CAP 5400 Lab Report

Reubin George

Christopher Kantor

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Contents

Lab 1

Microsoft Xbox Kinect v2

Introduction

For Lab 1, we used a variety of depth and stereo cameras. The devices we used were Microsoft Xbox Kinect v2, ZED stereo camera, and Logitech Brio webcam. Our objective was to take pictures - both regular and depth - and videos of the room, objects, and individuals - all enhanced with these devices' sensors and software.

The Microsoft Xbox Kinect v2 is a depth-sensing camera with a built-in array of microphones. This device implements time-off-flight to capture depth information, as opposed to laser grid projection that the Kinect v1 used. Intended to be used with the Xbox 360 or Xbox One game consoles, the Kinect devices gained significant interest over the years in research in computer graphics, physiology, and other fields due to its relatively superb image quality, depth-sensing capabilities, and human movement tracking. For instance, it is better at detecting when an actor crosses his arms. The Kinect software demonstrates many possible ways to obtain and display both live and pre-recorded data in a user-friendly manner.

Procedure

To capture data with the Kinect:

a) Ensure all parts are present. Plug all cables into their respective connectors, then plug the AC adapter into the wall.
    1. A full Kinect v2 setup involves five parts: Kinect itself, hub box, power adapter, power cable, USB cable.
b) Ensure the Kinect for Windows SDK v2.0 is installed. Open SDK Browser.
c) From there, click Run on an application pertaining to the desired type of data.
    1. Programs
        i. Regular/color: Color Basics-WPF
        ii. Depth: Depth Basics-WPF
    2. These programs only present live data and have no ability to capture/save. It is advisable to screenshot the window with the Print Screen key or Windows + Shift + S key combination.
    3. Only use one of these programs at a time.
d) If these programs are insufficient, Kinect Studio is a useful program for visualizing live and pre-recorded data.

