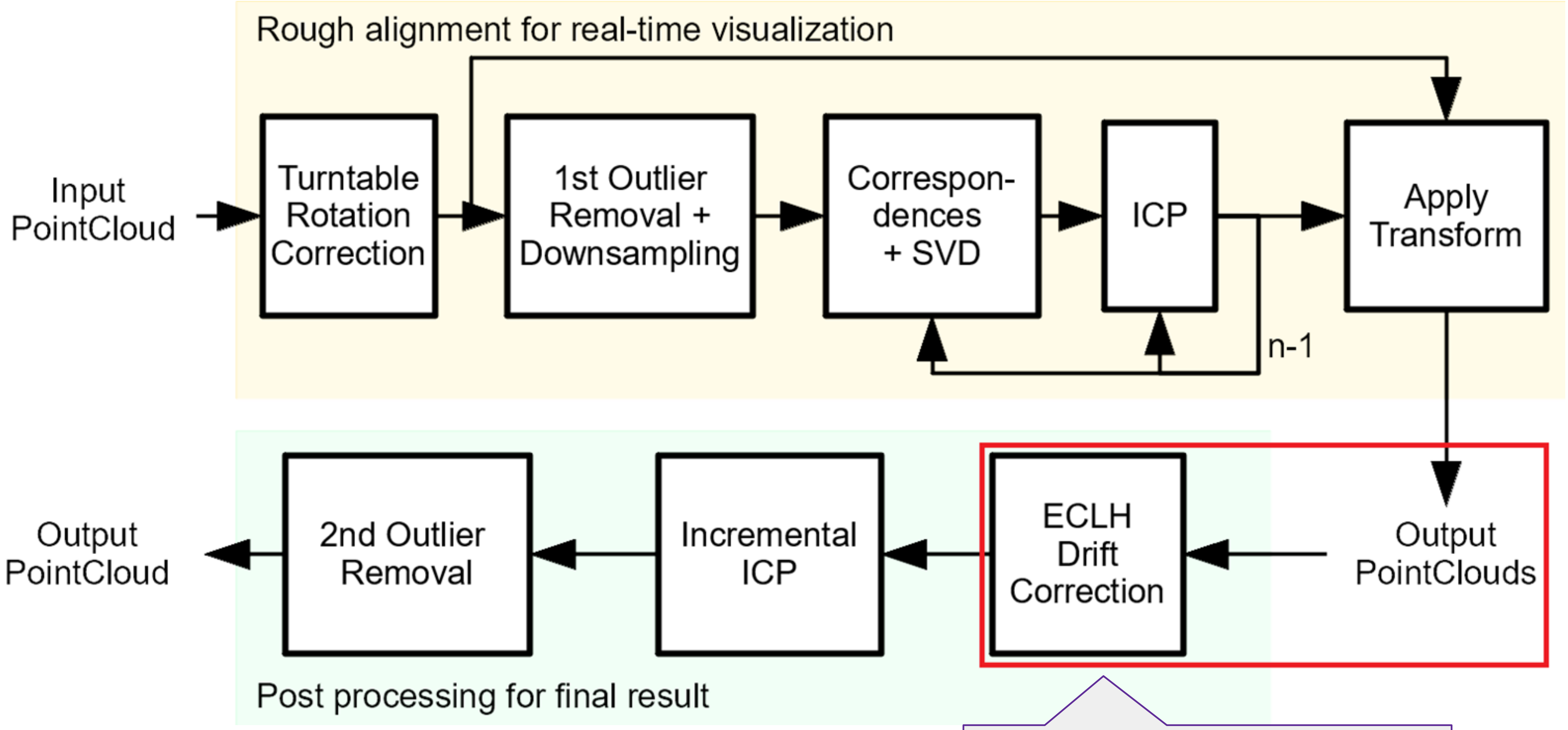
Rotation * Translation = Transformation

Pairwise Rough Alignment.



Registration chartflow. Rough and precise correction alignments (yellow and light-blue blocks respectively).

