

OLA – Organizational Life Assistant

FOR FUTURE ACTIVE AGEING

D2.4 Multimodal data Collection

Project Identification	
Project Number	AAL 2014-076
Duration	38 months (1 st March 2015 – 30th April 2018)
Coordinator	Carla Santos
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Website	http://project-ola.eu/

Document Identification	
Deliverable ID	D2.4 Multimodal data Collection
Version/Date	V0.5 / 15.09.2016
Leader of the Deliverable	ISCTE-IUL
Work Status	Finished
Review Status	Accepted

Deliverable Information	
Deliverable Description	Details the unintegrated object classification system developed by ISCTE-IUL, the associated RGD-B dataset and low-cost scanner setup.
Dissemination Level	Public
Deliverable Type	Report
Original Due Date	M24

Authorship & Review Information	
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1 Executive Summary

The present deliverable 2.4 a) includes the description of the Off-line Data collection platform.

In relation to this platform, included in the OLA Environmental modules (see Deliverables 2.1 a) and b)), we here present the ISCTE-IUL RGB-D Dataset and Collection Setup that is used in the object classification module of the OLA platform.

The ISCTE-IUL RGB-D Dataset is a collection of objects scanned with the Scanner of everyday objects (ISCTE-IUL) which is being expanded in the context of the OLA project.

2 Document Context

2.1 Role of the Deliverable

This deliverable presents the offline Data collection platform of the OLA project.

Relationship to other Project Deliverables

Deliv.	Relation
D1.3	Title: Technical specification Specifications OLA system for the data platform ready and a multimodal database.
D2.1	Title: Space and object reconstruction and classification(a) 3D object and space reconstruction, b) System for proposing space transformations) This deliverable is based on the OLA environmental analysis described in D2.1
D2.3	Title: Multimodal interaction The data collection platform presented in this deliverables follows the input and output interface described on D2.3

2.2 Target Audience of the Deliverable

This document is a public deliverable. Still, it is mainly intended for the project partners and the European Commission services thus the document will be made public, but not specifically disseminated on a wider scale.

3 Project Description

3.1 General Description

This project aims to offer an answer to the societal challenges by providing an innovative Organizational Life Assistant (OLA), a virtual presence that supports instrumental activities relating to daily living needs of older adults allowing them to be more independent, self-assured and to have a healthier, safer and organized life, while easing caregivers work.

OLA will mediate and facilitate interaction (communication and collaboration) between senior citizens and their informal caregivers or other services or professionals, through technological devices such as standard computers, mobile devices (tablets) and home automation modules. These ICT (Information and Communications Technology) devices will be based on an innovative multimodal model, embracing various physical/healthy and cognitive characteristics of the older adults and will be specifically oriented to increase the level of independence of the elderly, by supporting the possibility of carers' assistance remotely and by improving the accessibility to existing services on the Web, such as on-line shopping services.

Moreover, the OLA will also provide personalized well-being and safety advices to older users in order to avoid unwanted age related health and safety situations in their own home. Such a well-being and safety advisor makes uses of a combination of user information that is collected (personal physical/health and cognitive characteristics) and extracted through emotion recognition and various sensors.

OLA also addresses a major issue that elderly face related to memory degradation and gradual decreasing of their cognitive capabilities, enabling them to remember primary health care and fiscal obligations (e.g. personal hygiene, medical and tax compliance) or helping them to find everyday items such as eyeglasses, wallet or keys. It is based on speech dialogue interfaces and space and object reconstruction and classification to capture and store daily routines and their related contexts.

The primary end-users are the big group of 65+ adults living alone with or without light physical or cognitive age related limitations, who need support from care systems. Secondary end-users are both formal and informal caregivers from public or private sectors, supporting them to cope with the increased demand for care.

3.2 System Description

OLA addresses specifically the following main issues:

- **Well-being advisor:** based on the combination of the collected user information (personal, healthy characteristics) and user interaction information (extracted through emotion recognition, sensors settings and contextual recorder capturing the routines as done by the older adult), the system will propose to the older adults personal advice adapted to their situation contributing to their preservation and well-being status in home environment. In case of risk (e.g. irregular heart rate, extreme fatigue) the system may ensure an alert to a local medical emergency service.
- **Collaborative care organizer:** based on the ISCTE-IUL and LM's knowledge of developing human-computer interaction platforms (HCI), OLA will provide online care collaboration between family and professional caregivers, by enabling a local care network to communicate, access sensor data, and coordinate care tasks. With the OLA assistant, seniors will be able to actively participate in the care organization through voice, even when they are unwilling or unable to use traditional web applications.
- **Safety advisor:** based on the combination of collected user environment information through real-time analysis and augmented reality settings, the system will propose suggestions of environment changes that interfere with accessible paths and provide alerts for intruders or other situations that can create hazard situations. In case of risk (e.g. checking intruders or fire), the system may contact local emergency services.
- **Every day instrumental daily living activities memory support:** the system will anticipate medical and fiscal compliances, remember primary health care and food requirements and could help elderly to find displaced everyday items.
- **Environment analysis:** algorithms for real-time object recognition and scene understanding will be developed based on a number of inputs (i.e. 3D object and space reconstruction by using time-of-flight and augmented reality technology) in order to analyze and decide which action to be taken in order support the elderly by suggesting environment changes and providing hints/advice for safety and accessible environments.
- **Multimodal interaction for elderly:** An adaptive organizational life assistant, a virtual presence will be developed in order to facilitating communication and collaboration between older-adults and informal caregivers or other services or professionals. This will be a user-friendly system that uses multimodal approaches based on non-invasive



and minimally obtrusive technologies (i.e. speech, silent speech, touch, gestures, RGB-D sensors).

The overall OLA system will be an easy to download and install software making use of multimodal integrated settings. OLA is in essence a service that enables the elderly user to reduce the demand of care through prevention and self-management, while at the same time also facilitating the supply of formal and informal care assistance.

A series of well-selected use cases where older adults have been supported by caregivers and care professional services will be developed, as well as pilots representing different use cases. Care units will use the system over a one year period. A new evaluation approach will be used during the pilots, investigating up to which point the OLA services alleviate caregivers support and maintain, or even improve the self-management, health and safe lifestyle of the older adult at home.

3.3 Status and Future Developments

This deliverable is in its final version achieved with some delay; given the availability of a prototype and the possibility of undertaking end-to-end use cases concerning data usage.



4 Offline Data Collection Platform

4.1 RGB-D technology in the Context of the OLA project

With the arrival of the Kinect devices, in November 2010, the Kinect SDK, in June 2011, and in particular the Kinect for Windows kits, in February 2012, low-cost RGB-D sensing technology was made available to the consumer.

Currently this technology has gain wide acceptance in the scientific community and is rapidly entering consumers' homes and lives with devices like the Kinect V1 and V2, from Microsoft (Microsoft Corporation, 2016), the RealSense Cameras, from Intel (Intel Corporation, 2016), and Project Tango, from Google (Google, 2016).

This opened a wide range of new applications that make use of these technologies on day to day tasks, from new search queries types and augmented reality experiences to space analysis and object scanning.

In the context of the OLA project we use these technologies to facilitate the interaction with the Organisational Live Assistant application, with the introduction of gesture inputs, and in the OLA Environmental Analysis, for part of the detection of architectural barriers and hazards on the users' homes' system.