Collected Data

Figure 1: color image of box

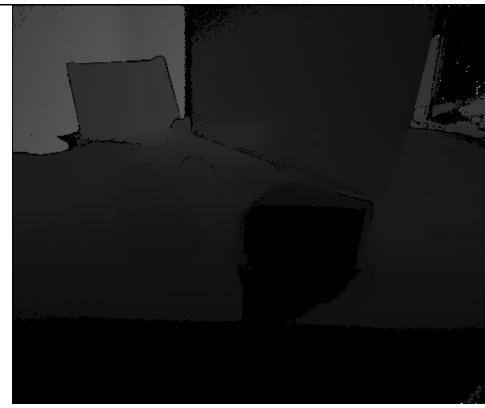

Figure 2: depth image of box

Figure 3: color image first aid kit

Figure 4: Depth image of first aid kit

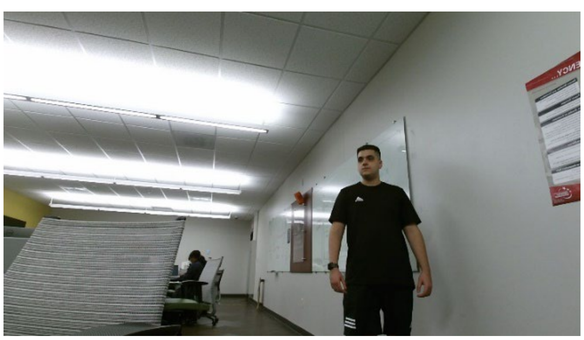

Figure 5: color image of Chris

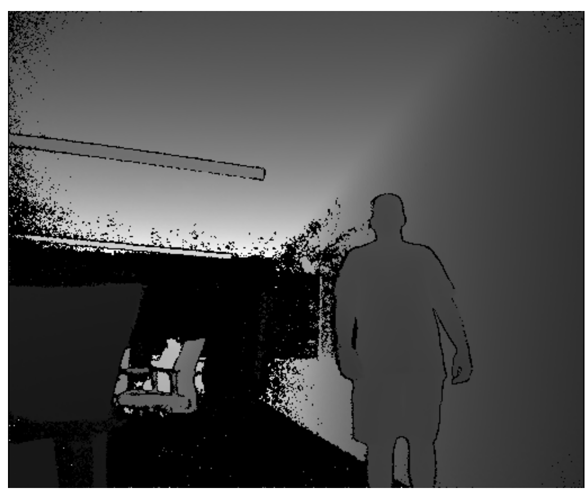

Figure 6: depth image of Chris

Processed Data

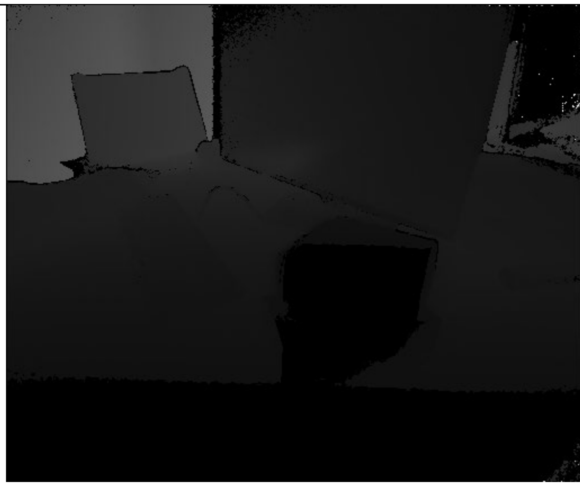

Figure 7: Original depth image of box

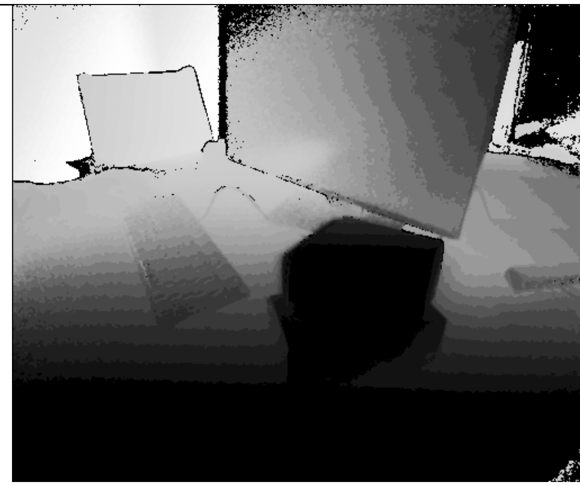

Figure 8: Histogram equalization applied to depth image

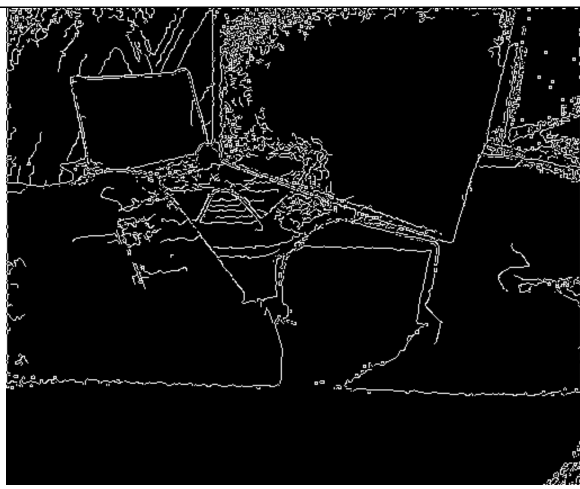

Figure 9: Canny Edge detector applied to depth image

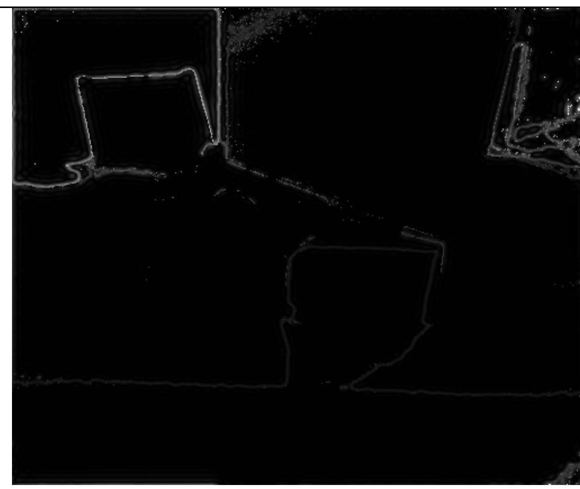

Figure 10: High Pass filter applied to depth image


Figure 11: Original depth photo of first aid kit

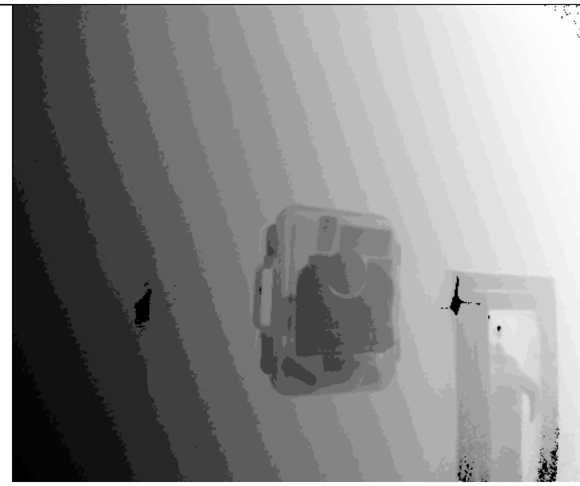
Figure 12: Histogram equalization applied to depth image


Figure 13: Canny edge detector applied to depth image


Figure 14: High pass filter applied to depth image

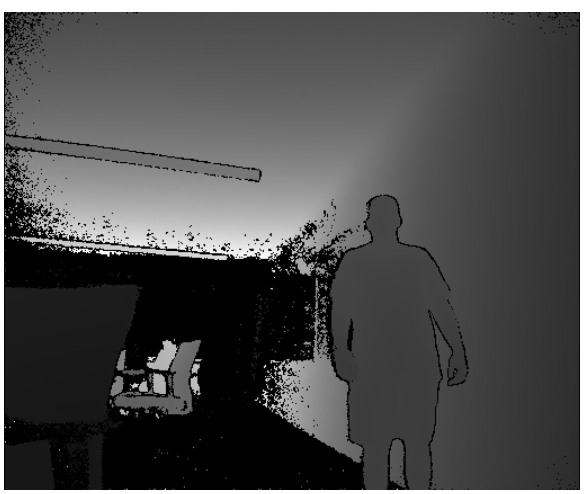
Figure 15: Original depth photo of Chris

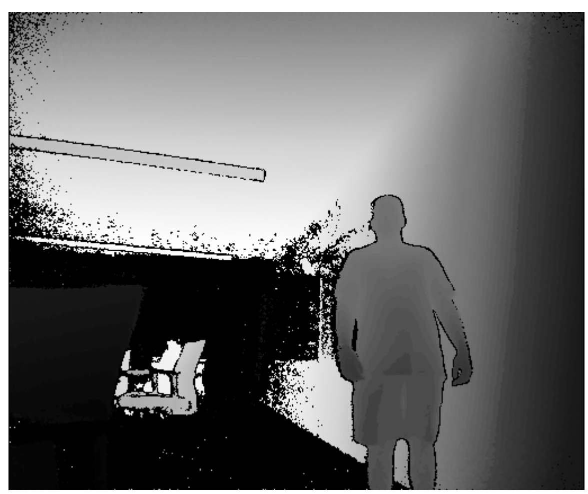
Figure 16: Histogram equalization applied to depth image

Figure 17: Canny edge detector applied to depth image

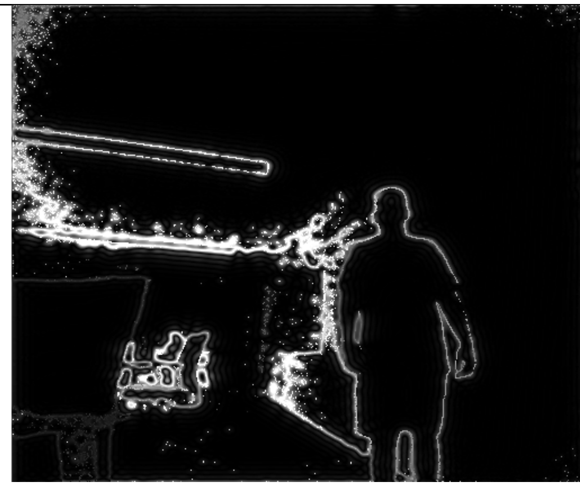

Figure 18: High pass filter applied to depth image

Logitech Brio Webcam

Introduction

This device functions as a normal webcam, with up to 90 fps recording. We recorded a 20 second clip using the Logitech webcam software and extracted specific frames using ImageMagick.

Procedure

The procedure for capturing photos from the Logitech webcam is as follows:

a) Launch the Logitech Webcam software.
b) Select quick capture.
c) Choose the path you want to save the recording to.
d) Record a video using the webcam.
e) Open the video in ImageMagick and select different frames to save as images.

Collected Data

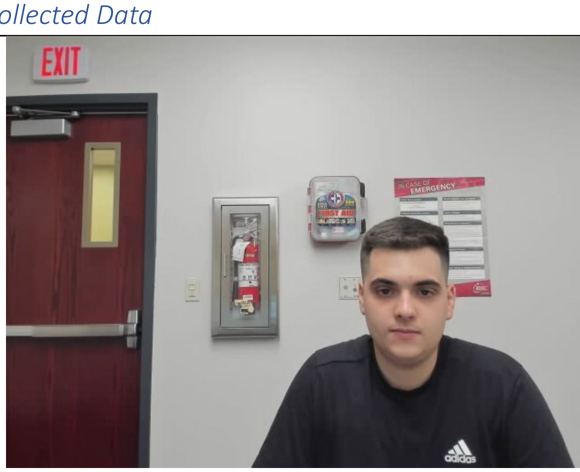

Figure 19: Photo taken on the Logitech webcam

Figure 20: Collected photos from Logitech webcam

Processed Data

Figure 21: Converting RGB image to HSV, then performing histogram equalization on the V channel

Figure 22: High pass filter applied to the image, which detects edges

Figure 23:Converting RGB image to HSV, then performing histogram equalization on the V channel

Figure 23: High pass filter applied to the image, which detects edges

Zed Stereo Camera

Introduction

Another device we collected data on is the ZED stereo camera. Unlike the Kinect with its time-of-flight and IR sensors, this is equipped with only two image sensors. The device with its software produces photogrammetry from these two image sensors.

Procedure

To use the ZED stereo camera:

a) Ensure it's plugged in and run the ZED Explorer Application
b) Hit REC to start recording, and slowly rotate the camera to scan the room. The recording will be saved as an SVO file.
c) Open the ZED Depth Viewer application to view the recording. Here, we can see RGB, depth, and point cloud data from the recording we took.
d) Save different images of the different data types.
e) To generate a mesh of the scene, open the ZEDfu application, and load the SVO file of the recording we took. Click setting at the top right, ensure apply texture is enabled, and then click "Start" to start processing. The mesh will be saved automatically.