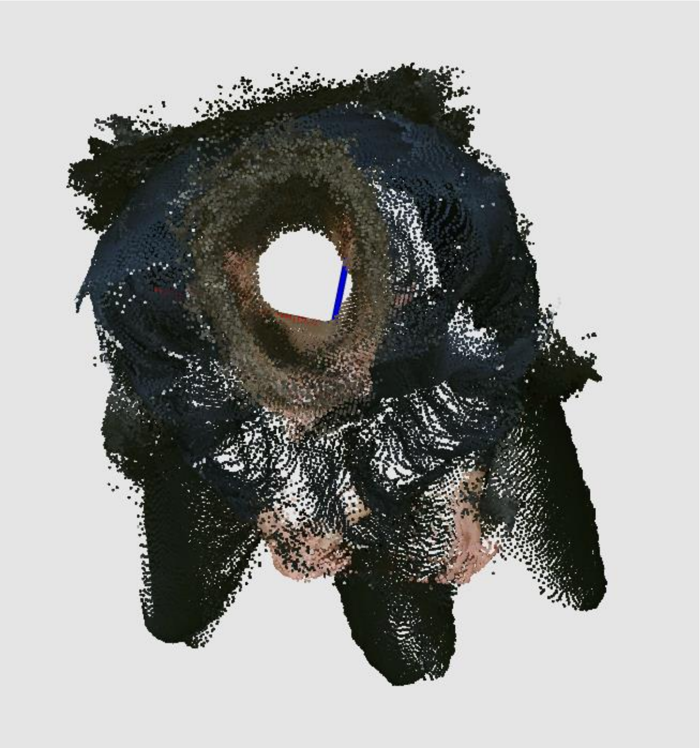
Loop Closing Correction.



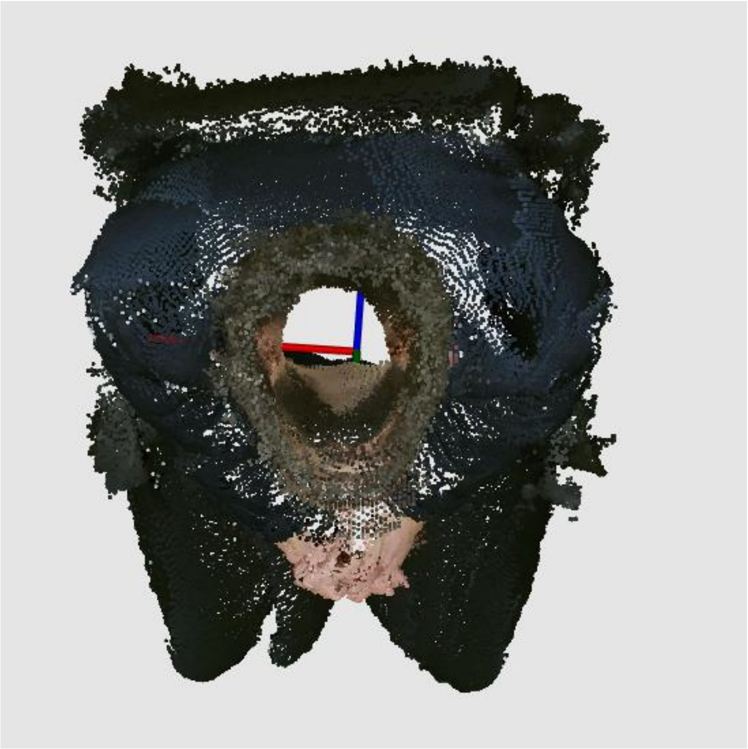
Explicit Loop Closing Heuristic (*Sprickerhof et. al* 2011)

Registration chartflow. Rough and precise correction alignments (yellow and light-blue blocks respectively).

Loop Closing Correction.

