Open Source Desktop Scanner

The scanner is a multiplatform application that allows anyone to experiment with various 3D reconstruction technologies. It provides a graphical interface that allows anyone to connect with the scanner, set scanning parameters and scan 3D objects. A 3D scene of the point cloud is obtained and can be viewed with any 3D rendering application.

1. Structure from Motion (SfM)

The SfM technique uses a 4 step operating procedure.

Step 1

The method for reconstruction is chosen in this step. Currently only the SfM technique is supported in this user interface.

Step 2

During this step, the number of images chosen for 3D reconstruction can be specified. The user can choose the number of images by using the denoted sliders in the GUI application. A default value of 50 images is used

In addition, the resolution at which the images can captured can also be specified. Higher resolution images allow denser 3D points to be created but at the cost of higher processing times. Currently the application supports images to be captured at 640 by 480 or 1920 by 1080.

The webcam images tend to produce images that can be out of focus occasionally. These images add noise to the reconstruction algorithms. In order to reject blurry images, the Blur reduction value slider, can be used to reject images that are blurry. A default value of 5 is recommended. The value of course can be deduced experimentally depending on the hardware used.

Finally, the user interface provides image segmentation antics to eliminate the foreground (object of interest) from the background. This can be activated by clicking the mask image button.
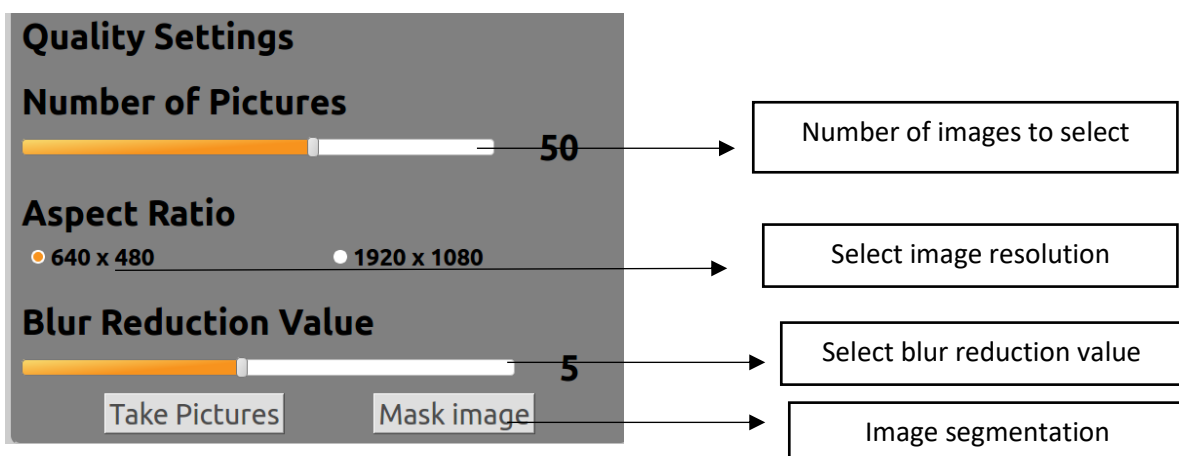
Raw image
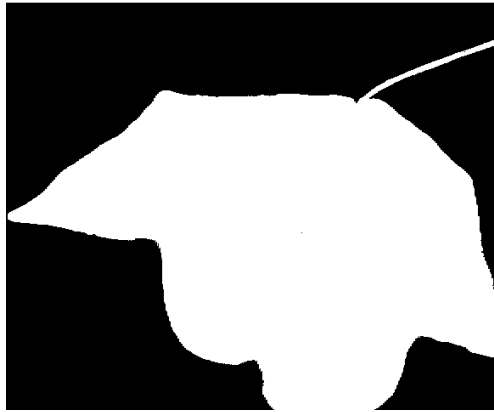

Binary image

Filtered image

Step 3

The point cloud can be generated by clicking the generate point cloud button. The processing time is usually about 2-3 minutes for images at 640 by 480 pixels and about 9-11 minutes for images captured at 1920 by 1080 pixels. Once the point cloud have been generated, a pop up box like the one shown below should appear to indicate to the user that the process has been completed.
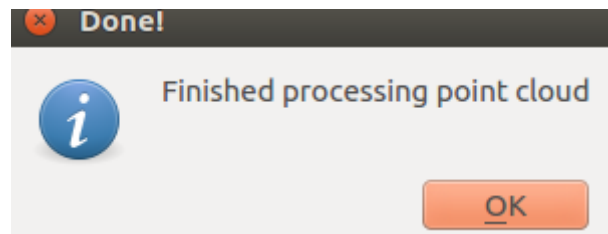
Now the user can click on the *preview point cloud* button to view the raw point clouds using MESHLAB. The point clouds can contain noise and they can be cleaned using the sliders in the user interface.