Collected Data

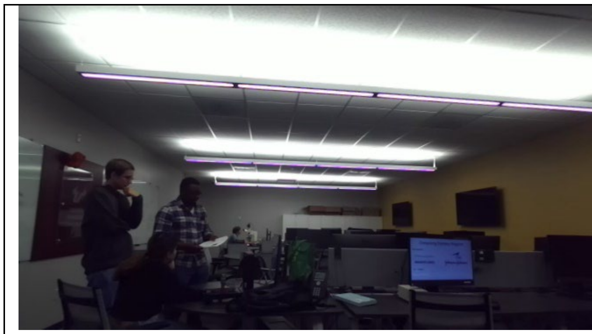

Figure 24: Color Capture

Figure 25: Depth Capture

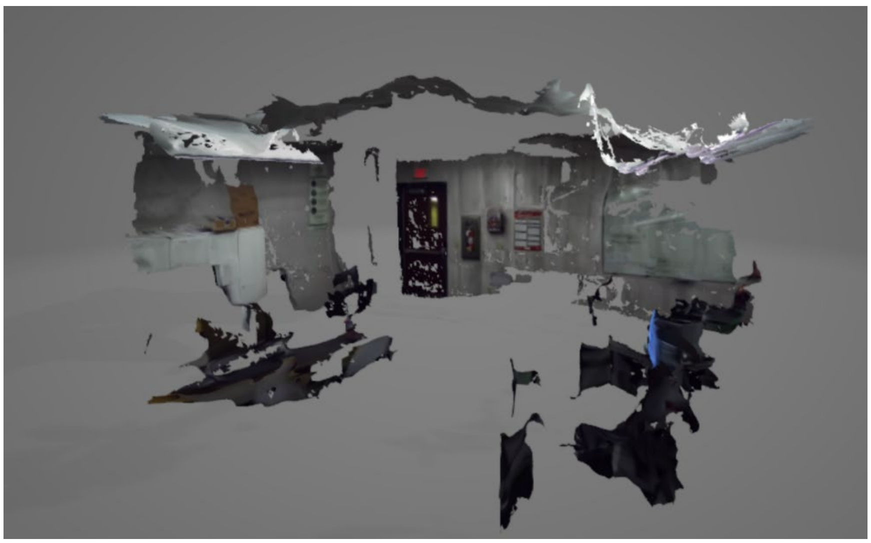

Figure 26: Mesh Capture

Processed Data

Figure 27: Histogram Equalization on depth capture

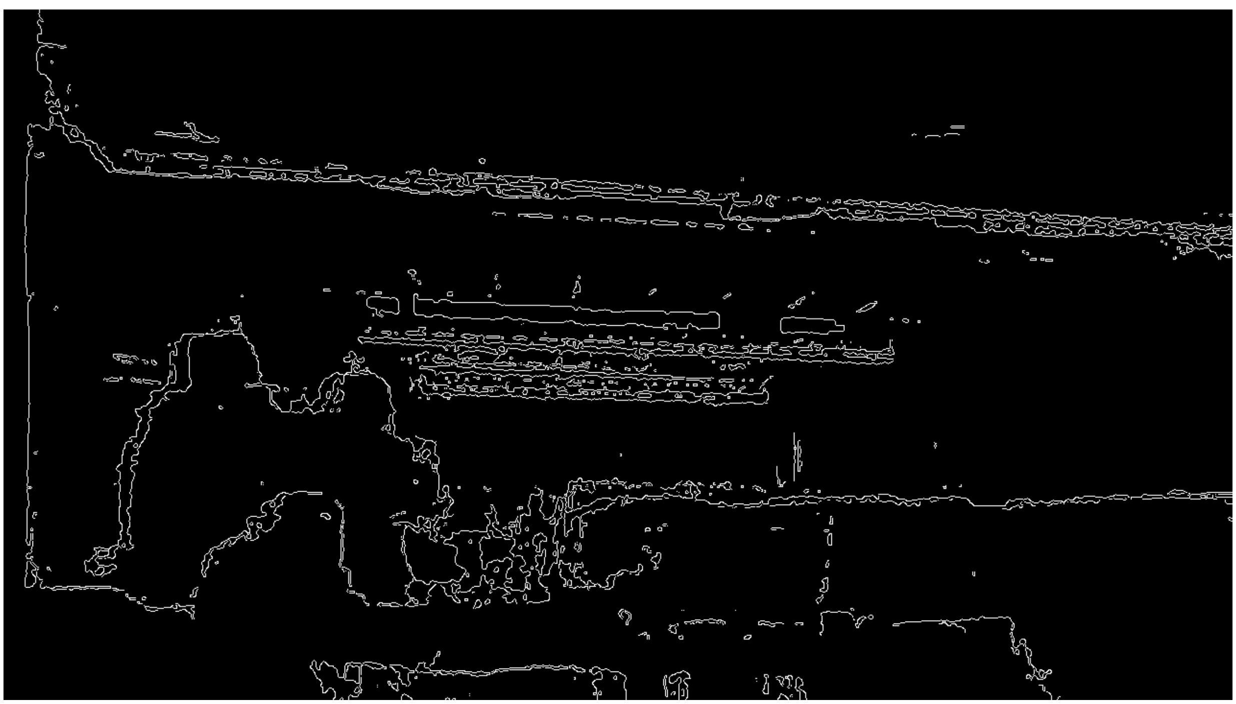

Figure 28: Canny Edge Detector on depth capture

Lab 2

Intel RealSense Depth Sensor

Introduction

The Intel RealSense D435 features three lenses, a standard 2D camera for photos and videos alongside an infrared camera and an infrared projector. The IR camera and projector allow the device to measure the distances between various objects which allows segmentation between foreground and background objects.

Procedure

To capture data using the Intel RealSense Depth Sensor:

a) Launch the Intel RealSense Viewer application.
b) Turn the stereo module and the RGB camera to on.
c) Click the small triangle at the top left of the camera to change settings.
d) To capture an image, take a screenshot of the screen or use the save button.