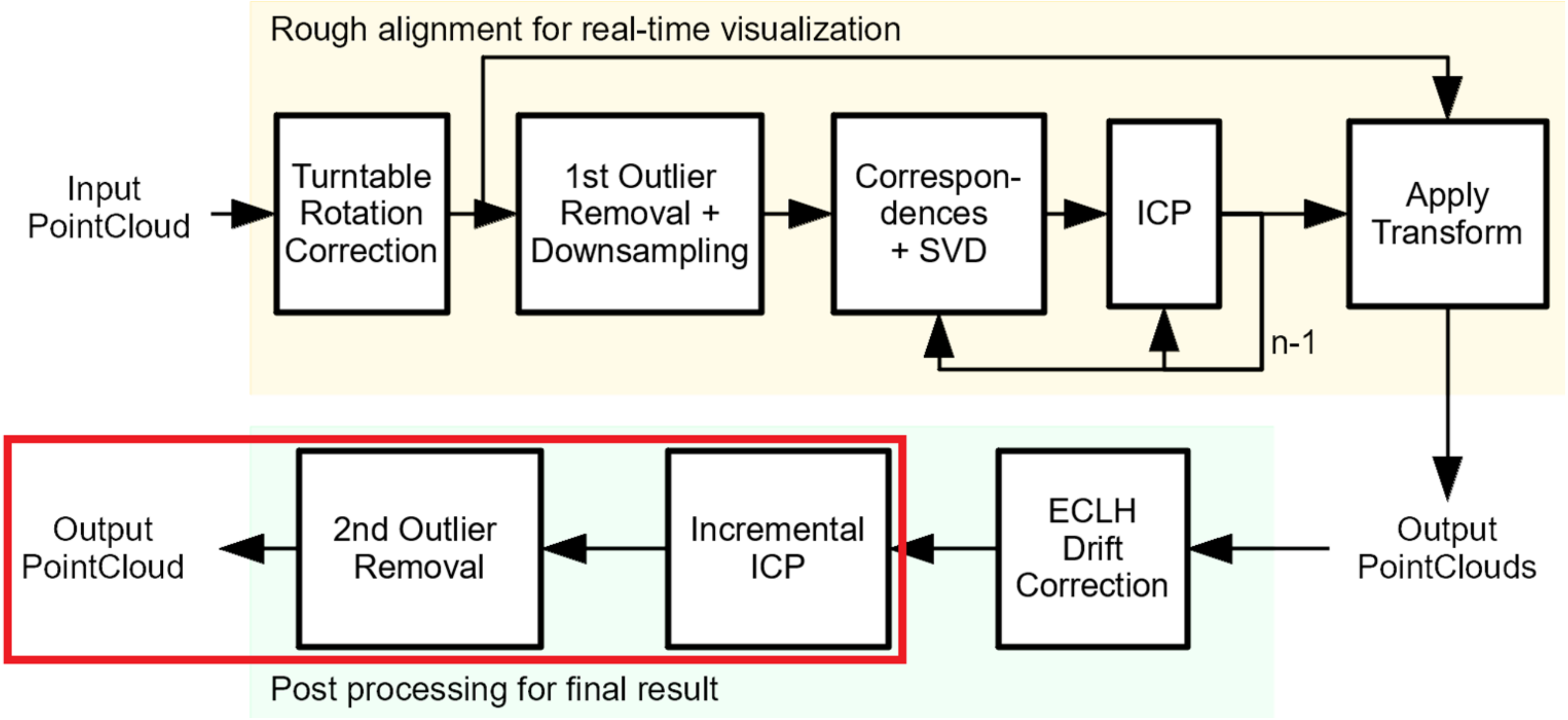


a) Pairwise Alignment.



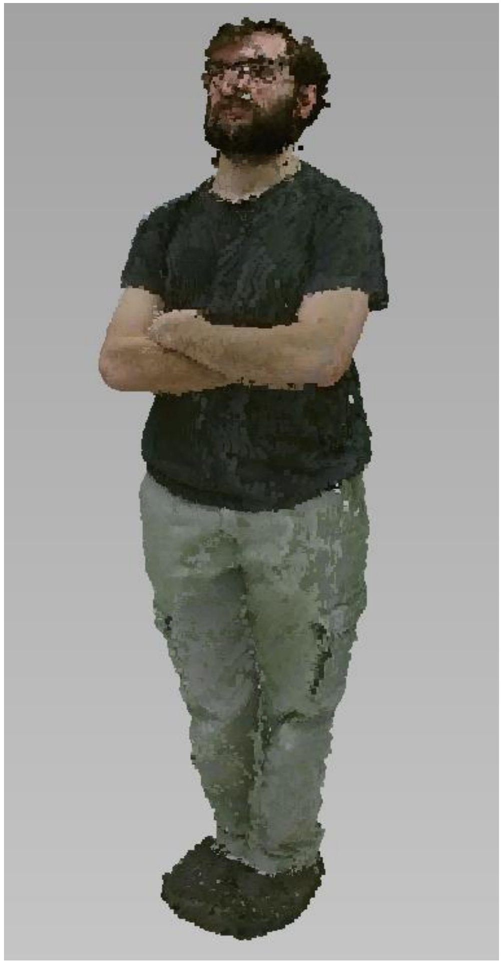
b) Alignment post ELCH.

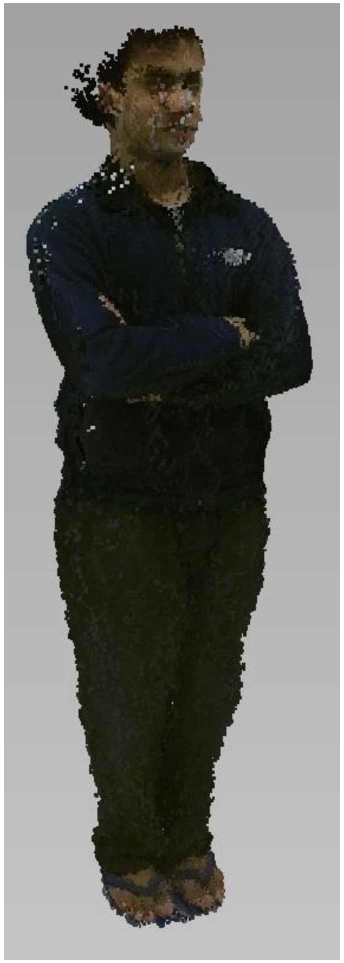
Second ICP layer and denoising.

