FINAL LAB REPORT: DIGITAL IMAGE PROCESSING

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1 STEREO CAMERA, KINECT AND REGULAR CAMERA WITH FACE TRACKING

In this section, we will discuss about 3D imaging and its procedure to obtain 3D images.

1.1 PROCEDURE

1.1.1 BUMBLEBEE2

To begin with, we use the point grey Bumblebee2 stereo camera for illustrations, which includes:

1. Micro-lenses
2. Status LED
3. IEEE 1394a cable
4. 12 PIN General Purpose Input/output (GPIO) connector.

Note that the camera are able to capture 648×488 video at 48 FPS. We now need to capture stereo images of a object by running the FLIR Triclops Demo. One the select camera window, select the Bumblebee2 as device. The trclopsDemo allows us to preview the image, use the "Save/Load" (on taskbar), select Raw $\rightarrow$ Stereo. In order to access the disparity image, go to the drop-down list on the application toolbar. The disparity image is represented as temperature heat map from blue (remote) to red (proximity). Moreover, we are able to tuning the parameters by using the "Stereo Parameters" menu. On the left-hand side, there are 4 slide bars, which tune: stereo mask, max/min value for disparity and edge mask. We save the disparity image by "Save/Load", choose "Save Image" then "Disparity".

1.1.2 ZED STEREO CAMERA

The ZED Stereo Camera has the Motion tracker, which is used to capture stereo images and generate the 3D scan from recorded files. Firstly, we need to run the ZED Explorer, click REC to record the room. Secondly, we turn the camera slowly to capture the video of the room (at least 20 seconds). Later on we can experiment with different moving speed and compare their results. We are also setting the ZED Explorer by accessing the setting menu (top-right), which allows us to adjust the Initialization, runtime and save setting.
We now reconstruct the room by saved SVO file. First, we use the ZEDfu to switch apply texture to on, the click "Start" to begin the process. Secondly, we need to use the MeshLab to view the 3D image. (The saved path is located in the bottom-left, we can also turn on/off the show camera path and draw edges).

1.1.3 KINECT V1

The Kinect camera uses structured light technique to measure the distance (Time of Flight technique). We have two choices of function, which are ColorBasicsWPF and DepthBasicsWPF in "Kinect Developer Kit". The images are captured by "Capture" button, allow us to take multiple images with different distance.

1.1.4 LOGITECH C910 HD WEBCAM

In the last section of this lab, we experiment the face tracker using Logitech C910 HD webcam. On the control menu, we enable the "follow my face" and start record the video and experiment by adjust changes such as cover parts of the face or multiple faces tracking at the same time.

1.2 PARAMETER ANALYSIS

1.2.1 ZED STEREO CAMERA

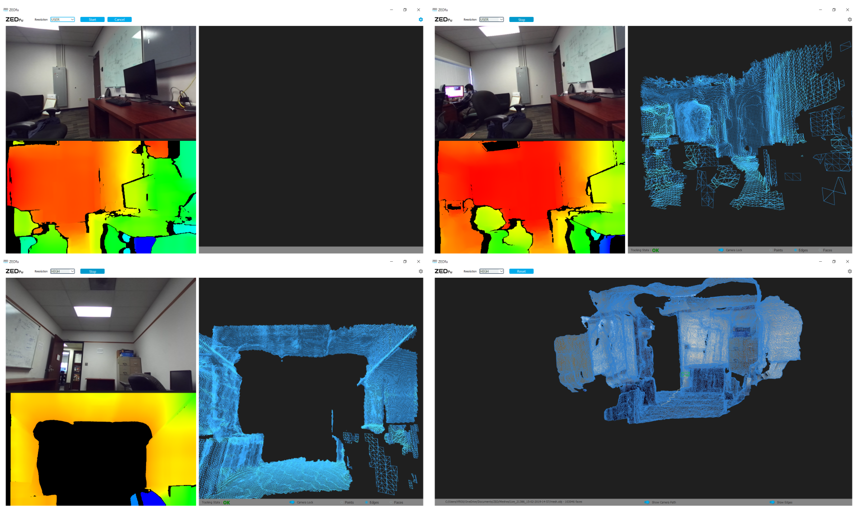

Figure 1: Stereo images captured by ZED camera from a room.