Collected Data

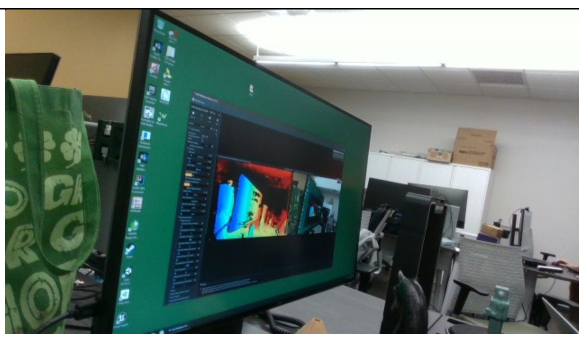

Figure 29: Captured color image

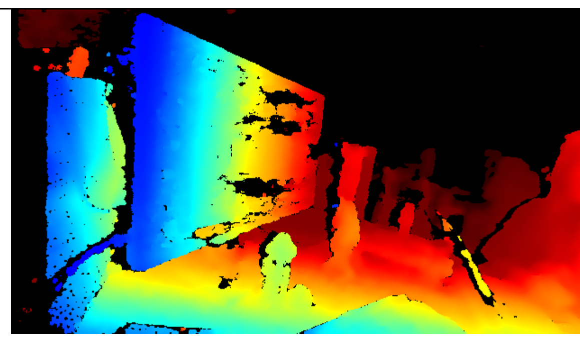

Figure 30: Captured depth image

Processed Data

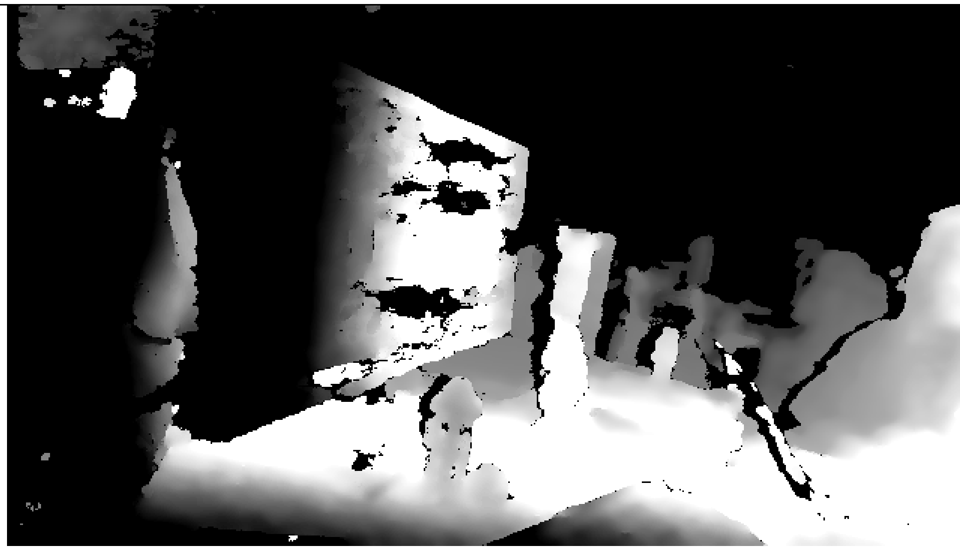

Figure 31: Red Channel of depth image

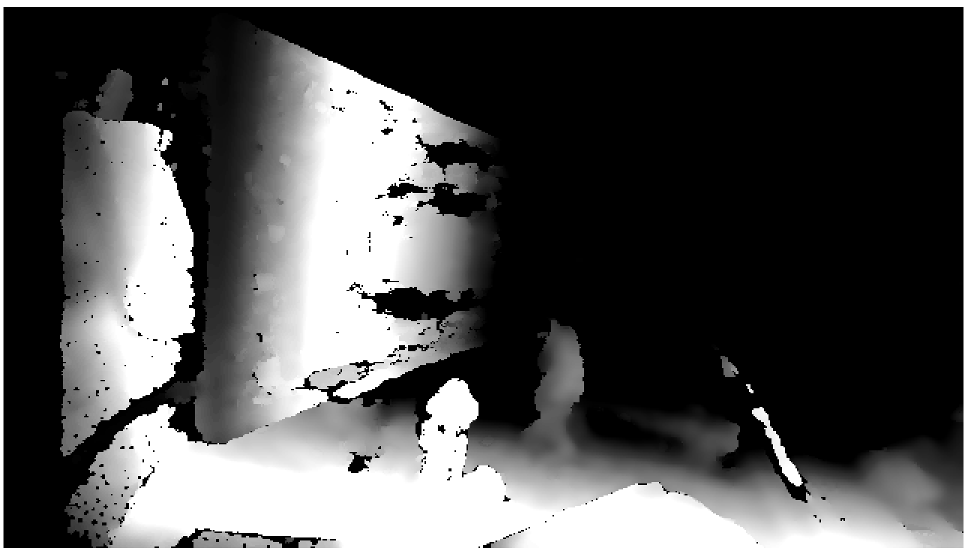

Figure 32: Green Channel of depth image

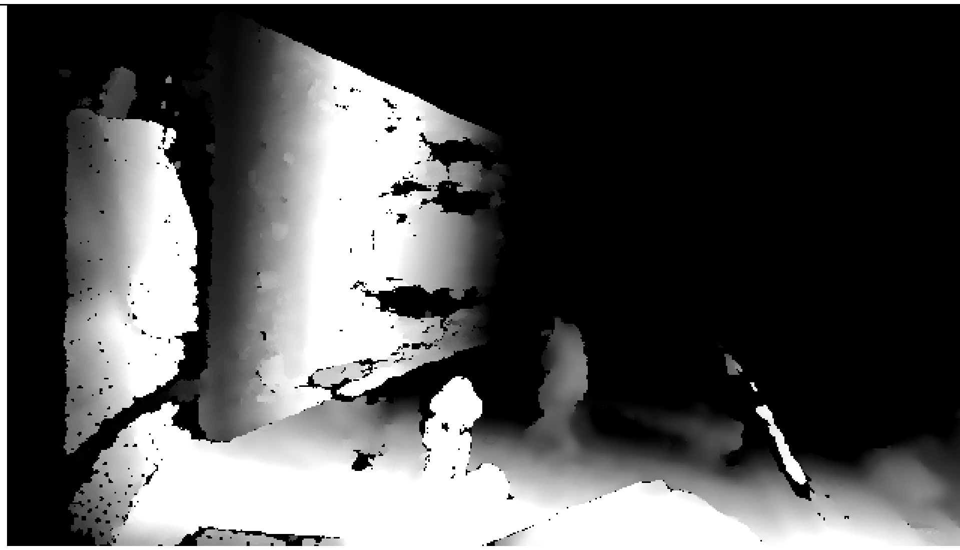
Figure 33: Blue Channel of depth image

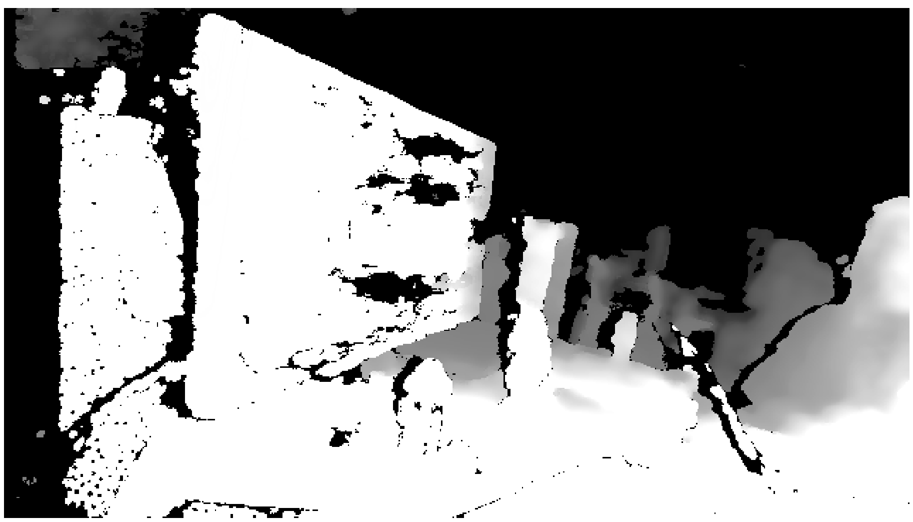
Figure 34: Intensity channel after converting from RGB to HSV


Figure 35: Threshold intensity channel to pick out objects closest to camera

Laser 3D Scanner

Introduction

The Matter and Form Desktop 3D Scanner is a small, portable 3D scanner that uses a turntable and lasers to scan objects.

Procedure

To use the Matter and Form Desktop 3D Scanner:

a) Open the MFStudio program.
b) Generate a new project.
c) Put the object you want to scan on the turntable.
d) Start a new scan and use quick scan to quickly set up scan settings, including scan height, laser and RGB exposure level, and scanning degree.
e) After scanning the object, clean up noise using the paintbrush tools.
f) Switch to Mesh and generate the mesh of the object. Take screenshots of the mesh at this point for use in processing.