4.2 RGB-D Scanner

4.2.1 Overview

The ISCTE-IUL RGB-D Scanner (Figure 1) was initially developed by Pedro Proença and further consolidated by Pedro Pascoal (Pascoal et al., 2015) with the goal of developing a low-cost setup that allowed to cheaply and quickly scan small-sized objects. This research was the first step for the creation of ISCTE-IUL Dataset which currently is being used to the collection of new objects and categories for the OLA project.



FIGURE 1 - RGB-D SCANNER

4.2.2 System Specification

The ISCTE-IUL RGB-D Scanner is constituted by a hardware setup and a software suite, scanning and processing programs.

Hardware

The Scanner setup is constituted by a Kinect V2 on a height adjustable tripod and a turning table driven by a Stepper motor, respective motor driver and Arduino Uno controller board.

Additionally, a computer is needed with the following hardware and software requirements:

- Hardware:
 - 64-bit (x64) dual core processor with 4 threads at 3.1GHz;
 - 4 GB of RAM memory;
 - 1x USB 3.0 controller dedicated to the Kinect V2 sensor;
 - 1x USB 2.0 controller dedicated to the Arduino One Board;
 - DX11 capable graphics.
- Software:
 - Visual Studio 10 and 12;
 - [PCL 1.6.0 x64](#);
 - [Kinect SDK 2.0](#);

- [Arduino Drivers](#);
- [Notepad ++](#).

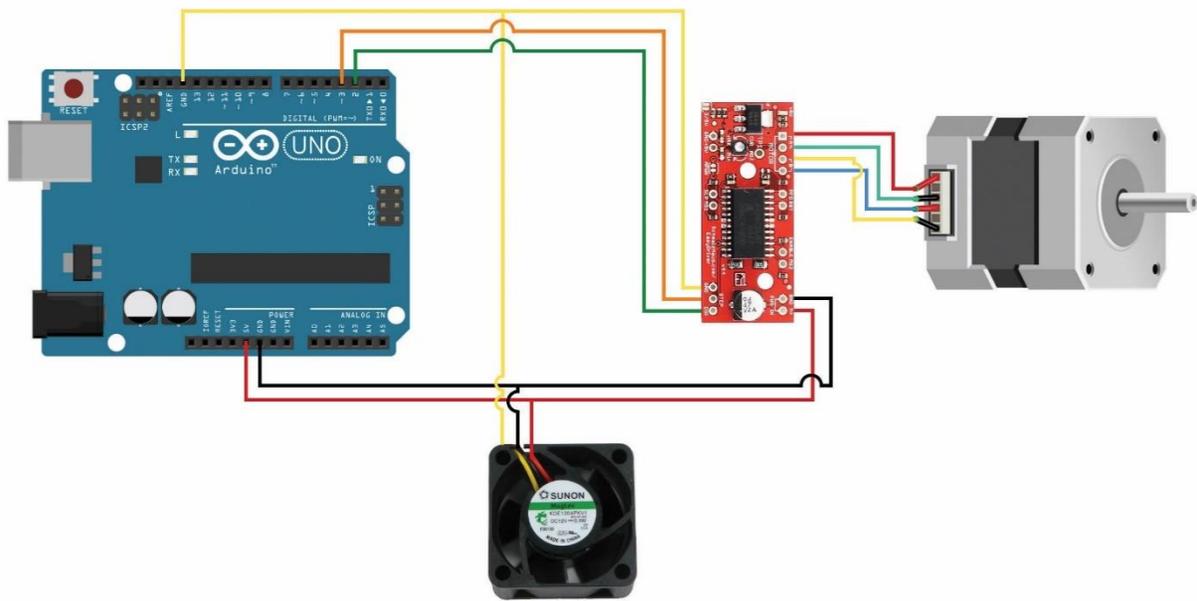


FIGURE 2 - RGB-D SCANNER SETUP SCHEMATIC

Data Collection

The data collection software suite was developed by Pedro Proença and allows a semi-automatic data collection that only requires intervention to adjust the height and angle of the Kinect sensor. It utilizes the Arduino software with personalized code and the CaptureDataset program.

For a Step by Step guide on the Data Collection process please consult Annex 1 - RGB-D Scanner User guide.

Processing

The processing software suite was developed by Pedro Proença and automatized by Pedro Pascoal. It can process individual instances or entire categories of objects and generates segmented and registered point clouds and mesh models.

For a Step by Step guide on the Data Processing please refer to Annex 2 - RGB-D Data Processing User guide.

4.3 RGB-D Dataset

4.3.1 Overview

Originally created in 2013, the RGB-D ISCTE-IUL Dataset Collection was envisioned as the first Portuguese developed collection on RGB-D data of household objects available to the scientific community.

As of November of 2015 (Figure 3) it was made publicly available on the internet for non-commercial research and educational usage, under the MIT Licence (Open Source Initiative, 2016).

As of today the RGB-D ISCTE-IUL Dataset is a free and ever increasing dataset that comprises more than 200 household object ranging from remotes and mugs to tables and chairs (Figure 4).



FIGURE 3 - RGB-D ISCTE-IUL BANNER

For each object 90 frame pairs of RGB and Depth Images, from hereon called raw data, are provided as well as registered and segmented point clouds and mesh models.

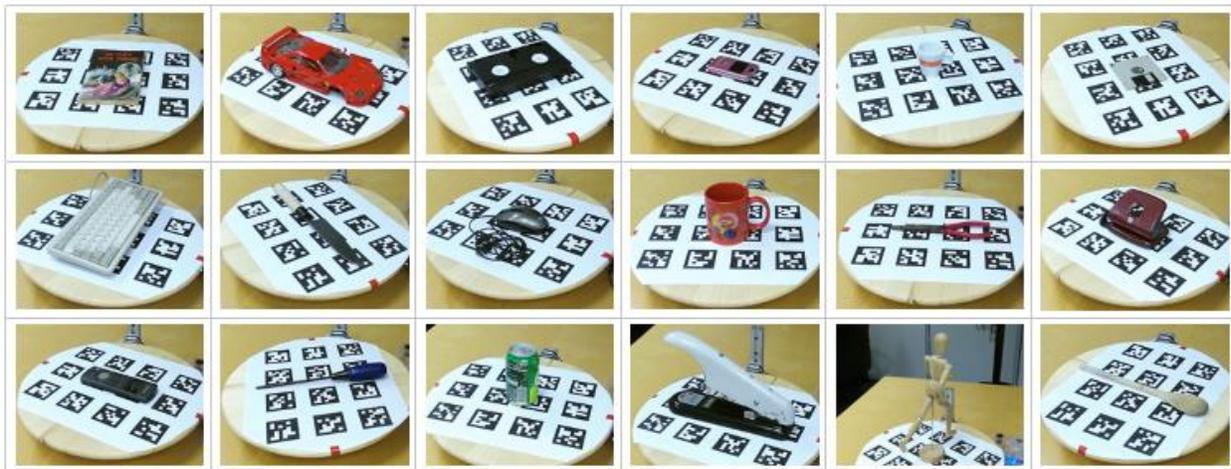


FIGURE 4 - EXAMPLES OF OBJECTS COLLECTED FOR THE DATASET

This dataset is developed with special focus on the needs of the Computer Vision, Computer Graphics and Machine Learning scientific communities among other particular domains.