Step 4

In this step, a mesh can be generated from the filtered point clouds. The sliders below can be used to specific the quality of the generated mesh and how much unwanted faces to eliminate from the mesh models. A default value of 8 has been used and has been tested for a range of objects. The generate mesh button can be selected to generate the mesh model and the preview mesh model can be selected to view the generated mesh. Finally, clicking the view textured mesh model should project texture on the generated mesh model.
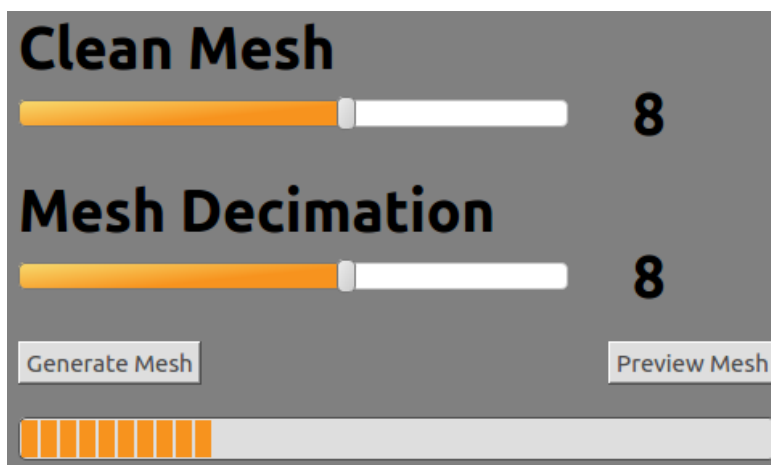
All generated mesh models and point clouds are stored in a folder called DIGIART_SCANS in the home directory. The folders have been timestamped for the user's convenience. In order to ensure the pictures and point clouds are saved make sure the application is exited after scanning operation has been completed.

Pointcloud.ply – contains the raw unfiltered point clouds.

Finalcloud.ply – contains the point filtered point cloud

Surface_trimmed.ply is the mesh model

Textured.obj is the obj file generated from the point clouds; the mtl and png files are also stored in the same directory.

2. Structured light

The user can click the scan button, which allows the fringe patterns to the projected unto the object as shown below.

The software runs on a windows partition now and is developed using MATLAB. The point clouds are stored in the RESULTS directory for the user to view. Image segmentation techniques are also applied to isolate the object of interest from the background as discussed in the previous section.

3. Equipment Selection

Part	Link	Price
Logitech brio 4k	https://cpc.farnell.com/logitech/960-001106/webcam-brio-4k/dp/CS30865	204
DLP projector	https://cpc.farnell.com/acer/mr-jq411-001/projector-c101-led/dp/SB07035	230
Turntable	https://www.amazon.co.uk/Leadleds-Motorized-Rotating-Turntable-Collectible/dp/B012A0LK8S	17
arduino nano	https://uk.rs-online.com/web/p/products/1245509/?grossPrice=Y&cm_mmc=UK-PLA-DS3A-_-google-_-PLA_UK_EN_Semiconductors-_-Semiconductor_Development_Kits%7CProcessor_And_Microcontroller_Development_Kits-_-PRODUCT_GROUP&matchtype=&aud-359743317810:pla-410498058944&s_kwcid=AL!7457!3!243845768854!!!g!410498058944!&gclid=Cj0KCQiA-c_iBRChARIsAGCOpB0wxt-ne7vxY8eiQURIxE3gLFBL5TqZ3wLpb3D_oY5A4-CeKd6izJ4aAjaqEALw_wcB&gclsrc=aw.ds	17
VIDEO LENS-CFZOOM 13-130MM	https://www.edmundoptics.com/p/EO-5012-Color-USB-30-Lite-Edition-Camera/32175/	421
EO-5012M LE COLOR USB3.0 CAMERA	https://www.edmundoptics.com/p/10x-13-130mm-fl-c-mount-close-focus-zoom-lens/11144/	505
frame	**Slide nuts** https://uk.rs-online.com/web/p/connecting-components/4667297/ **Tnuts** https://uk.rs-online.com/web/p/connecting-components/4667281/ **2W corners** https://uk.rs-online.com/web/p/products/4667433/ **3W corners** https://uk.rs-online.com/web/p/products/4667427/ **black end caps** https://uk.rs-online.com/web/p/tube-stops-plugs/4667247/ **internal angles** https://uk.rs-online.com/web/p/connecting-components/4667354/	115