Collected Data

Figure 36: Back of robot

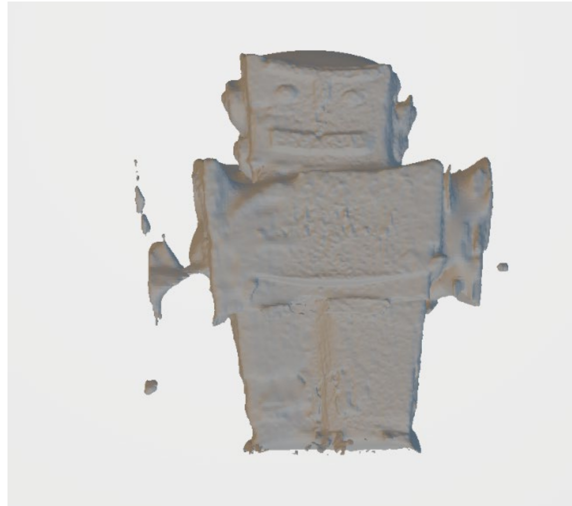

Figure 37: Front of robot

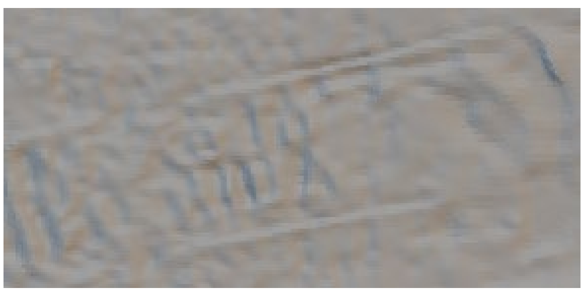

Figure 37: Closeup of decal on back of robot

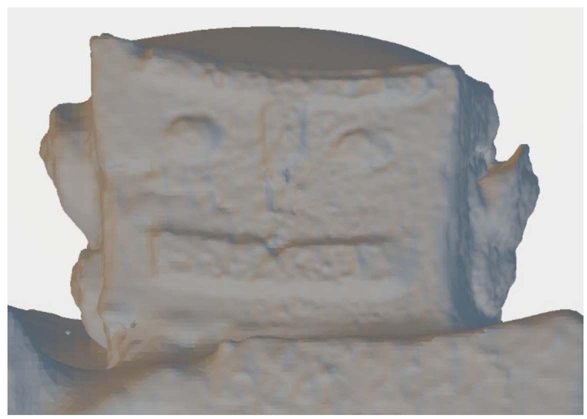

Figure 38: Closeup of face

Processed Data

Figure 38: Histogram equalization with threshold

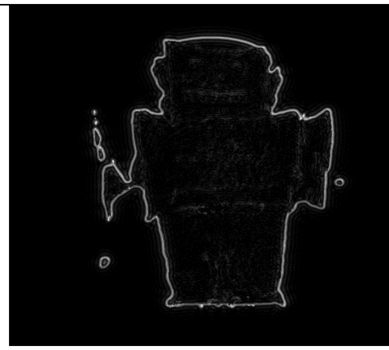

Figure 39: High pass filter

Figure 40: Canny edge detector

Figure 41: Histogram equalization with threshold

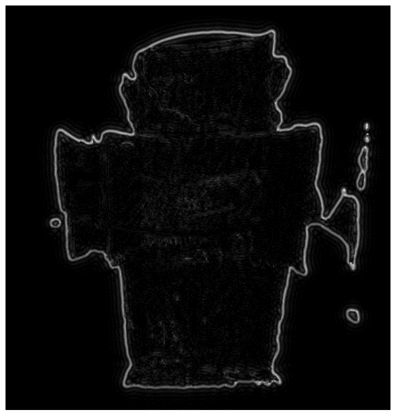

Figure 42: High pass filter

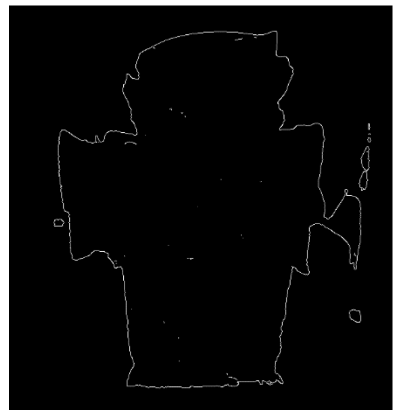

Figure 43: Canny edge detector

Figure 44: Histogram Equalization with threshold

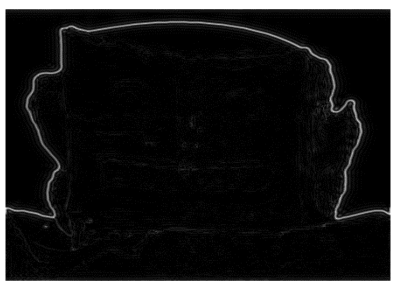

Figure 45: High pass filter

Figure 46: Canny edge detector

Figure 47: Histogram Equalization with threshold

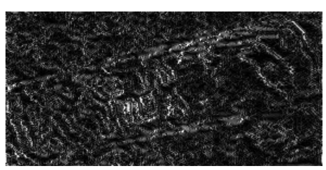

Figure 48: High pass filter

Figure 49: Canny edge detector

Lab 3

Zeiss Axioskop Mcroscope

Introduction

For Lab 3, we used a Zeiss Axioskop microscope to capture images at 4x, 10x, 20x, 40x and 60x magnifications. This Axioskop microscope is a hefty device. Such devices are used for research in institutions such as hospitals, universities, and research labs. The microscope has a built-in light source controlled by a potentiometer and a diaphragm that restricts the amount of light that enters the lens of the microscope. Students are given prepared slides of various biological matter and asked to capture images using a digital camera preinstalled on the microscope. Utilizing the camera requires the use of the ProgRes CapturePro software. This program has a comprehensive number of controls to adjust the on-screen image. Furthermore, it offers a live preview and the ability to capture a high-resolution image.

Procedure

To acquire the images, one must:

a) Turn on the lamp and adjust the potentiometer to increase/decrease the light intensity.
b) Adjust the diaphragm aperture to adjust the amount of light that passes through the lens.
c) Place the slide on the specimen stage by placing the slide underneath the clip holder.
d) Look at the sample though the eyepiece starting from the smallest magnification.
e) If the image appears unfocused, move the sliders to move the specimen bed closer or farther away from the objective lens using the focus controller.
f) Use the filter magazine to cycle through various polarizers.
g) Connect the microscope to the computer via USB and open ProgRes CapturePro software.
h) Click either Capture to save an image or Live to see a live preview.

Collected Data

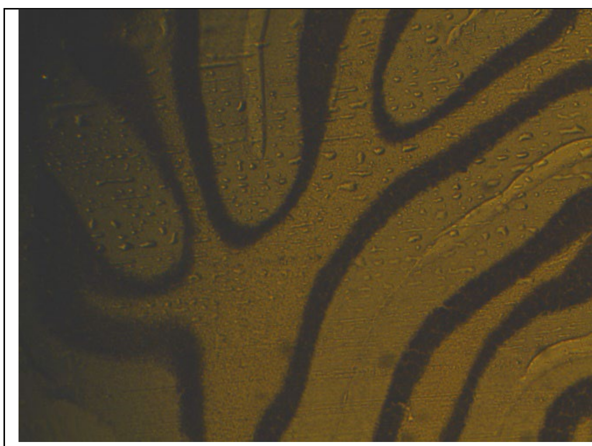

Figure 50: Organic matter captured with yellow polarizer on at 4x magnification.

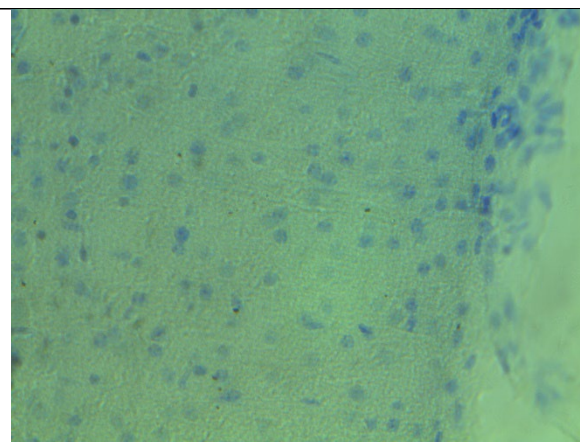

Figure 51: Organic cells captured by the microscope at 40x magnification and white light.

Processed Data

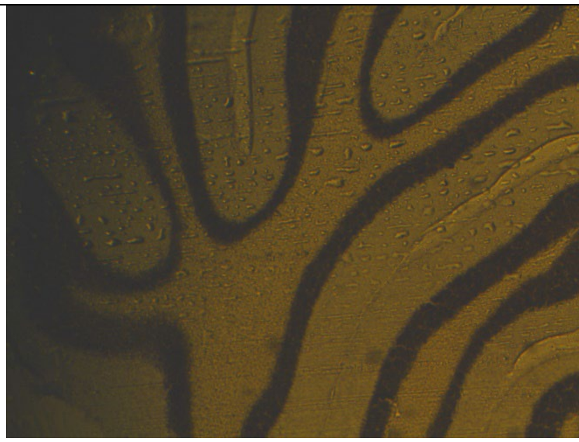

Figure 52: Original image taken from the microscope at 4X magnification.