We first set up the Initialisation as Ultra mode and enable the stabilization. For the runtime, on the standard sensing, we use the max range of 15M and 100% confidence. Moreover, the capture setting is HD720 and FPS of 15, reproducing 1280×720 video at 15 FPS.

1.2.2 KINECT V1

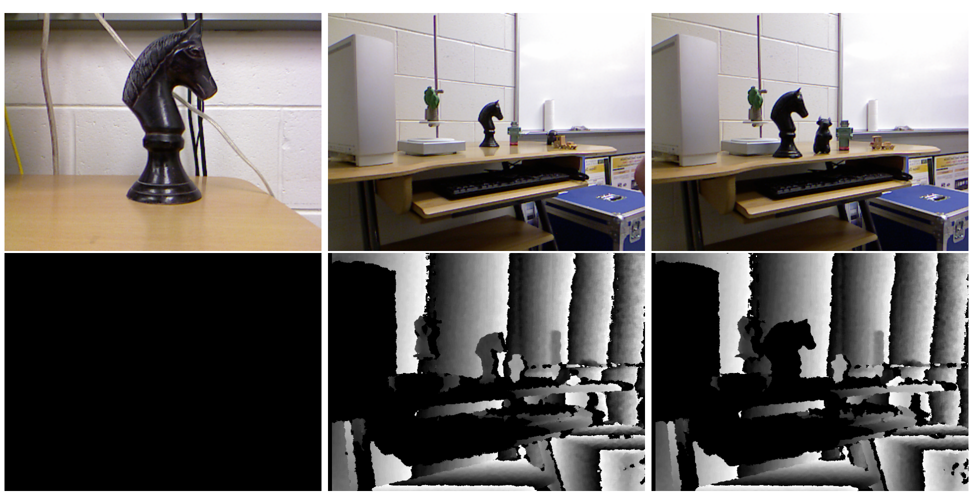

Figure 2: Stereo images captured by Kinect v1 camera from a room.

In this experiment, we rather concentrate more on the distance of captured objects. We first begin with close distance to the camera and then move the object far from the camera. When we move the object (the horse) away from the camera, it becomes faded in the depth map, while too close cause a complete back image.

1.3 Implementation of Developed Toolbox

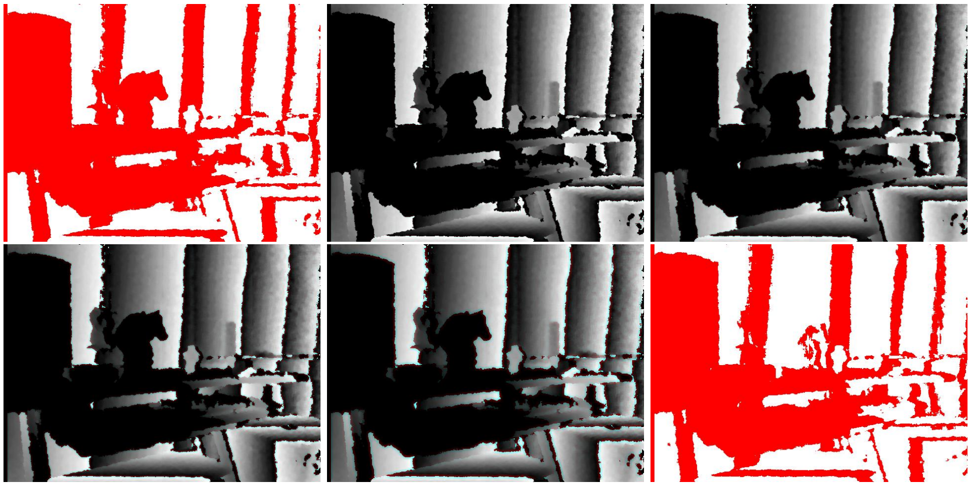

Figure 3: Color Binarization and uniform smoothing with increasing window size, ranging from 3,5,7 and 11.