In the context of the OLA project and by utilized the low-cost RGB-D Scanner, described in the previous chapter, ISCTE-IUL is adding new object categories to this dataset, mainly furniture, through new scans of scale models (Figure 5). With these new categories of objects this dataset can be utilized in the OLA Environmental Analysis Application (Deliverable 2.1), in particular in the object classification module.



FIGURE 5 - EXAMPLE OF FURNITURE SCANNED

4.3.2 Dataset Technical Specification

For each individual object, from here on called instance, the dataset stores RGB-D Data and Depth Raw Data, as well as, Segmented Point Cloud, Registered Point Cloud, Greedy Fast Triangulation and Poisson Surface Reconstruction.

Raw Data

Unprocessed data collected by the scanner. Typically, 270 frames (3 angles of view and 90 frames per angle) for each RGB and Depth totally 540 frames.

RGB

Colour images in .png file format of the object scanned (Figure 6).

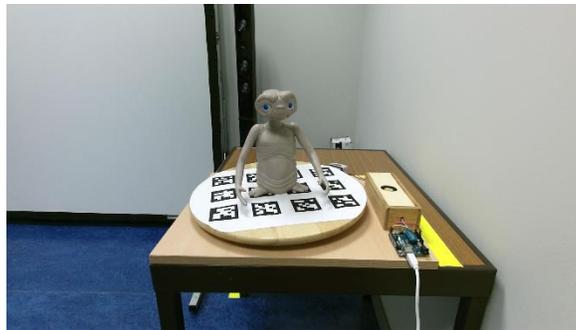


FIGURE 6 - RGB RAW IMAGE OF TEST MODEL

Depth

Depth images with data expressed in millimetres saved in .png file format.



FIGURE 7 - DEPTH RAW IMAGE

Segmented Point Clouds

Partial point clouds of the object created from the information for each frame pair of RGB and Depth images.

Registered Point Clouds

Contains the complete point cloud of the objects generated by combining the segmented point clouds into a single registered one (**Figure 8**).

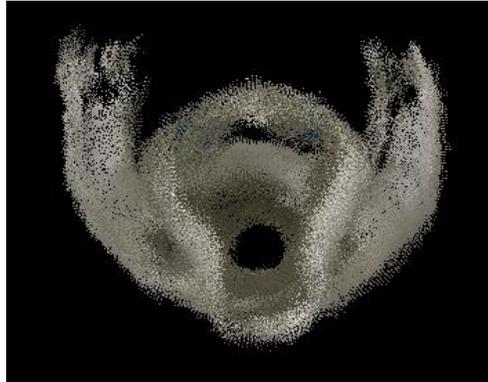


FIGURE 8 - REGISTERED POINT CLOUD

Mesh Models

Two types of mesh models are created Poisson Surface Reconstruction and Greedy Fast Triangulation.

The Poisson Surface Reconstruction (Figure 9) utilizes the methods and techniques developed by Kazhdan, Bolitho and Hoppe (2006) and it's characterized by its resilience to noise in the registered cloud point.



FIGURE 9 - POISSON SURFACE RECONSTRUCTION

The Greedy Fast Triangulations provided through our dataset is based on the PCL "Fast triangulation of unordered point clouds", initially proposed by Marton, Bogdan and Beetz (2009). It utilizes the Registered Cloud Point and the normal of the individual points to obtain a triangle mesh (Figure 10).

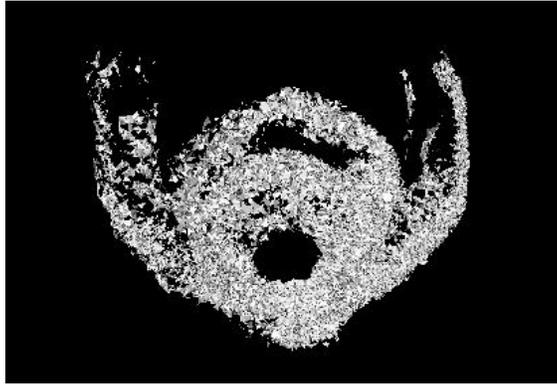


FIGURE 10 - GREEDY FAST TRIANGULATIONS



5 Conclusion

In this document the description of the Off-line Data Collection Platform was made. This data collection is closely linked to the Environmental Analysis Module of OLA, and constitutes the ISCTE-IUL RGB-D Dataset and Collection Setup that is used in the object classification module of the OLA platform. In the context of the OLA project and by utilising the low-cost RGB-D Scanner, new object categories were added to a previously publicly made available dataset, mainly furniture, through new scans of scale models. With these new categories of objects this dataset can be utilized in the OLA Environmental Analysis Application, in particular in the object classification module.

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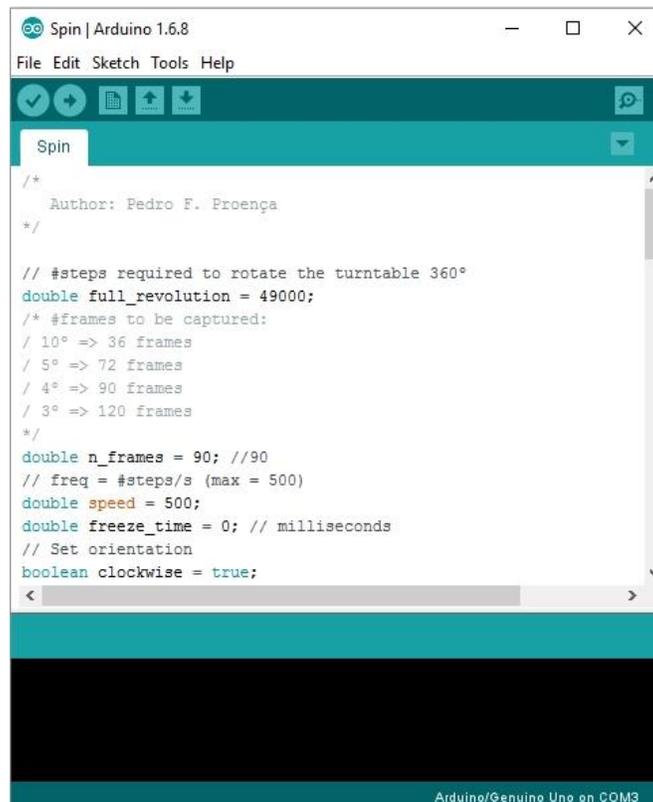
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Annexes

Annex 1 - RGB-D Scanner User guide

1. Connect Kinect Power supply to socket;
2. Connect Kinect to PC via USB 3.0 port;
3. Connect Arduino via USB – the turn table should perform a full turn, let it finish;
4. Place the object to be scanned in the centre of the turntable;
5. Open Arduino App:
 - a. In the app open Spin.ino - */DatasetToolkit/SRC/Arduino/Spin/Spin.ino;