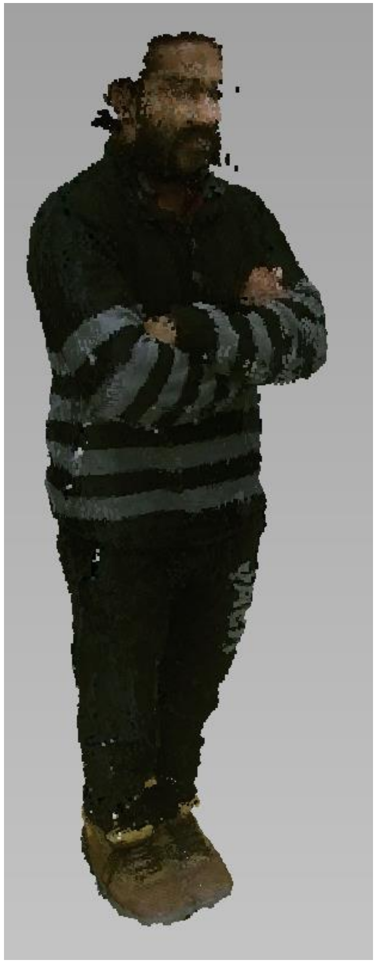


Registration chartflow. Rough and precise correction alignments (yellow and light-blue blocks respectively).

Registration Results.







Conclusions

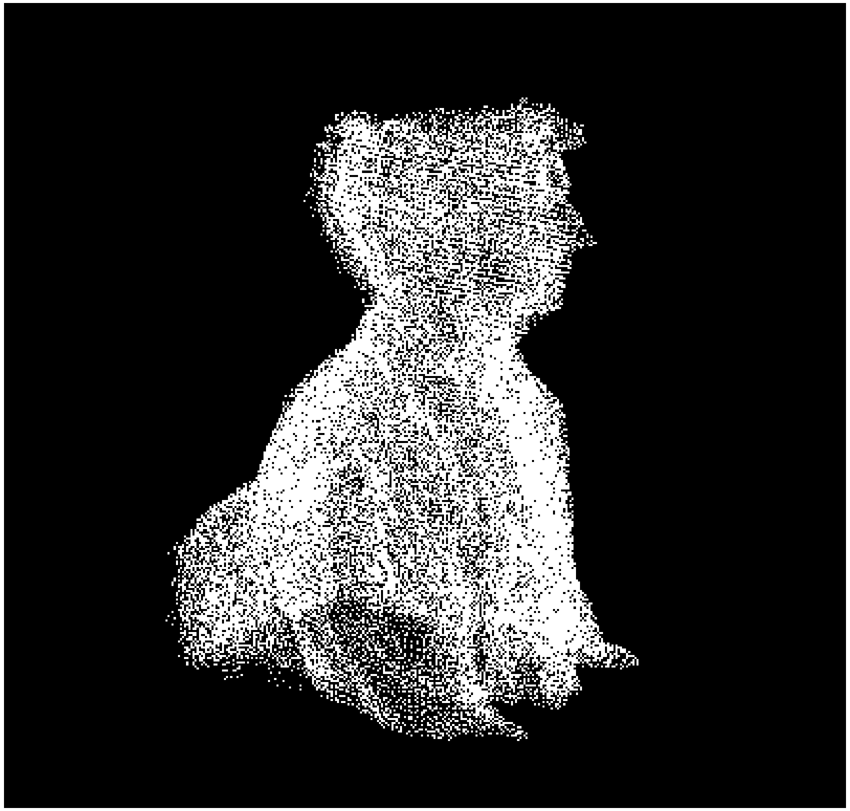
- Fast and easy prior knowledge pre-aligning strategy.
- Registration algorithm able to work with few amount of clouds (12 frames, 30 º).
- Rough registration allows real-time alignment preview.
- Cascade alignment steps provides extra robustness of the method to noise or poor parameter estimation.
- The developed class is modular and flexible for ease of future development.