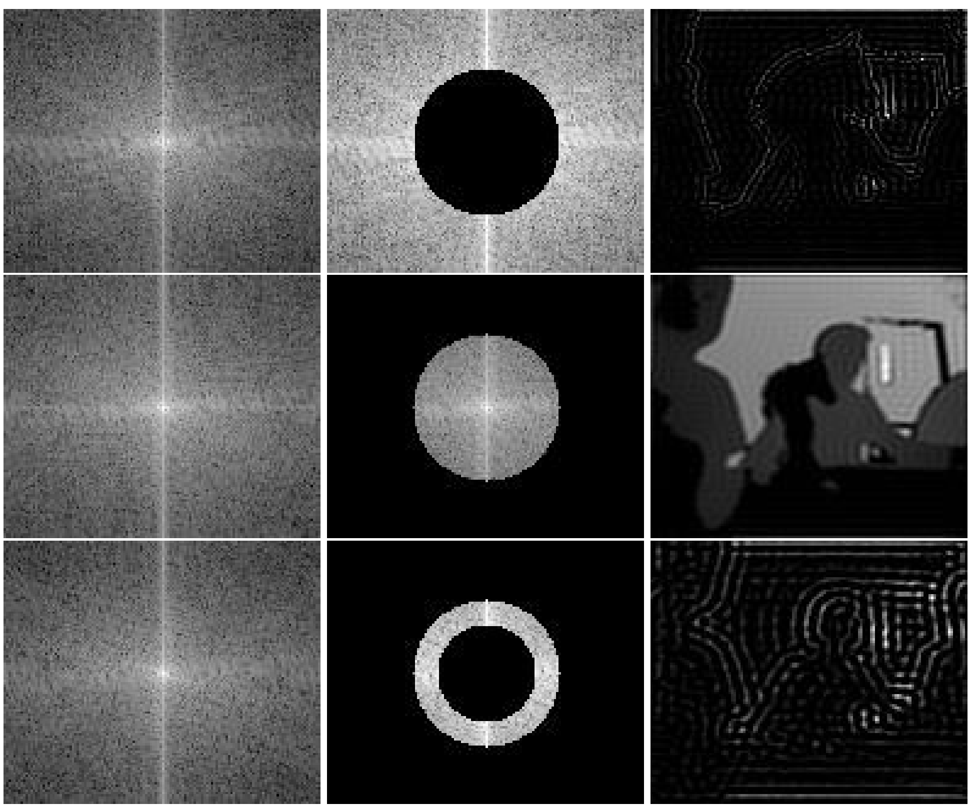

Figure 4: The Fourier domain of captured images with applying high-pass, low-pass and notch filter.

We apply the uniform smooth on the grey-level images, since the input images have noisy edges. The window size increases from 3 to 11 leading to enhancing noise removal effect. The same effect is witnessed when apply the low-pass filter with $D_0 = 20$. In contrast, applying the high-pass filter with the same D_0 has edge enhancement effect, thus the edge from the object (horse) is highlighted. Moreover, the notch filter highlights the human in the background and the edge of the horse now is disappeared.

2 Intel RealSense Camera and Laser 3D scanner

2.1 Procedure

2.1.1 Intel RealSense SR3000 and D435

In this experiment, we aim to capture the depth images by using the Intel Sense SR3000, which include a single IR projector, IR sensor and RGB camera for capturing texture. To begin with, on the Intel RealSense SDK browser, we see 2 windows for current color image, its depth estimation. We start the streaming process by the "Play" button and use the *"CreateDepthImageMappedToColor"* to get the separated depth map. A convenient way to save the depth map is to use the build-in Snipping Tool of Window 10. Additionally, we investigate the effect of distance and the object's material on the captured depth maps.

The structure of Intel RealSense D435 is a quite different from RealSense SR3000, which involves two IR sensor driven by IR stereo technique. First, we use the Intel RealSense Viewer and enable the Stereo Module and RGB camera. The advanced setting can be accessed by the small triangle on the left of the camera. In the parameter menu, we can adjust a set of parameter for different experiments. Similar to previous experiment, we can investigate more on the intrinsic characteristics of captured objects, such as distance, color and material.