The image shows a screenshot of the Arduino IDE interface. The window title is "Spin | Arduino 1.6.8". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". Below the menu bar is a toolbar with icons for saving, undo, redo, and other functions. The main editor area displays the code for "Spin.ino". The code includes a comment for the author "Pedro F. Proença" and defines several variables: "full_revolution" (49000), "n_frames" (90), "speed" (500), and "freeze_time" (0). It also sets "clockwise" to true. The status bar at the bottom indicates "Arduino/Genuino Uno on COM3".

```
/*
  Author: Pedro F. Proença
*/

// #steps required to rotate the turntable 360°
double full_revolution = 49000;
/* #frames to be captured:
 / 10° => 36 frames
 / 5° => 72 frames
 / 4° => 90 frames
 / 3° => 120 frames
*/
double n_frames = 90; //90
// freq = #steps/s (max = 500)
double speed = 500;
double freeze_time = 0; // milliseconds
// Set orientation
boolean clockwise = true;
```

FIGURE 11 - ARDUINO GENUINO APP

6. Adjust the tripod to the correct angle parameters;

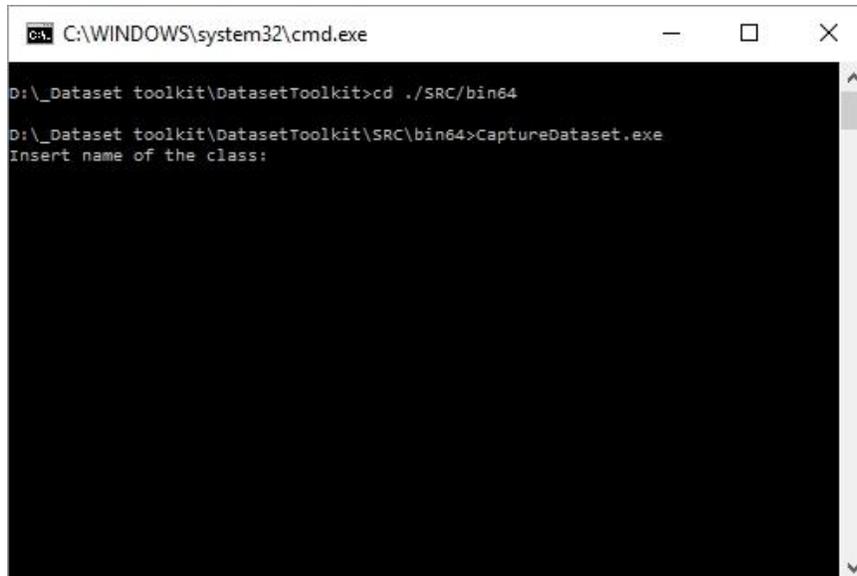


FIGURE 12 – TRIPOD LEGS POSITIONS



FIGURE 13 – TRIPOD HEAD POSITIONS

7. Open CaptureDataset.bat - */DatasetToolkit/CaptureDataset.bat:
 - a. Insert class name and press "Enter" – ex: test;



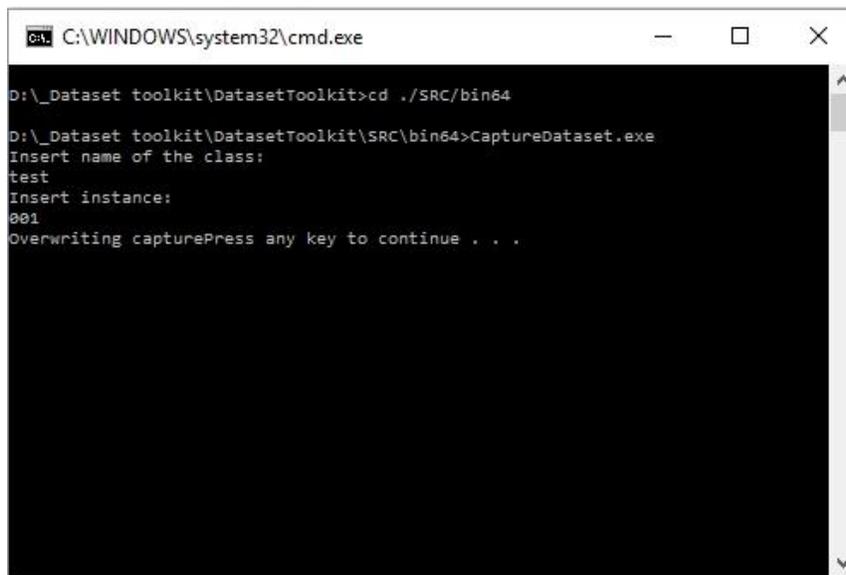
```
C:\WINDOWS\system32\cmd.exe
D:\_Dataset toolkit\DatasetToolkit>cd ./SRC/bin64
D:\_Dataset toolkit\DatasetToolkit\SRC\bin64>CaptureDataset.exe
Insert name of the class:
```

FIGURE 14 - CAPTURE DATASET – INSERT CLASS NAME

- b. Insert instance number and press "Enter" – ex: 1 (App will ignore all the zeros placed on the left);

FIGURE 15 - CAPTURE DATASET - INSERT INSTANCE NUMBER

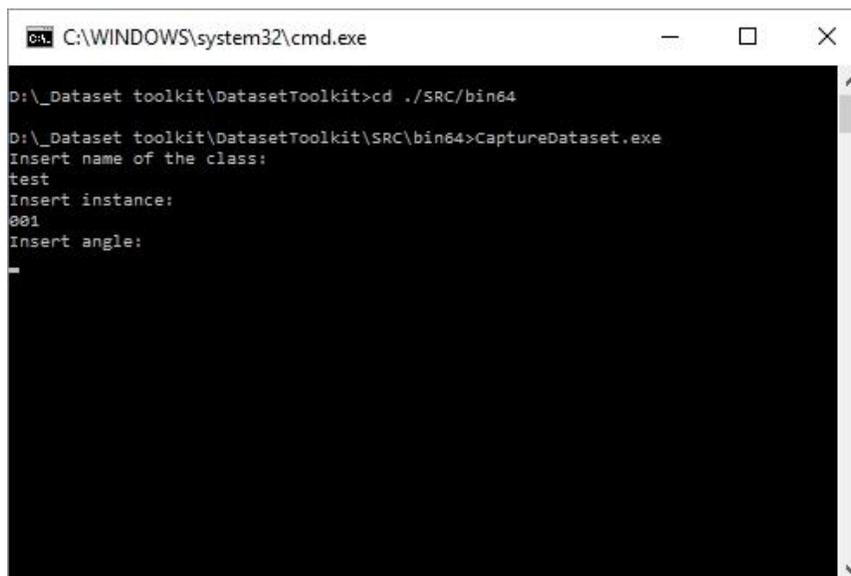
- c. When repeating or performing a scan of the 2nd or the 3rd angle, the message "Overwriting capture press any key to continue" will appear, press "Enter". If not proceed to the next step;



```
C:\WINDOWS\system32\cmd.exe
D:\_Dataset toolkit\DatasetToolkit>cd ./SRC/bin64
D:\_Dataset toolkit\DatasetToolkit\src\bin64>CaptureDataset.exe
Insert name of the class:
test
Insert instance:
001
Overwriting capturePress any key to continue . . .
```