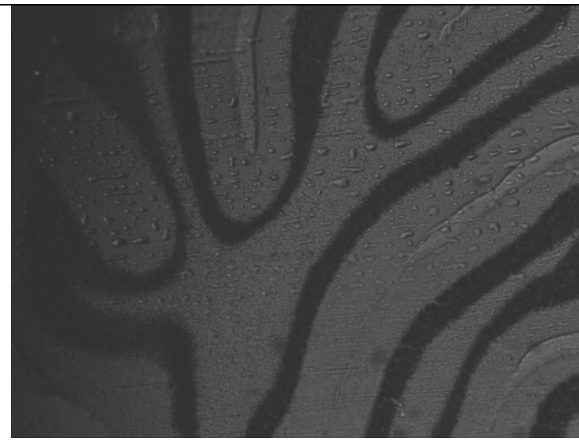

Figure 53: Grayscale image of the original image

Figure 54: Pseudo colored image with "Autumn Colormap"

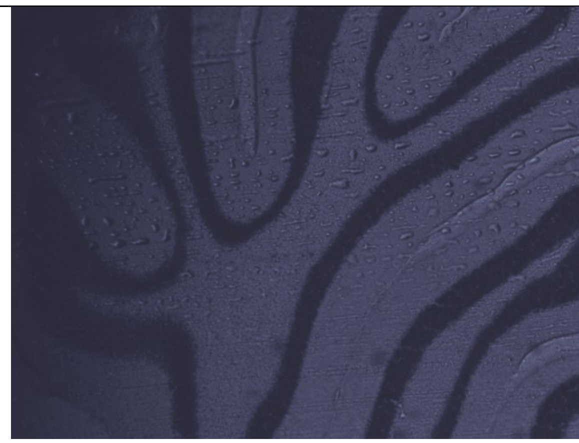

Figure 55: Pseudo colored image with "Bone Colormap"

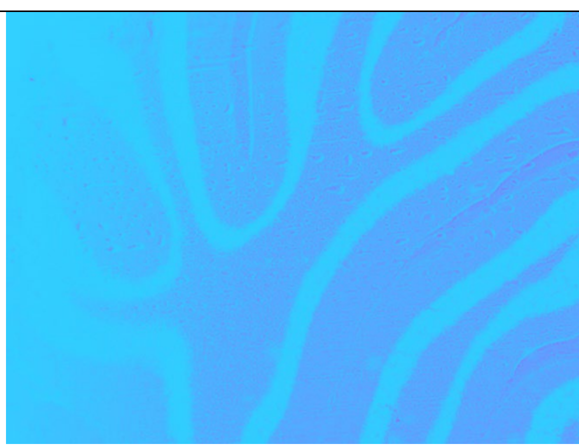

Figure 56: Pseudo colored image with "Cool Colormap"

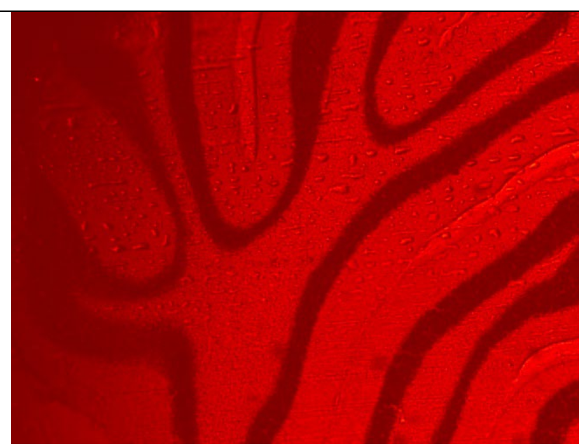

Figure 57: Pseudo colored image with "Hot Colormap"

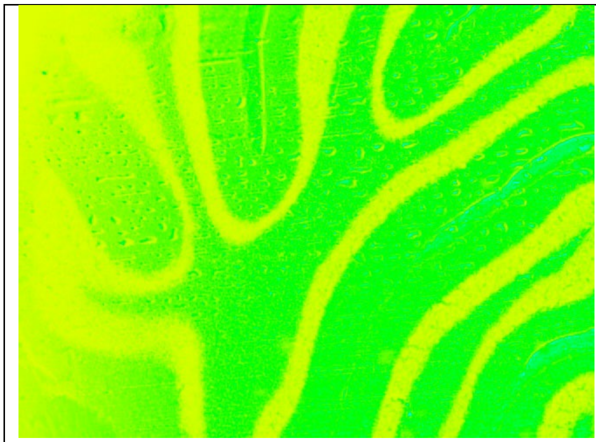

Figure 58: Pseudo colored image with "HSV Colormap"

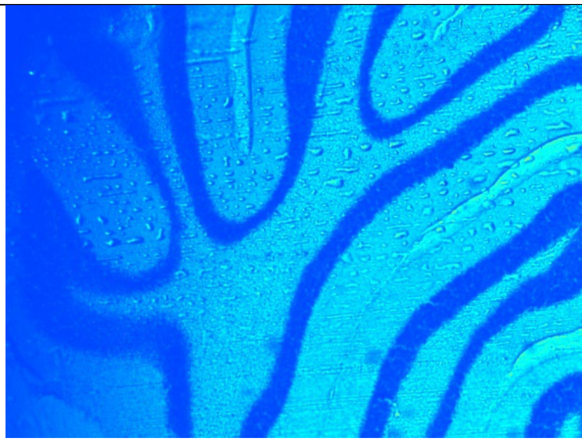

Figure 59: Pseudo colored image with "Jet Colormap"

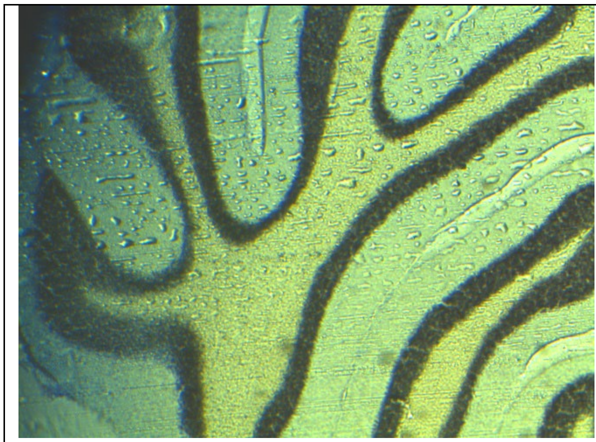

Figure 60: Original image taken from the microscope at 4x magnification and white filtered light.

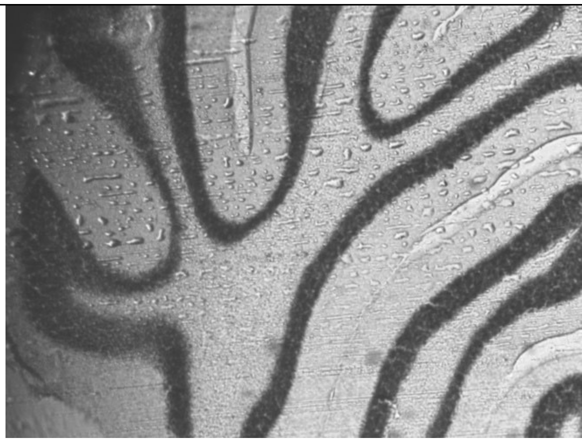

Figure 61: Image converted to grayscale and blurred using a 5x5 Gaussian Blur Kernel.

Figure 62: Laplacian Filter applied to the blurred image and binarized to distinguish edges.

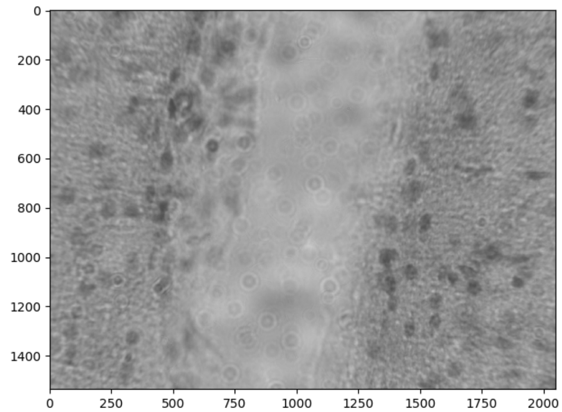

Figure 63: Grayscale image capturing organic matter at 60x magnification.

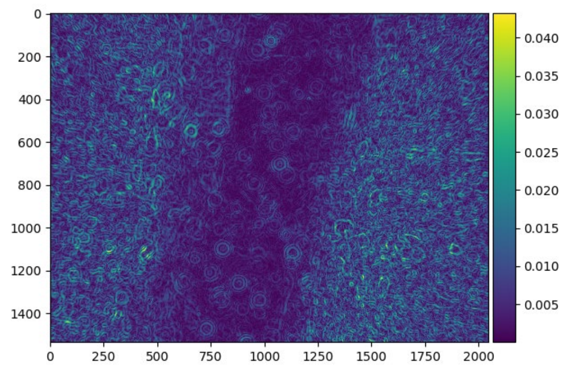

Figure 64: Low pass filter applied to the image on the left. A Sobel Kernel was applied to capture edge information.