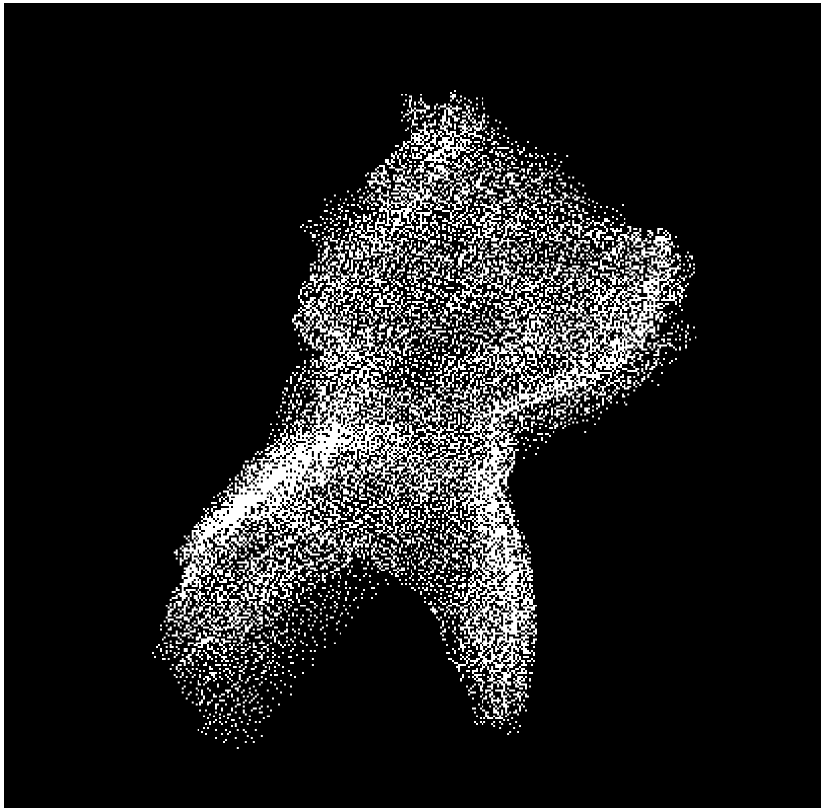
Point Cloud Operations

Point Cloud Operations

- Cropping Process
- Creating Mesh
- Saving & Loading & Converting

Point Cloud Operations : Cropping Process





Point Cloud Operations : Creating Mesh

- **Prepare the point cloud**

Voxel Filtering

MLS Smoothing

- **Three methods to create the mesh**