FIGURE 16 - CAPTURE DATASET - OVERWRITING CAPTURE

- d. Insert angle of the Kinect Sensor and press "Enter" (30° - 45° - 60°);



```
C:\WINDOWS\system32\cmd.exe
D:\_Dataset toolkit\DatasetToolkit>cd ./SRC/bin64
D:\_Dataset toolkit\DatasetToolkit\src\bin64>CaptureDataset.exe
Insert name of the class:
test
Insert instance:
001
Insert angle:
-
```

FIGURE 17 - CAPTURE DATASET - INSERT ANGLE

- e. **Don't press any key** when the message "When Arduino becomes ready Press any Key to continue ...";

FIGURE 18 - CAPTURE DATASET - STANDBY FOR ARDUINO

1. In the Arduino Genuino App, press the Upload Code and a progress bar should appear at the bottom right corner of the window with the message “Compiling Sketch” followed by “Uploading”, **quickly (~5 seconds) select the command line/power shell windows** and when the message “Done uploading” appear in the Arduino app quickly press any key, e.g. “Enter”;

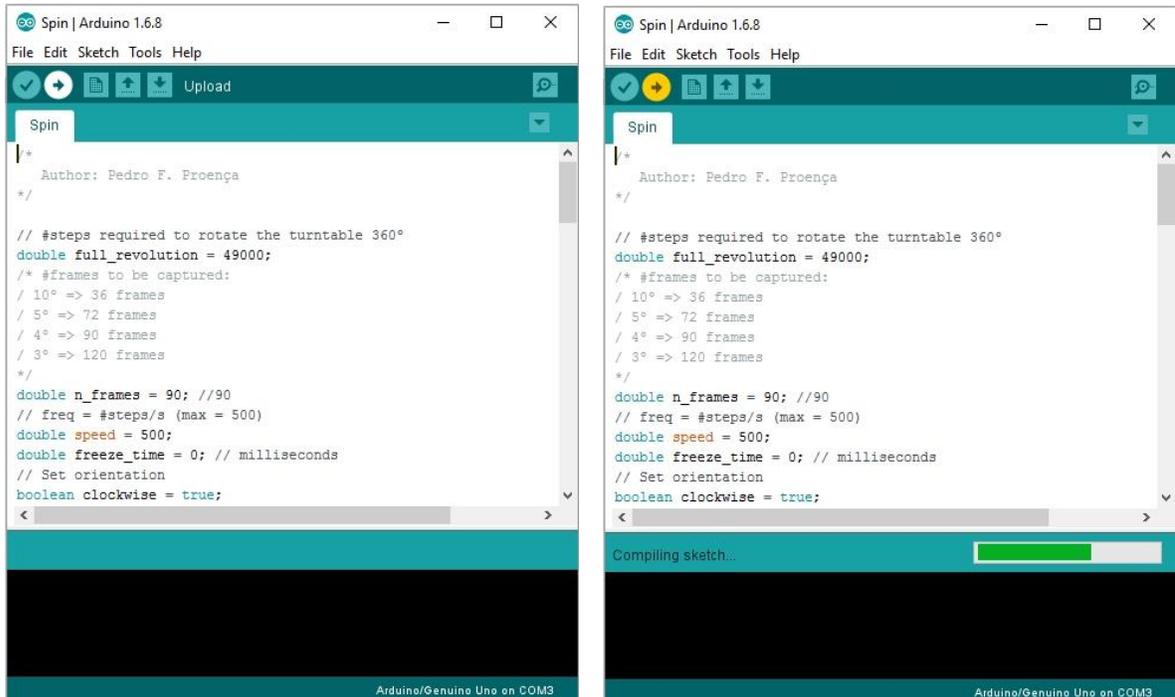


FIGURE 19 - CAPTURE DATASET – ARDUINO GENUINO

FIGURE 20 - CAPTURE DATASET - COMPILING CODE ARDUINO

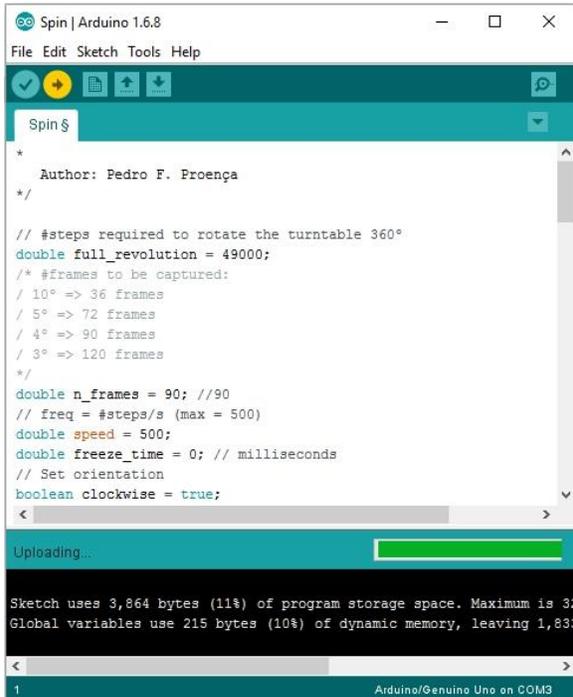


FIGURE 21 - CAPTURE DATASET - UPLOAD CODE ARDUINO

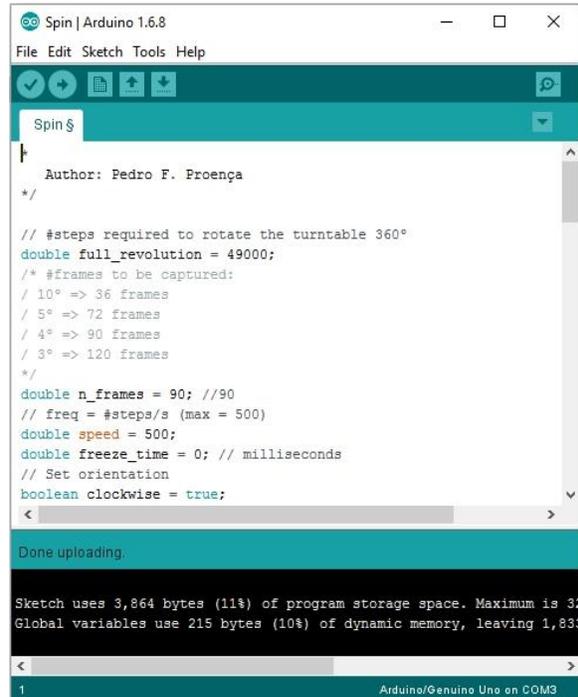


FIGURE 22 - CAPTURE DATASET – DONE UPLOAD CODE ARDUINO

- Two new windows should popup, one with the RGB feed and the other with the depth data feed, followed by the turn table starting to spin;