2.1.2 NextEngine and Matter and Form Desktop 3D Scanner

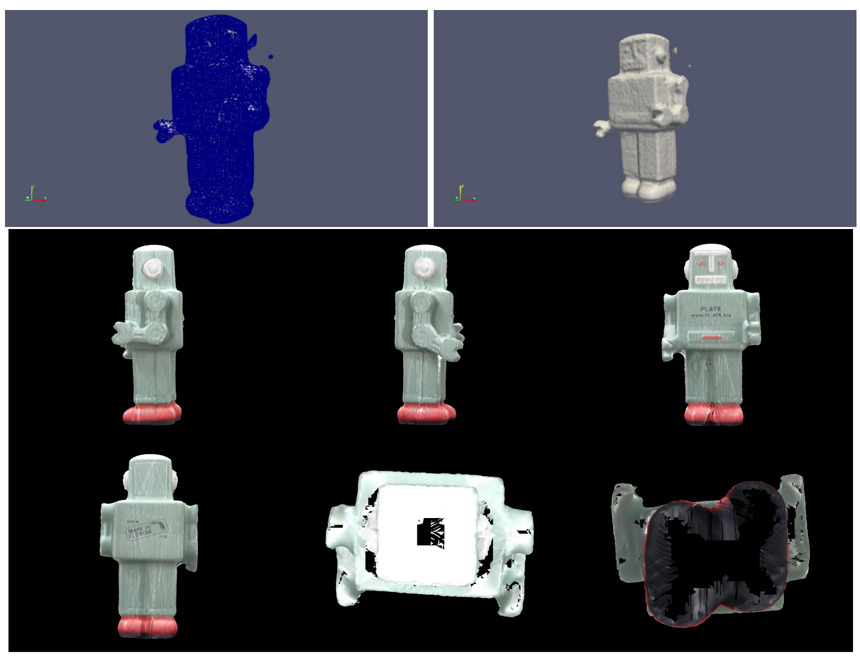

Figure 5: Stereo images captured by ZED camera from a room.

The main objective of this lab section is to capture the 3D scan of a given object then generate its 3D model by aligning, trimming and fusing the scans. In the scanning setting, we have several options, related to scan style, resolution, color option, range and the time and memory. To initiate the scan, we need to locate the object in the center of the stand, and then start View and Trim function. After scanning, we can save the scans as SCN files (more popular options are STL,PLY and OBJ).

Similarly, the MF desktop 3D scanner performs the same task as previous scanner, however we are further generated the Mesh. The scan is enabled by MFStudio. Before the scan, we need to set up some parameters, such as laser exposure level, RGB camera exposure level, height of the object, scanning degree and estimated time. After receiving the output scan, we can perform noise removal process by add/remove the points with brush. The processed object can generate Mesh that is saved as obj, mtl or jpg file for MeshLab.

2.2 Parameter analysis

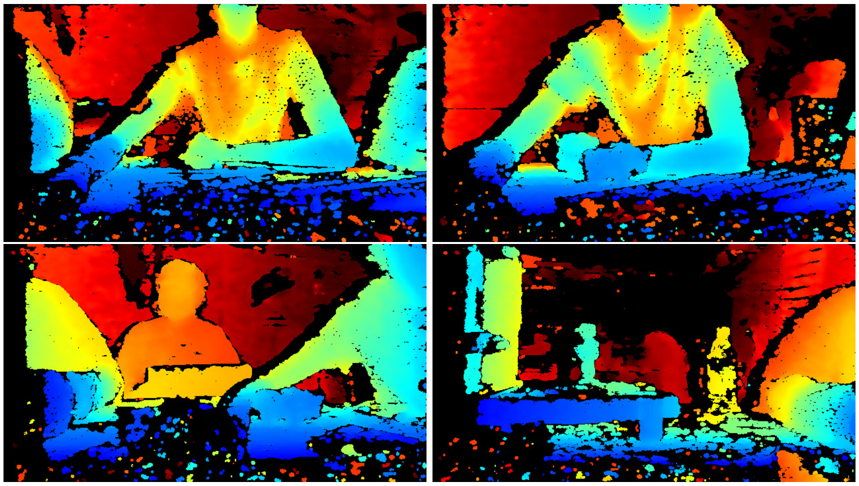

Figure 6: Images captured by RealSense camera from a room.