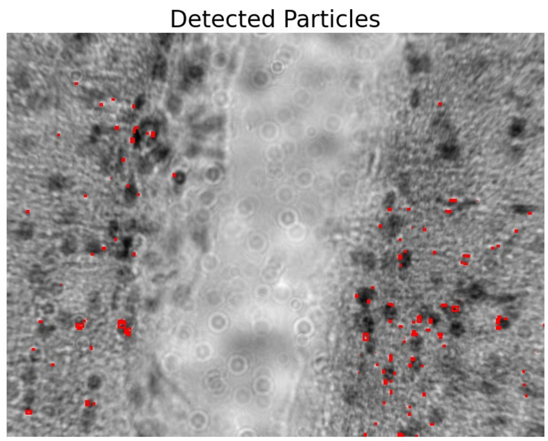

Figure 65: Object detection was applied using an in-built labeler which uses connectivity neighbor to detect closed edges.

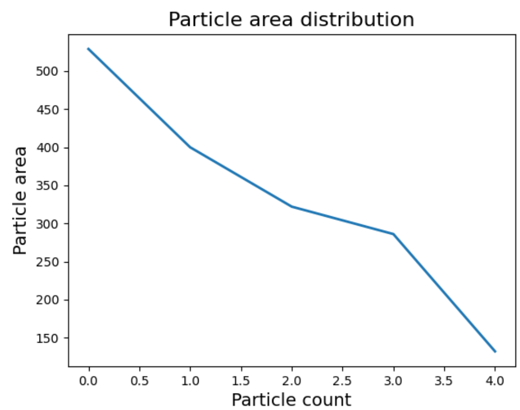

Figure 66: Distribution of the number of objects detected by the program.

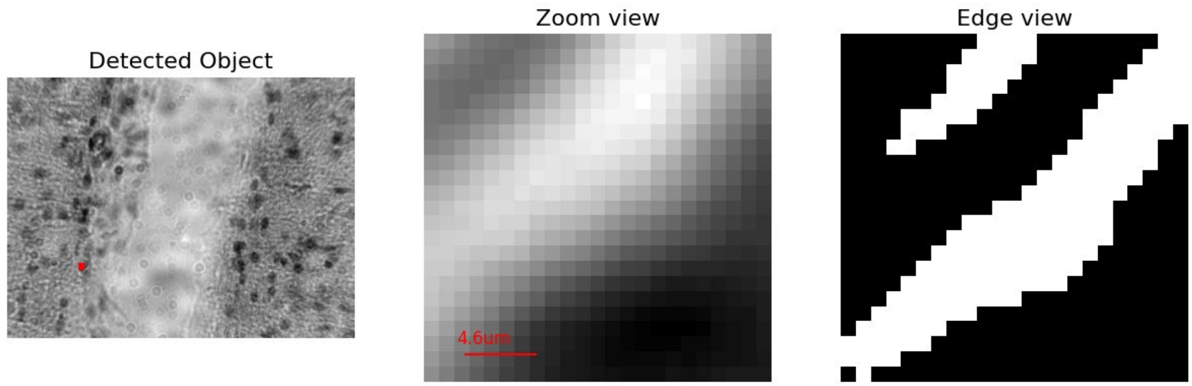

Figure 67: Zoomed in view of the largest detected object with the Canny edges.

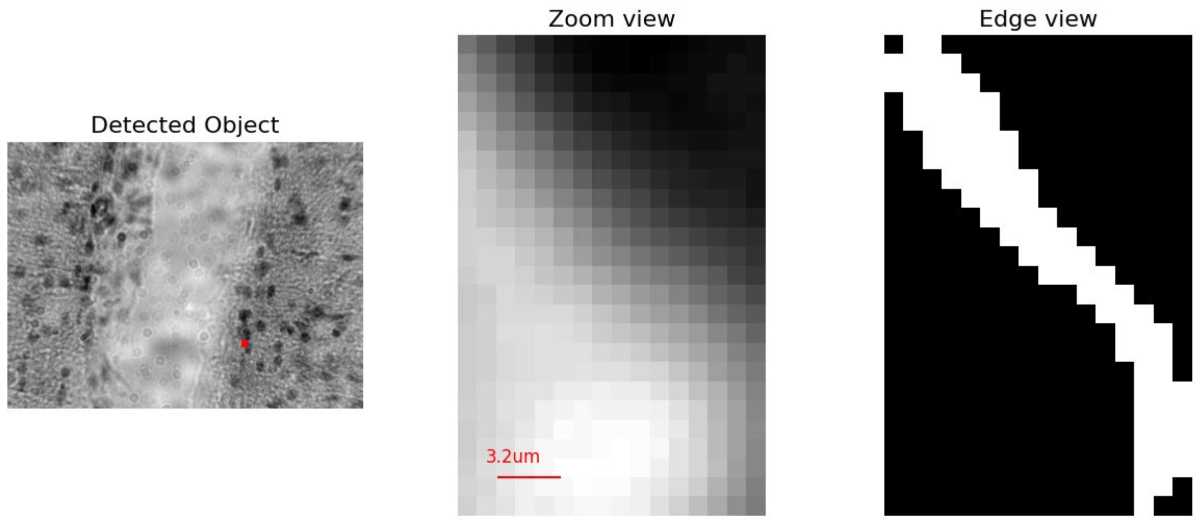

Figure 68: Zoomed in view of the second largest object detected with the Canny edges.

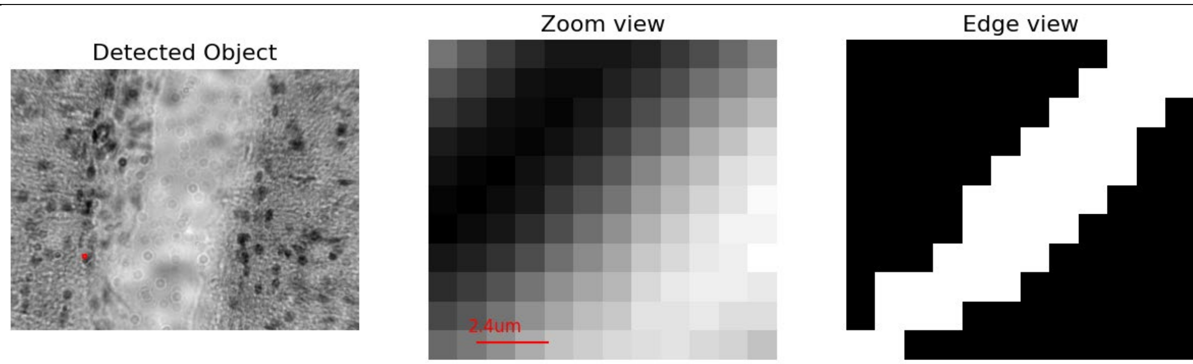

Figure 69: Zoomed in view of the smallest detected object with the Canny edges.

FLIR C3 Thermal Camera

Introduction

The second part of this lab is to use a FLIR C3 Infrared Camera to capture thermal images on several objects. The most common applications of a thermal camera are as follows:

a) Electrical wire and PCB maintenance.
b) Firemen use it to see beyond the thick cloud of smoke and make entry where the temperature is relatively low.
c) Security perimeters often use thermal cameras to catch intruders even in low light environments.
d) Gas leak detection systems often use thermal cameras to detect gas leaks because of the temperature differentials created at the leak point due to pressure variances.

FLIR is a company that produces thermal imaging solutions. They have a variety of models, ranging from consumer to professional-grade cameras. Some are mounted to a smartphone; others are standalone devices. The FLIR C3 is a standalone device with a robust feature set on the device. Its manner of operation is like a modern smartphone, and thus was simple to understand. While FLIR offers computer software for interacting with the device, this is not needed since the C3 appears as a portable camera under Windows. This is the easiest method for extracting images.