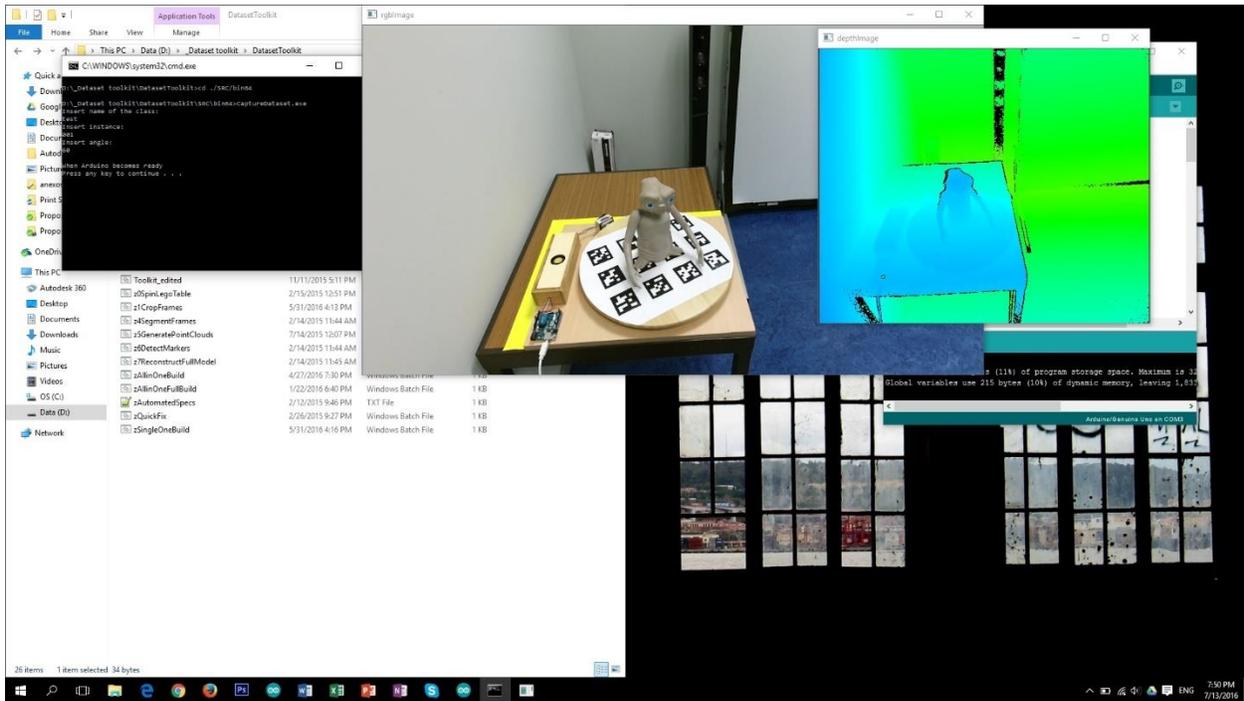


FIGURE 23 - CAPTURE DATASET - SCAN

3. The trigger message "Saving Frame" should appear in the command line;
4. The turning table should automatically stop at frame 89;

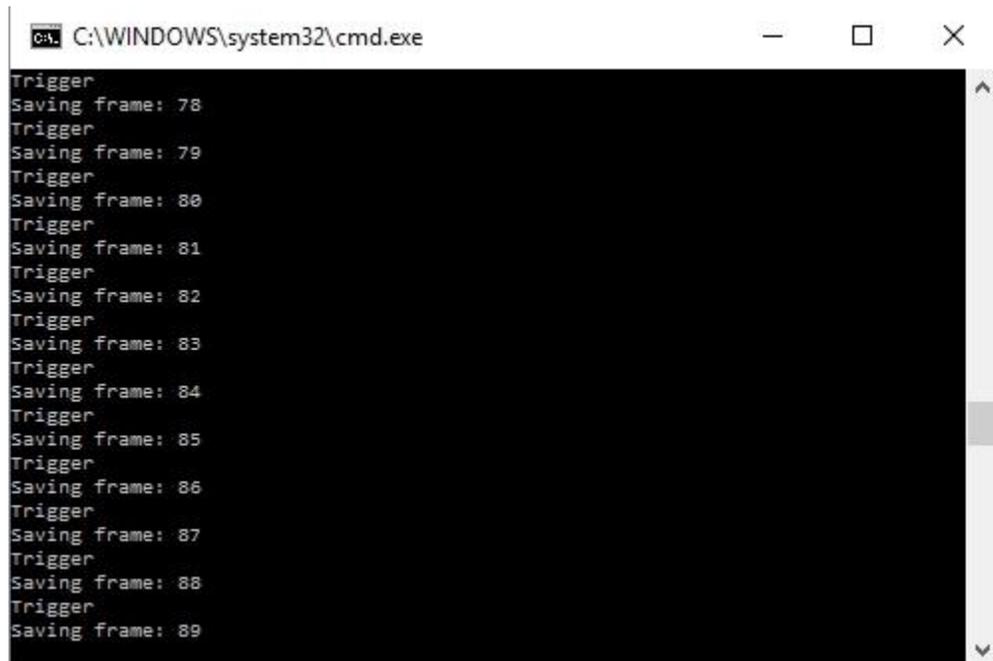


FIGURE 24 - CAPTURE DATASET – FRAME 89

- 
5. Close the app by pressing "Q";
 6. Repeat from step 6 until all 3 angles are collected.

Annex 2 - RGB-D Data Processing User guide

1. Open zSingleOneBuild.bat in Notepad++ (Figure 25):
 - a. Edit line 6 "set class=*" substituting "*" with the class name of the object to process;
 - b. Edit line 7 "set /a VAR1=*" substituting "*" by the instant number to process;
 - c. Save the modification.

```
1 @echo off
2 setlocal EnableDelayedExpansion
3
4 cd ./SRC_edited/bin64
5
6 set class=Test
7 set /a VAR1=1
8
9 :: Instruction
10 :: Toolkit64.exe "CLASS_NAME" "CLASS_INSTANCE" "NUM_ANGLES" "ANGLE_1" "ANGLE_2" "ANGLE_3"
11
12 Toolkit64.exe %class% !VAR1! 1 3 30 45 60
13 Toolkit64.exe %class% !VAR1! 4 1 30 45 60
14 Toolkit64.exe %class% !VAR1! 6 1 30 45 60
15 Toolkit64.exe %class% !VAR1! 7 1 30 45 60
16
17 ::set /a VAR1=1
18 ::for /d %%a in ("D:\RGB-D ISCTE-IUL Dataset\DatasetToolkit\Data\Lx-RGBD\%class%\*.*") do (
19 :: echo !VAR1!
20 :: Toolkit64.exe %class% !VAR1! 7 3 30 45 60
21 :: set /a VAR1+=1
22 ::)
23
24
25 pause
```

FIGURE 25 - DATA PROCESSING - SET CLASS AND INSTANCE

2. Run SingleOneBuild - */DatasetToolkit/zSingleOneBuild.bat;
3. A command line window and a depth image of the object to be process should appear (Figure 26);

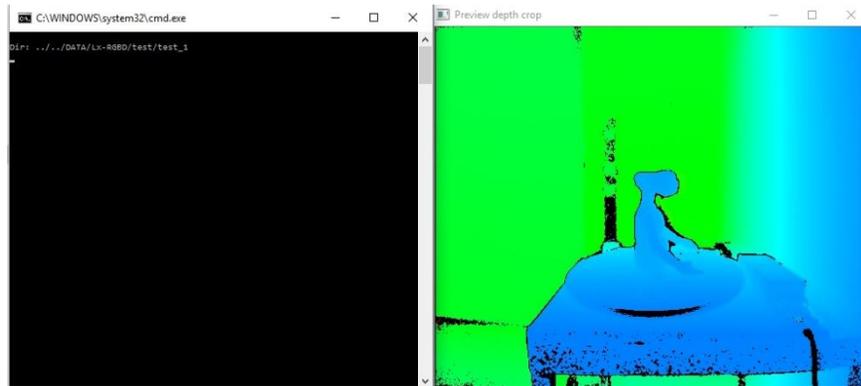


FIGURE 26 - DATA PROCESSING – RUN BATCH

4. Crop the image (Figure 27), to reduce processing time:
 - a. Click on the intended upper left corner of the crop area and press "ENTER";
 - b. Click on the intended lower right corner of the crop area and press "ENTER".