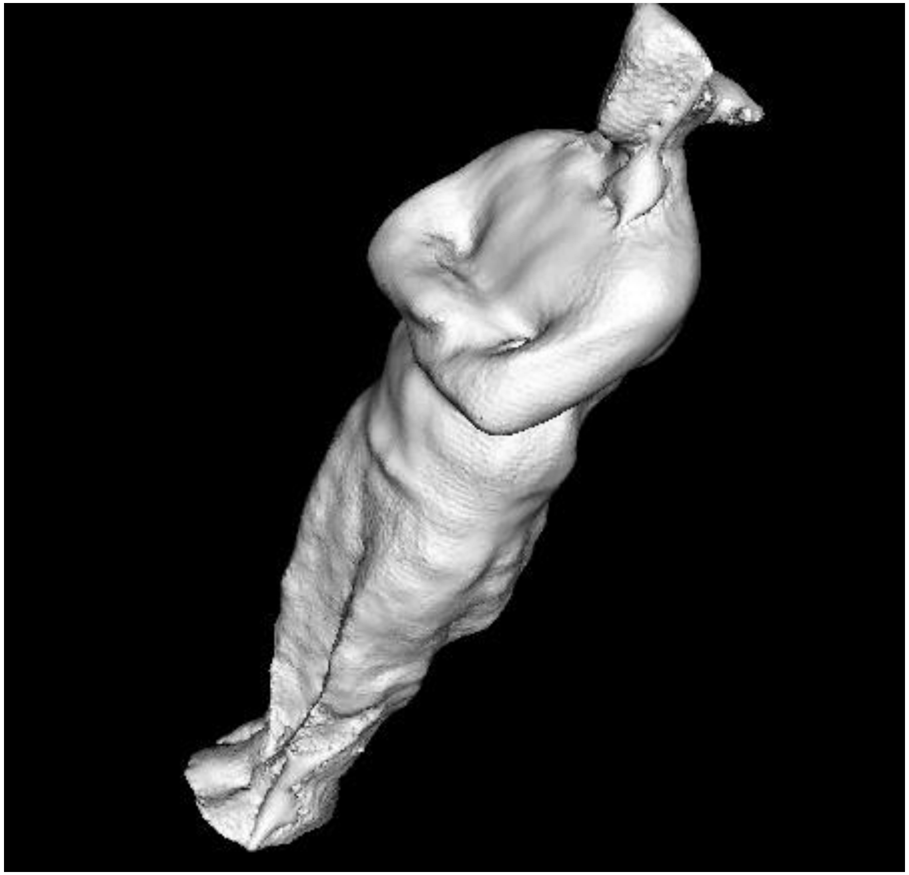
Poisson Algorithm

Greedy Algorithm

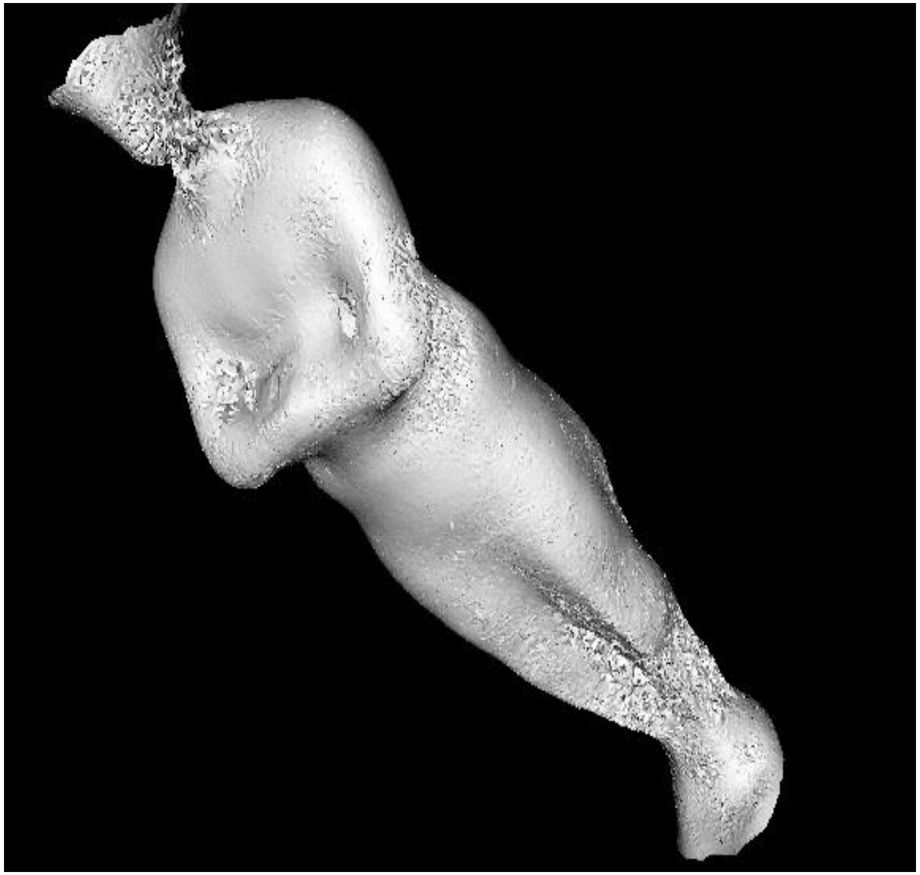
Marching Cube Algorithm

- **Postprocessing Algorithm Laplacian**

Point Cloud Operations :



Mesh from Poisson



Mesh from Greedy

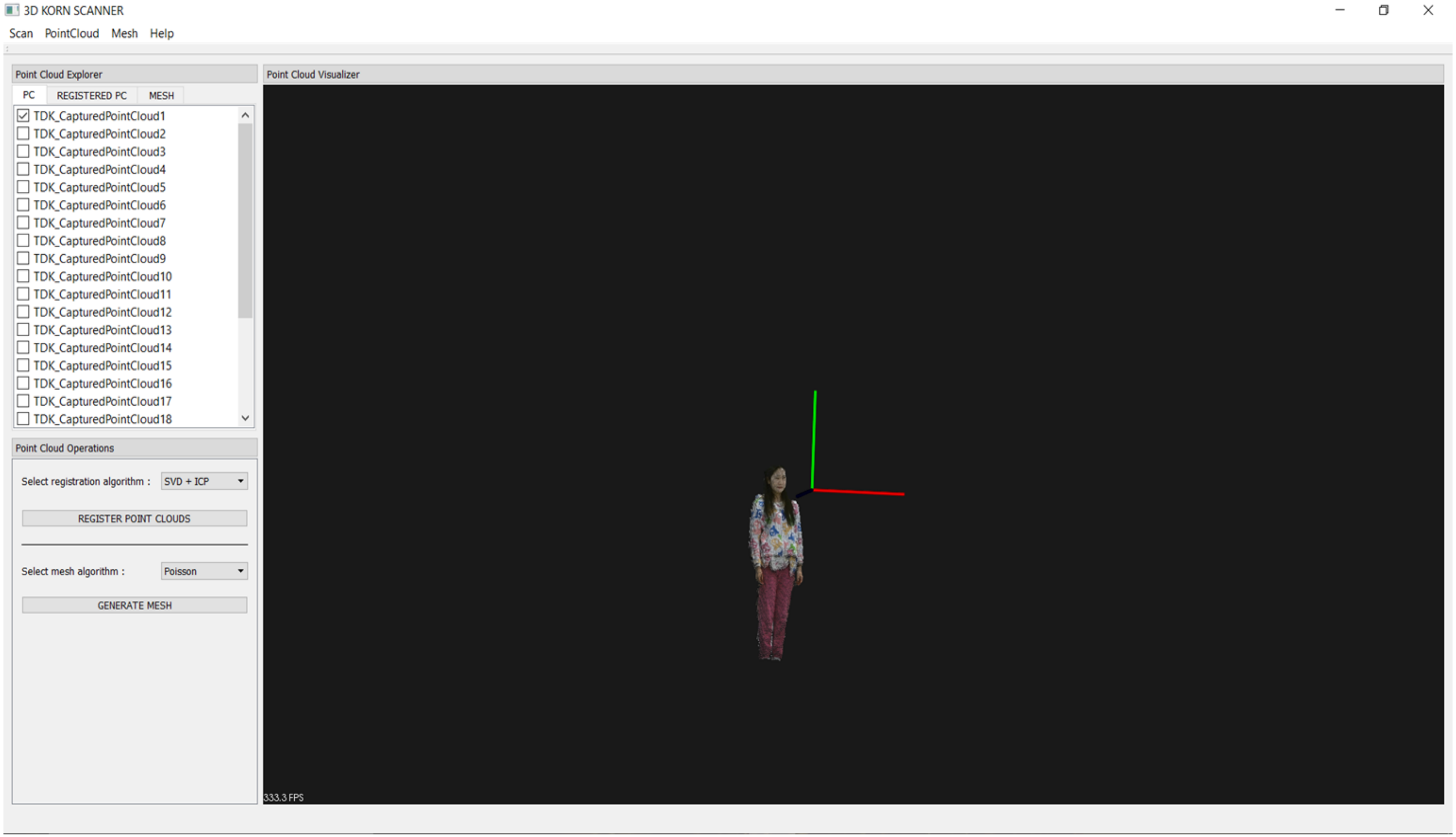
Point Cloud Operations : Saving & Loading