Procedure

To capture a thermal image, we must:

a) Turn on the camera (while ensuring that the USB cable is not connected to the camera) because the camera cannot save images with USB connected.
b) Take several images by pressing the trigger.
c) Finally, save the image on the desktop.

Data Collected

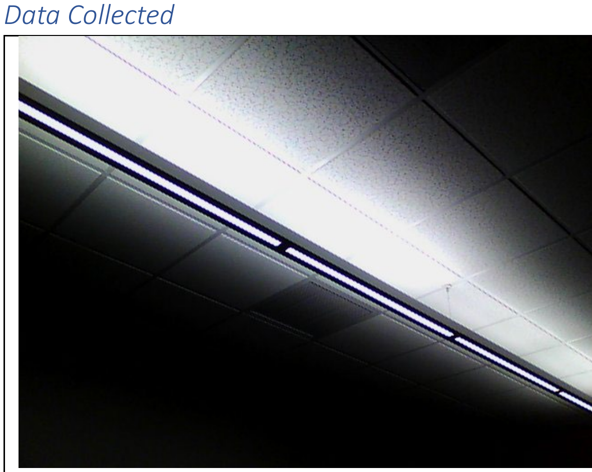

Figure 70: RGB Image of the ceiling lights

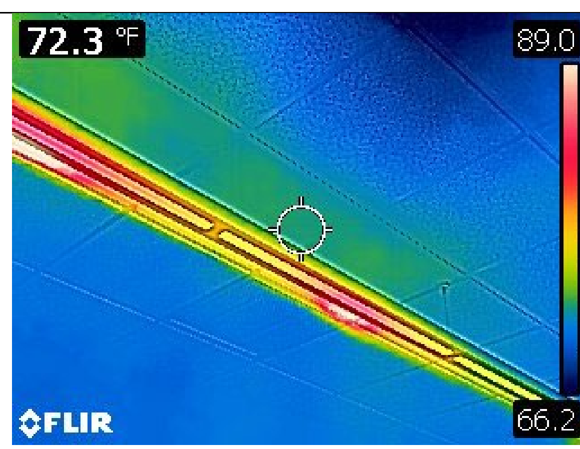

Figure 71: Thermal Image of the ceiling lights.

Figure 72: RGB Image of the storage cupboards

Figure 73: Thermal Image showing a slightly cool spot in the middle section.

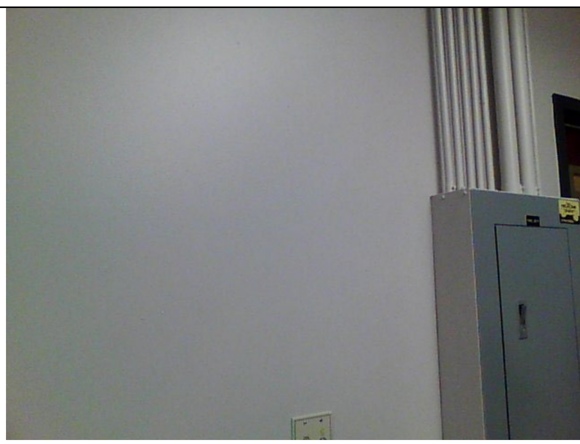

Figure 74: RGB Image of a plain wall

Figure 75: Thermal image showing a hand that had been recently placed on the wall.

Processed Data

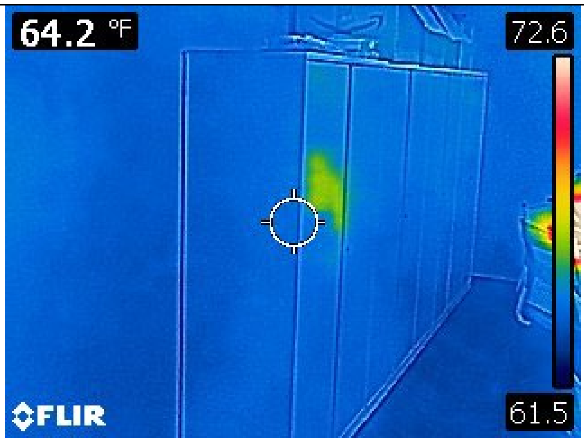

Figure 76: Thermal Image of the storage cupboards

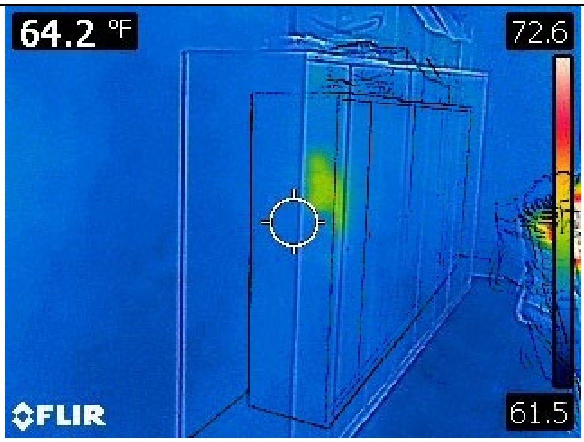

Figure 77: Thermal image with overlayed edges of the RGB image showing the difference in image sizes.

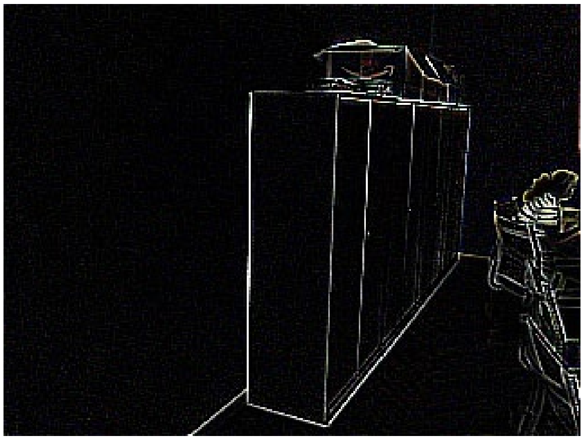

Figure 78: Edges of the RGB image taken using the Laplacian filter.

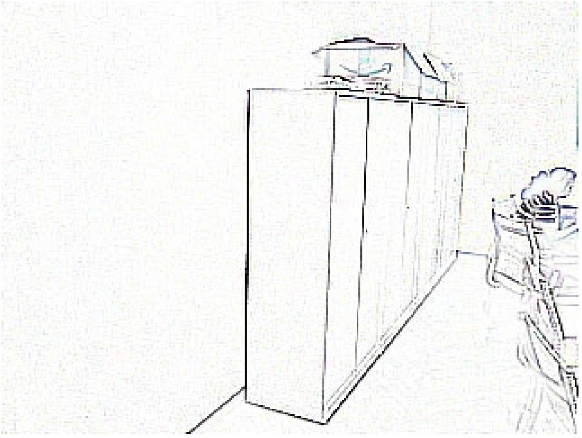

Figure 79: Inverted image obtained using a bitwise NOT operator applied to the edge image.

Conclusion

This series of labs provided an excellent experience using a wide range of instruments to collect various types of data. Processing this data was a great way to test the skills we've built throughout the semester and apply the different techniques we've learned.

Histogram equalization was used extensively in our processing to increase the contrast of images collected in adverse conditions. Increasing the contrast of our images this way allowed us to see greater detail in the image and made further image processing easier.

Edge detection using either the canny edge detector or a high pass filter separated different objects in a scene from each other, but figuring out the exact parameters for each scene was tricky and time consuming.

Thresholding was an easy way to separate foreground objects from the background in scenes where depth was captured.

The labs provided a great variety of data to process, including 3D scans of objects, Infrared data, samples taken from a microscope, and depth scans. Exposure to these data types was an invaluable experience, even if the devices used for collecting data were finnicky at times.

Performance

Most processing operations were executed very quickly thanks to OpenCV's extensive library. Basic functions such as thresholding, histogram equalization, and canny edge detectors were fast and easy to use. High/Low pass filters were a bit more complex and built upon other OpenCV functions such as the Fourier transform but were still fast. All processed images were done efficiently and took under a second to be performed.