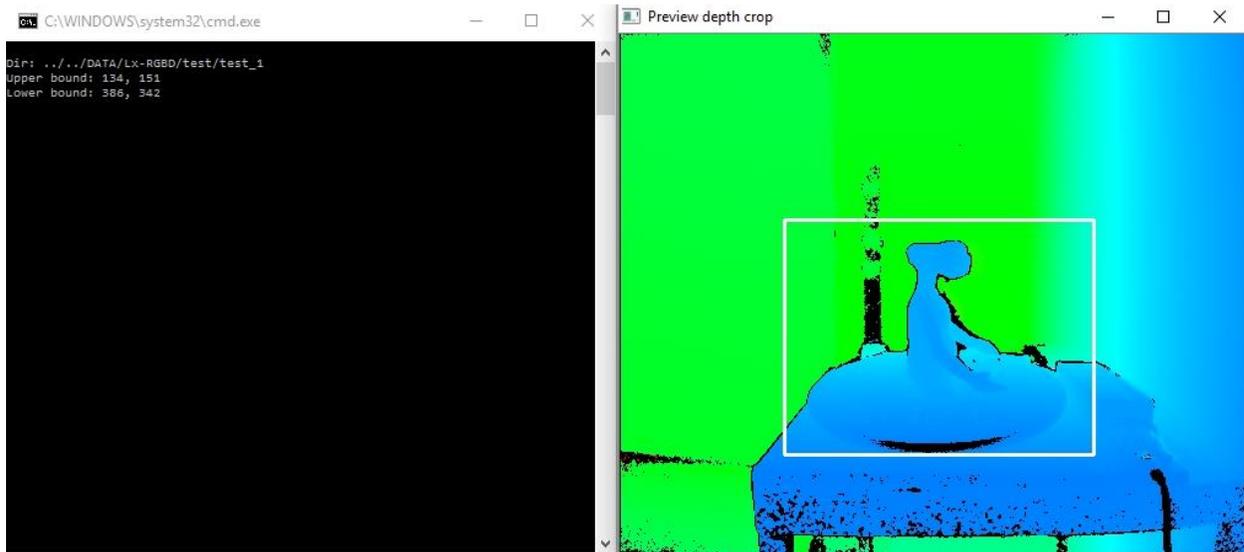


FIGURE 27 - DATA PROCESSING – SELECTION OF CROP AREA

5. A new window should appear with the RGB image with the selected area and the app will automatically crop the frames from the first angle (Figure 28);

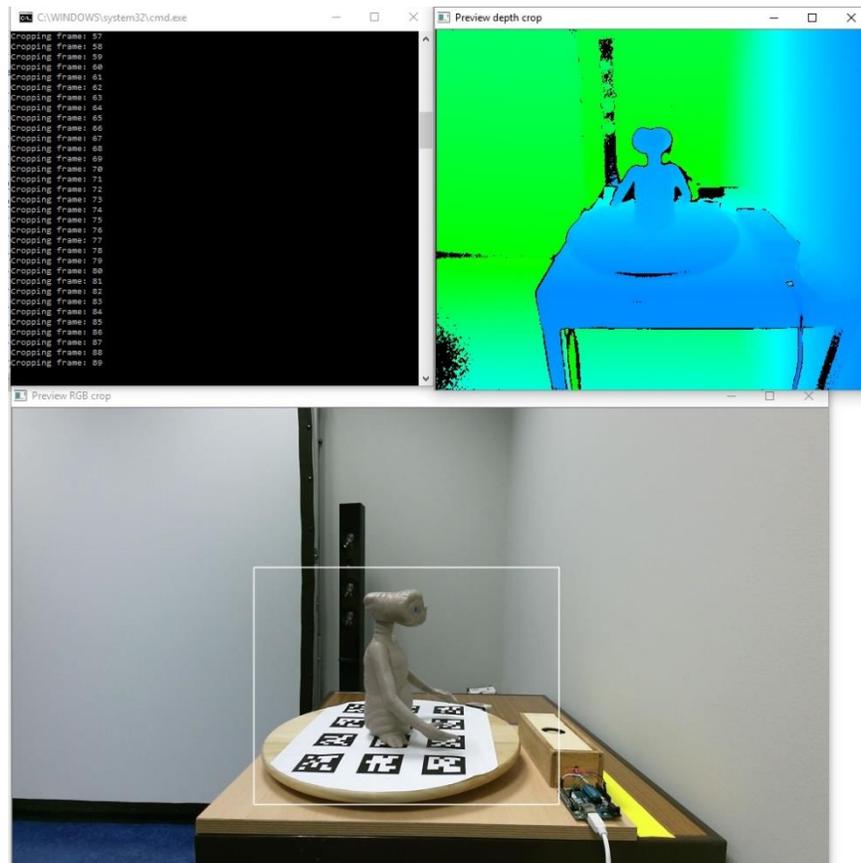


FIGURE 28 - DATA PROCESSING – AUTOMATIC CROPPING

6. When the app finishes cropping the 30° angle frames the Depth Image window will refresh;
7. Crop the new depth image for the 45° scan:
 - a. Click on the intended upper left corner of the crop area and press "ENTER";
 - b. Click on the intended lower right corner of the crop area and press "ENTER".
8. When the app finishes cropping the 45° angle frames the Depth Image window will refresh;
9. Crop the new depth image for the 60° scan:
 - a. Click on the intended upper left corner of the crop area and press "ENTER";
 - b. Click on the intended lower right corner of the crop area and press "ENTER".
10. After this crop the app will automatically start the processing stage:

- a. Firstly, it will create the segmented cloud point for each frame pair (Figure 29);

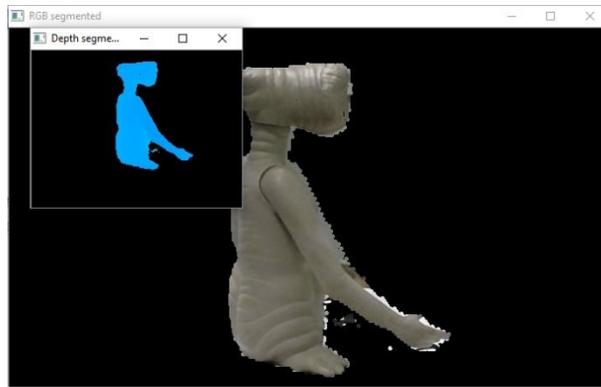


FIGURE 29 - DATA PROCESSING – GENERATION OF THE SEGMENTED CLOUD POINTS

- b. The registered cloud point will then be generated by identifying the QR codes in the turn table (Figure 30);