We adjust the distance of camera to see how the images captured by RealSense camera. If we move the camera away, the object is represented as more red region, while closer object is blue.

2.3 Implementation of Developed Toolbox

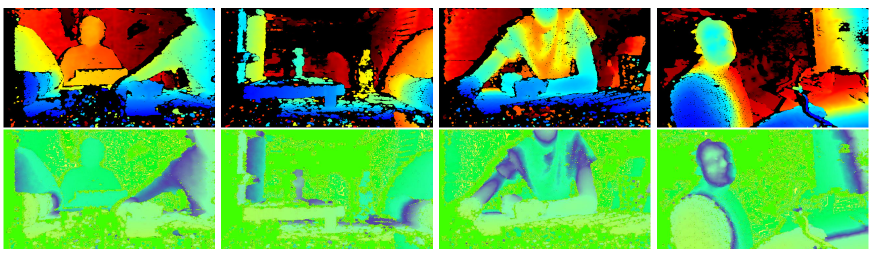

Figure 7: HSI conversion of depth estimation images.

We conversion the color of the images to HSI space. As we can see from the resulted images, not all red regions become the same color in the output images. Interestingly, the background in the third images become the same color with the table (green), while the shirt becomes coral. The same effect is appeared in the remaining images.

3 Microscope Images and Infrared Camera

3.1 Procedure

3.1.1 Axioskop Zeiss Microscope

The main task for this experiment is to capture images under a wide scale of magnifications and illuminations using ProgRes Capture Pro. The AZM is able to capture image at magnification $4\times, 10\times, 20\times, 40\times$ and $60\times$. We first need to turn on the source for lamp using the switch located in bottom-right side and ensure to open the diaphragm (at the center). Also, we set the potentimeter to 10 Volts. The microscopic slide is placed on the specimen stage. We see the object start with small magnification through the eyepieces, which can be adjusted to fully observe the object. To move the object around, we use the x-y controller and the coarse/fine controlling focuses to make the image sharp. By switching the objective, we can increase the magnification, along with adjusting the illumination. Typically, the higher magnification requires more light to capture images. We can capture images for various ROIs using the ProgRes CapturePro 2.8.8. On the setting menu, we can select saving directory and the image format after cropping the ROIs.

3.1.2 FLIR Infrared Camera

The objectives of this lab is to capture the thermal images by FLIR infrared camera under fixed/ varying scale of temperature. We first turn on the camera by the button on the front and open the lens by removing the cap. We then can capture images by using the trigger in the front side. The same procedure can be apply when using the FLIR C3. Note that both camera cannot save images with plugged USB cable, thus we need to unplug it before taking images. On the FLIR C3 screen, the temperature of spot meter is located on the top-left side, while the temperature scale is on the right. We also unlock/lock the temperature scale to see the effect. To obtain the digital photo (objects saved as both thermal model and digital mode), we need to use the FLIR Tools and go to the directory.