The point cloud and mesh can be saved in different formats:

- PCD, PLY (Mainly for point clouds)
- VTK, STL (For mesh)
- The final model can also be converted from VTK to STL which is readable for 3D printers.

Graphical User Interface

Main Window

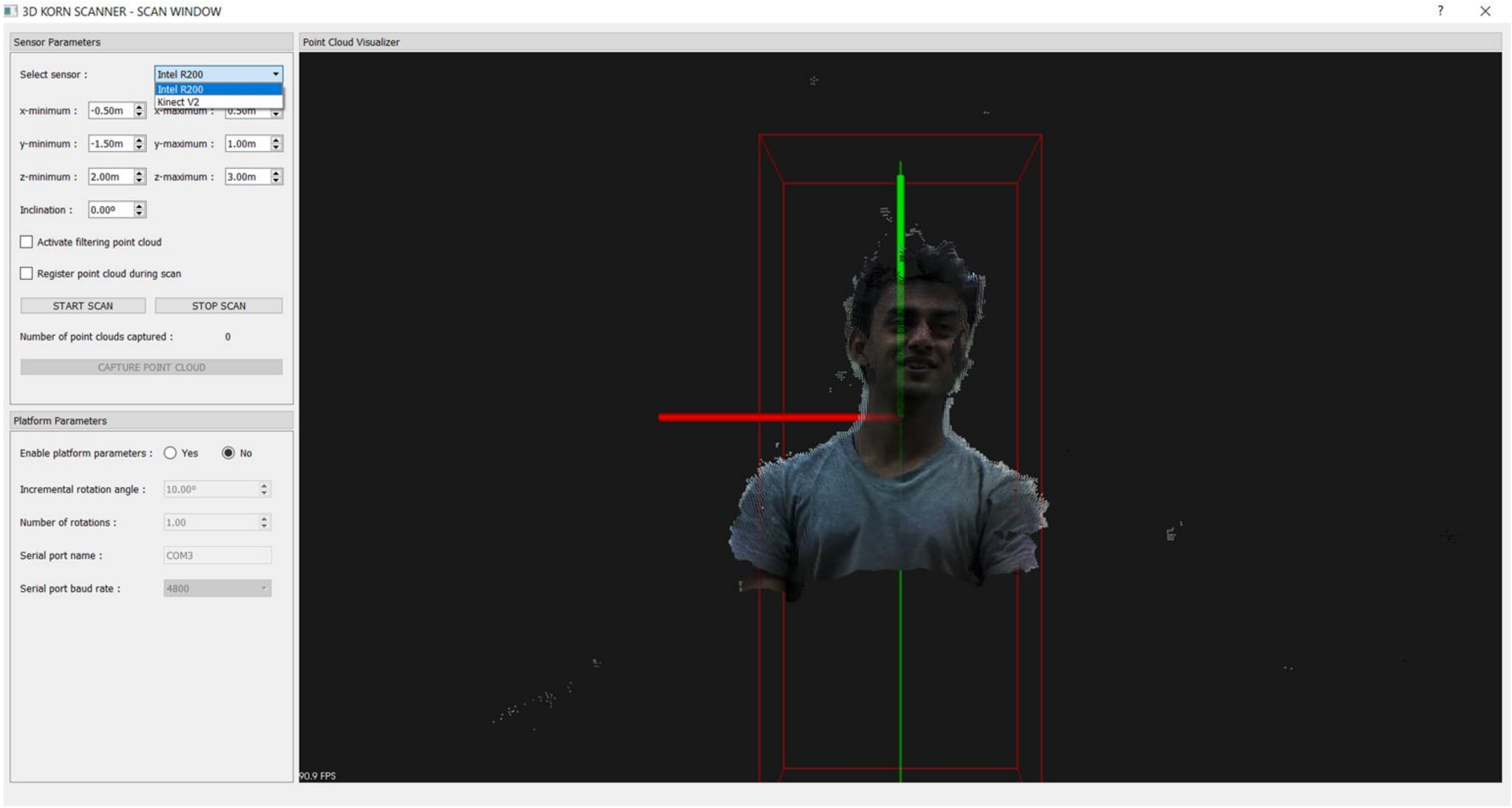


☑ TDK_CapturedPointCloud1
□ TDK_CapturedPointCloud2
□ TDK_CapturedPointCloud3
□ TDK_CapturedPointCloud4
□ TDK_CapturedPointCloud5
□ TDK_CapturedPointCloud6
□ TDK_CapturedPointCloud7
□ TDK_CapturedPointCloud8
□ TDK_CapturedPointCloud9
□ TDK_CapturedPointCloud10
□ TDK_CapturedPointCloud11
□ TDK_CapturedPointCloud12
□ TDK_CapturedPointCloud13
□ TDK_CapturedPointCloud14
□ TDK_CapturedPointCloud15
□ TDK_CapturedPointCloud16
□ TDK_CapturedPointCloud17
□ TDK_CapturedPointCloud18

Select registration algorithm : SVD + ICP

Select mesh algorithm : Poisson

Scan Window



Select sensor : Intel R200

x-minimum : -0.50m x-maximum : 0.50m

y-minimum : -1.50m y-maximum : 1.00m

z-minimum : 2.00m z-maximum : 3.00m

Inclination : 0.00º