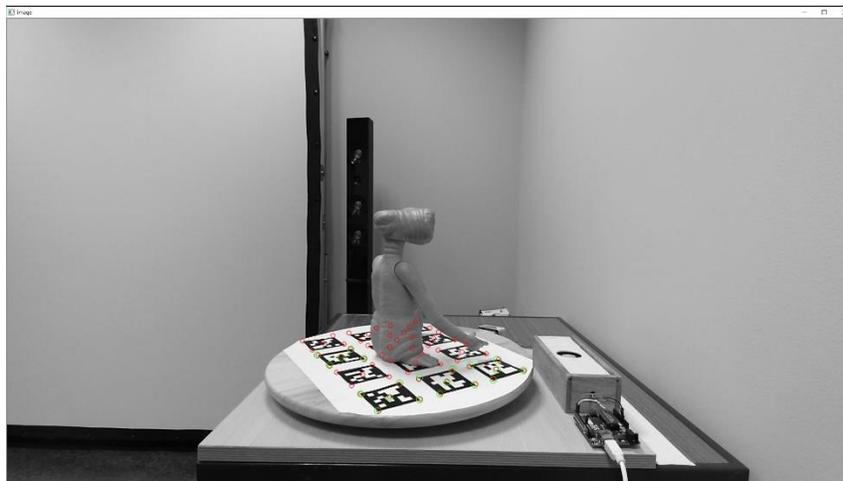


FIGURE 30 - DATA PROCESSING – GENERATION OF THE REGISTERED CLOUD POINTS

- c. The app will appear to stop responding you can close it (Figure 31);

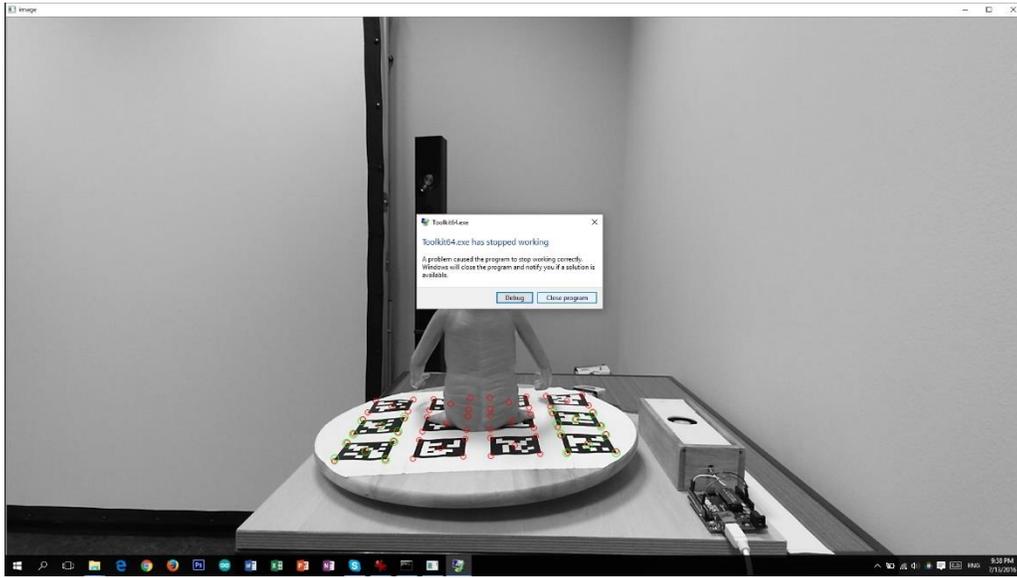


FIGURE 31 - DATA PROCESSING – APP STOP RESPONDING

- d. The registered cloud point will appear in a new window (Figure 32), followed by the cloud point with a smooth filter (Figure 33).

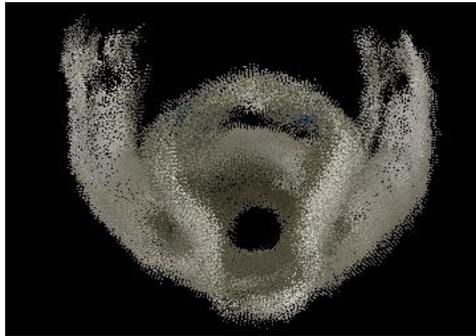


FIGURE 32 - DATA PROCESSING – REGISTERED CLOUD POINT

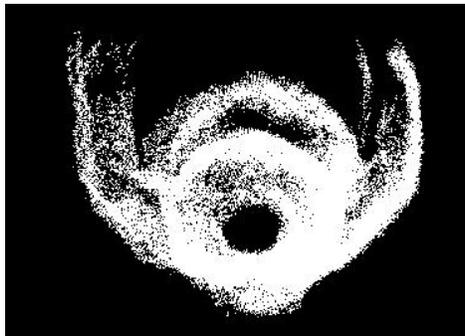


FIGURE 33 - DATA PROCESSING – REGISTERED CLOUD POINT WITH FILTER

- e. The app will then estimate the normals of the various points and the Greedy Fast Triangulations will appear in a windows (Figure 34).

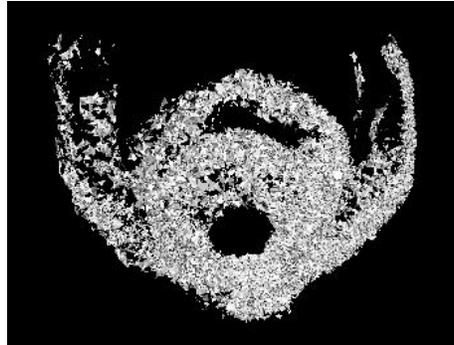


FIGURE 34 - DATA PROCESSING – GREEDY FAST TRIANGULATIONS

- f. Finally, the Poisson Surface Reconstruction will be calculated and appear in a new window for a few seconds (Figure 35).



FIGURE 35 - DATA PROCESSING - POISSON SURFACE RECONSTRUCTION

- g. Press enter to close the processing app to finish the process (Figure 36).

```
C:\WINDOWS\system32\cmd.exe
Reprojection error: 0.798158
Frame: 89
4 good Markers found.
Reprojection error: 0.768209

Completed pose estimation for test_1_30
Avg reprojection error: 0.706336
Avg #markers detected per-frame: 4
Missed #Frames missed: 5

Dir: ../../DATA/Lx-RGBD/test/test_1
Frame skiped.
Frame skiped.
Frame skiped.
Frame skiped.
Frame skiped.
Registration complete
351467
Set smooth filter radius [5-20] (mm):
Points retained after voxel filtering: 279106
Estimate Normals
MLS filtering concluded.
Perform basic triangulation.
Not enough neighbors are considered: ffn or sfn out of range! Consider increasing nnn... Setting R=1815 to be BOUNDARY!
Not enough neighbors are considered: source of R=140035 is out of range! Consider increasing nnn...
Number of neighborhood size increase requests for fringe neighbors: 3519
Number of neighborhood size increase requests for source: 227
Perform poisson surface reconstruction.
scale after settree 280.288361
Memory Usage: 0.000 MB
Press any key to continue . . .
```

FIGURE 36 - DATA PROCESSING - FINAL STAGE OF THE PROCESSING APP