The cost per final rig is shown in the table below

Section	Price (£)
Frame	115
Structured light & line scanner EO-5012M LE COLOR USB3.0 CAMERA + VIDEO LENS-CFZOOM 13-130MM+ DLP projector	1156
Structure from motion arduino nano + Turntable + Logitech brio 4k	238
Total price	**1509 (equivalent to 1670 Euros)**

4. Assembly guide

The scanner is constructed from the following building blocks:

- Rexroth beams
- Cameras
- A microprocessor to control the platform motor
- Turntable
- Projector
- A PC based software application used to invoke /control the scanning

Step 1

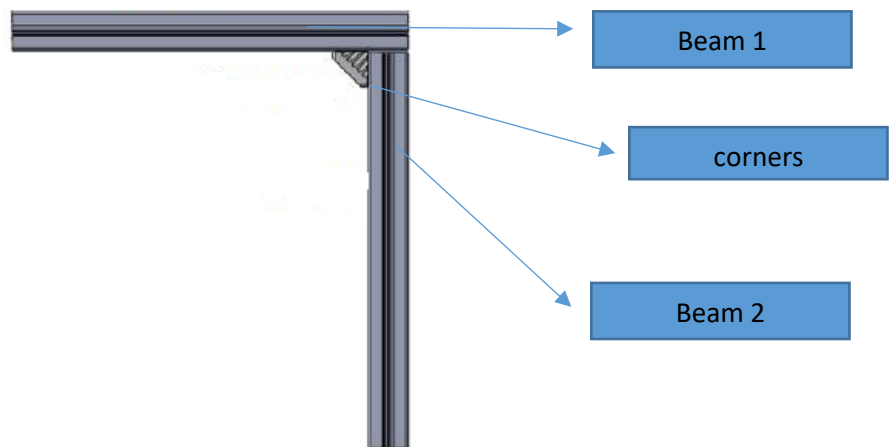The Rexroth frame is cut to the appropriate size

Size specification is shown below:

- 10 x 56cm lengths
- 8x 41cm lengths
- 2x 27cm lengths
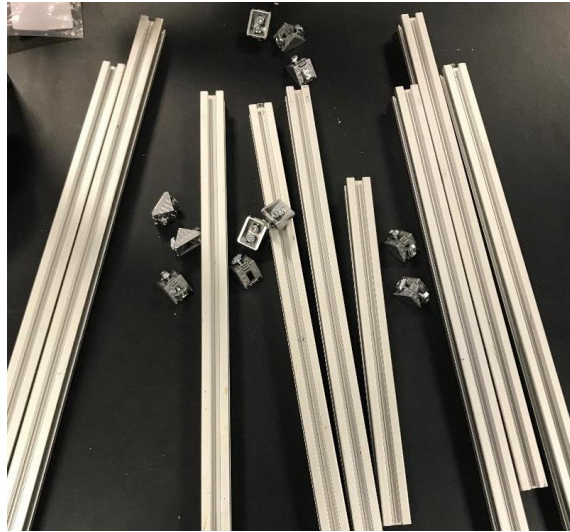
Step 2:

Insert sliders into beams prior to assembling of corners and screw the corners using a Philips screw driver
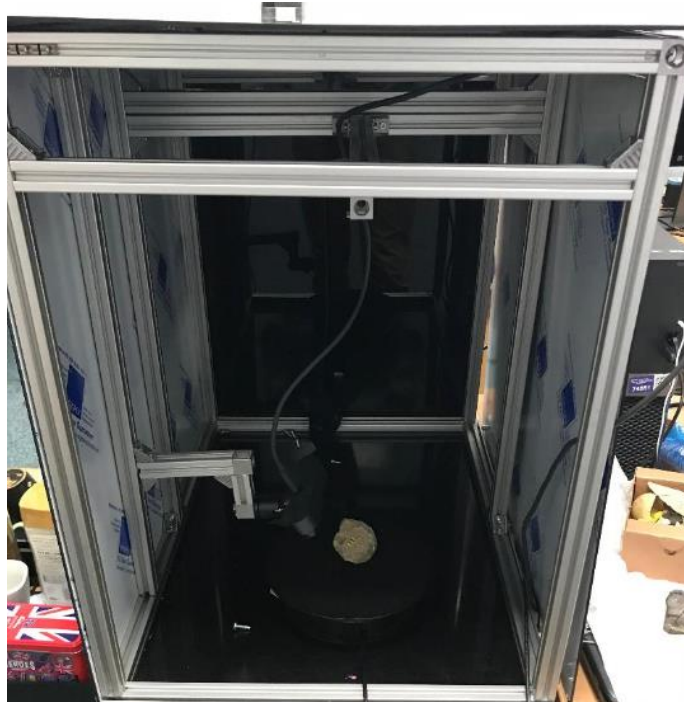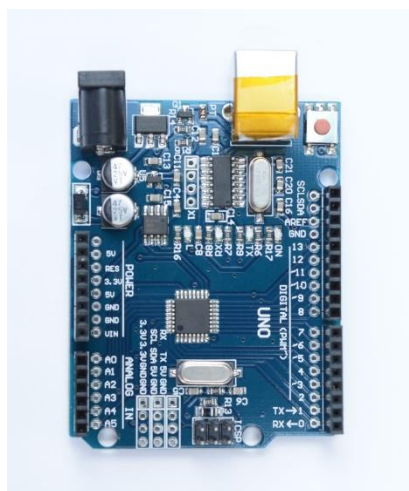

Beam 1

corners

Beam 2

Step 3:

The Logitech webcam and projector assembly is mounted

**The Final assembly of the scanner is shown below**

In order to control the turntable, the Arduino board is used for triggering a DC motor. The Arduino board is based around the ATmega328P control board