☐ Activate filtering point cloud

☐ Register point cloud during scan

Number of point clouds captured : 0

Enable platform parameters : ○ Yes ● No

Incremental rotation angle : 10.00º

Number of rotations : 1.00

Serial port name : COM3

Serial port baud rate : 4800

Hardware interface

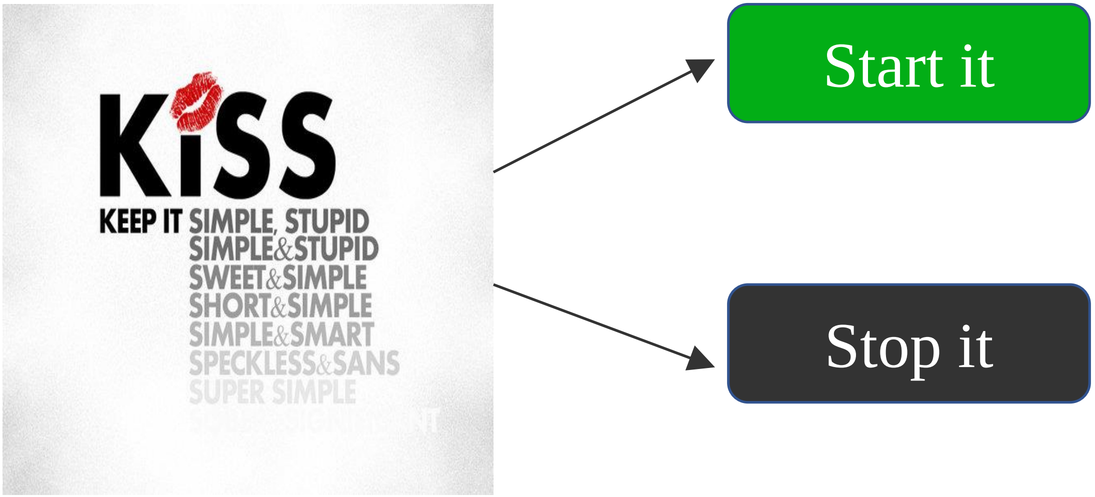
- Qserialport & Microcontroller
- Physical Turntable

QSerialPort & Microcontroller

- Bidirectional serial communication
- Minimal serial communication → Very low risk of serial overloading
- Core functionalities:
  - Start acquisition
  - Stop acquisition
  - Set step angle and number of rotations*
- Acquisition modes:
  - Manual acquisition
  - *EncodScan* TM *

QSerialPort & Microcontroller

EncodScan™



Start it

Stop it

<u>FULLY AUTOMATED ACQUISITION</u>

Physical turntable

Microcontroller	20€	1€
Waistboard	10€	2€
Conducting chain	15€	2€
DC motor	10€	5€
Driver	3€	1€
Encoder	20€	5€

16€ → **199€**

The Best is Yet to Come
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