Arduino IDE can be downloaded from the internet using the link below

https://www.arduino.cc/en/Main/Software

Connect the IDE to the board via the appropriate COM port as shown below. The COM Port might be different depending on the user. Under the Windows control panel open the device manager and check which COM port has been allocated.
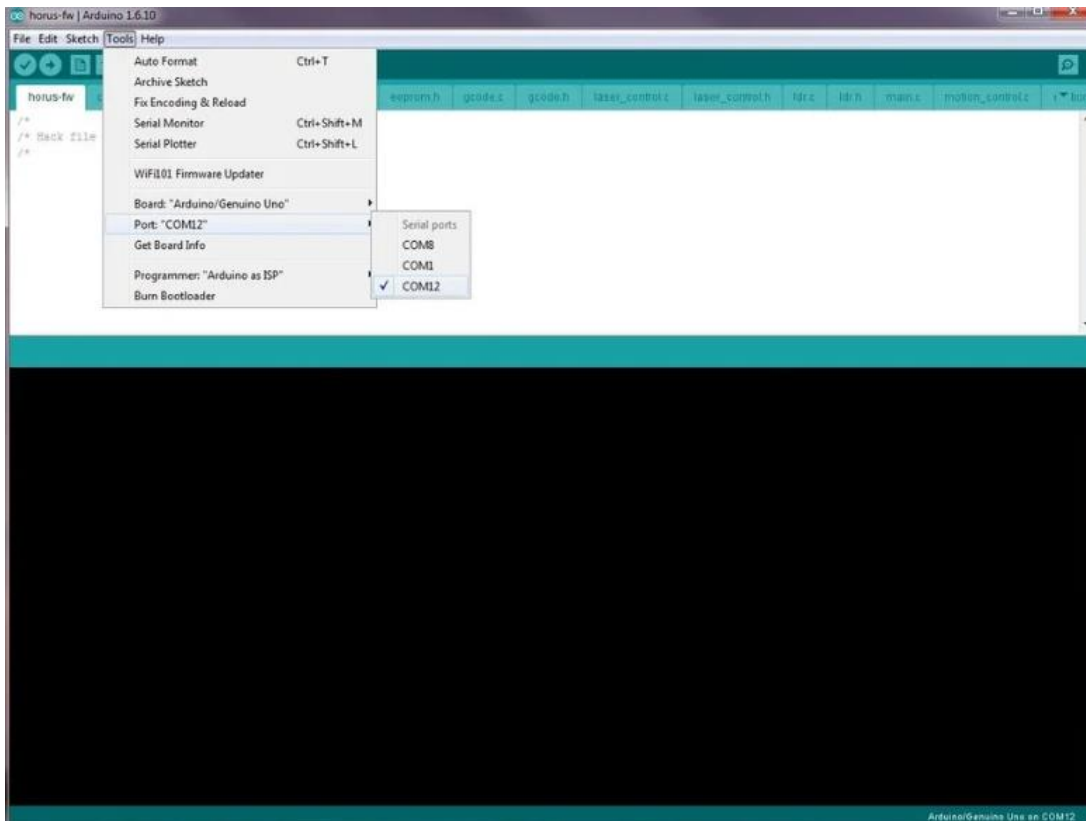
It is also important to select the right board type before uploading a sketch to the Arduino. This can be done by clicking the Tools option and selecting the appropriate board type that has been purchased.
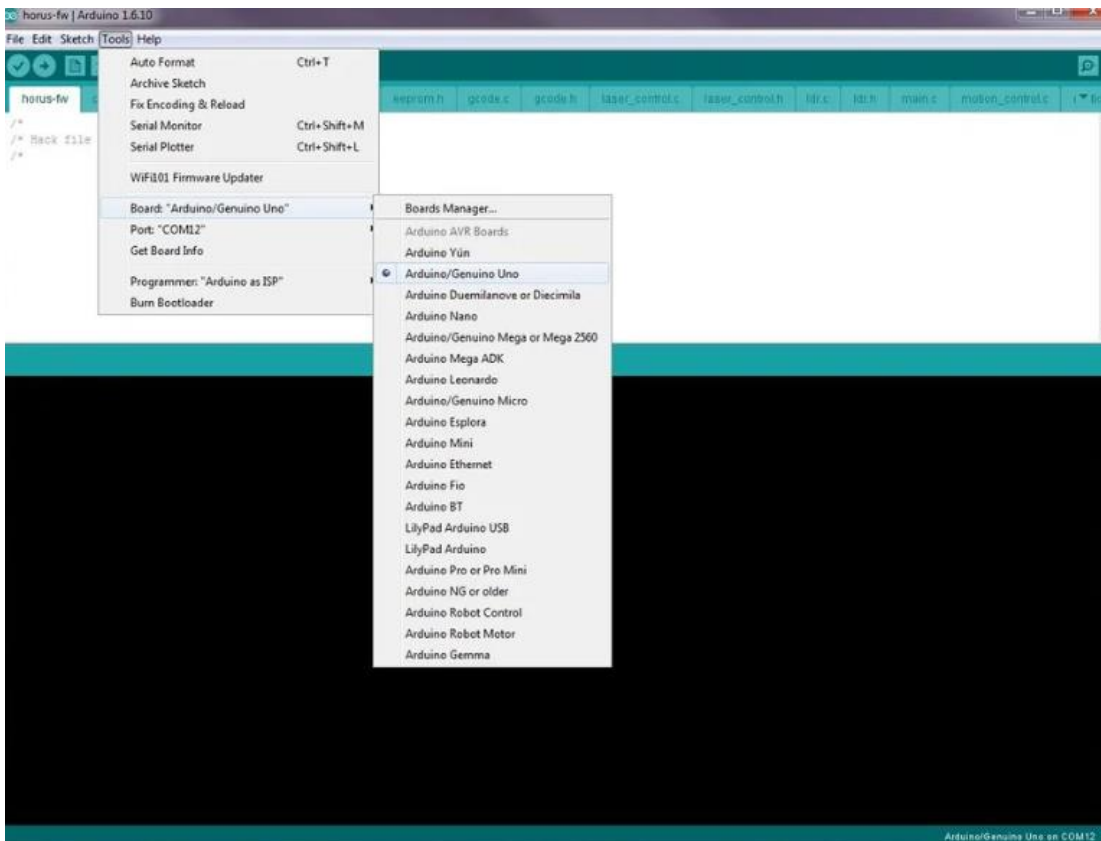
Finally, upload the appropriate .ino file to the board to allow control of the DC motor. Once the firmware has been successfully uploaded to the board, the hardware is now ready for integration into the scanner.