3.2 Parameter analysis

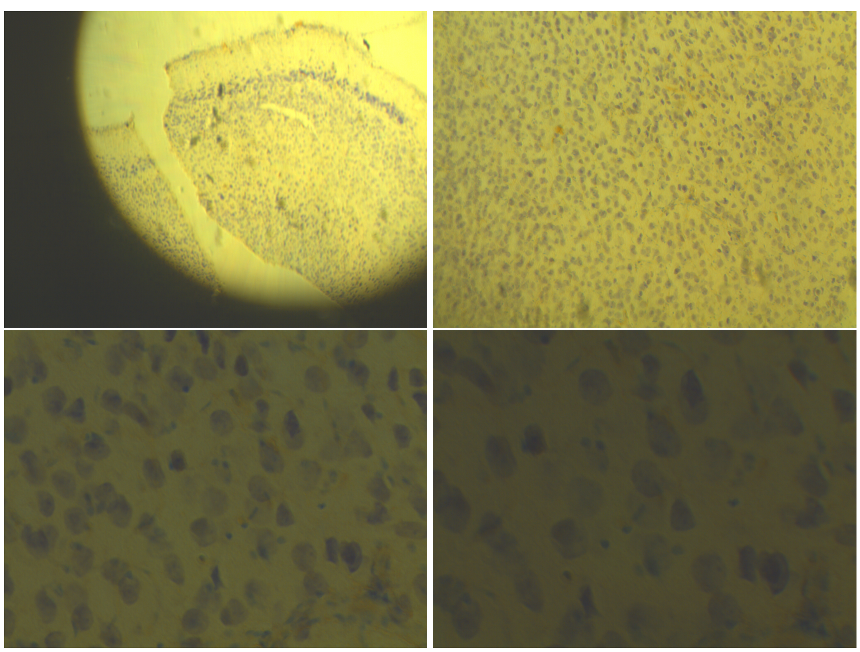

Figure 8: The microscope with adjust of magnification, raging form 4, 10, 40 and 60. As we can see the intensity of the image decrease as we increase the magnification.

For the Axioskop Zeiss Microscope experiment, we investigate the effect of illumination levels under the same magnification. Additionally, we can collect the images with different magnification

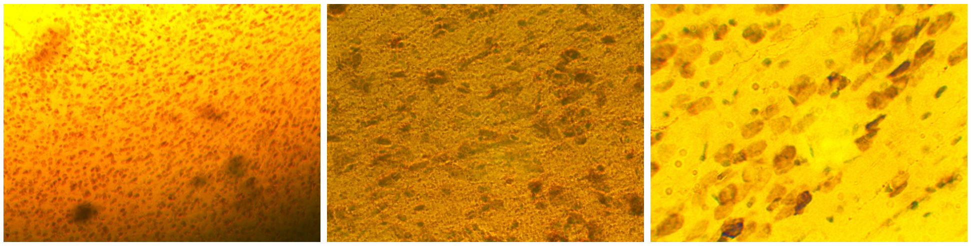

Figure 9: The microscope with adjust of magnification, raging from 20, 40 and 60 with adaption of illumination.

under the same illumination level (see Figure 8 and 9). For the experiment on FLIR camera, we lock/unlock temperature and see the effect. Also, we investigate further on the material, distance of the obstacles (Figure 10).

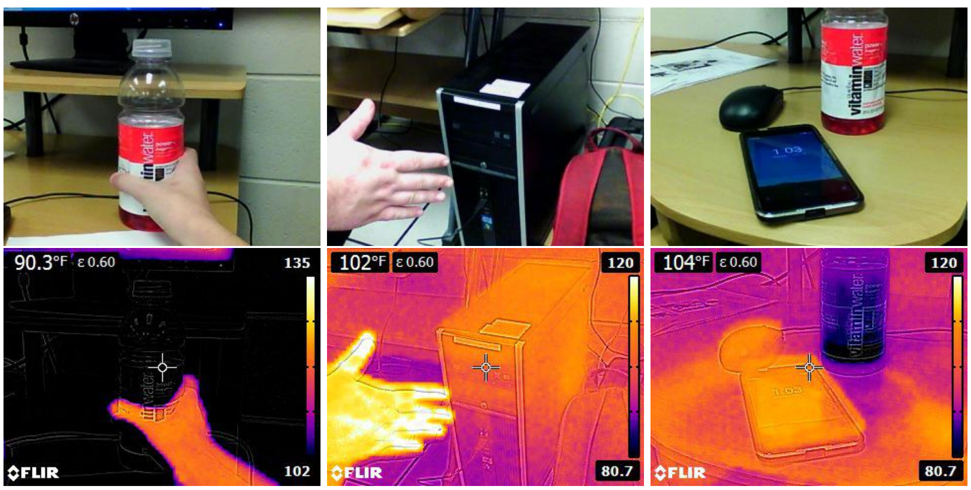

Figure 10: Images captured by FLIR camera from different object.

3.3 Implementation of Developed Toolbox

First, we mentioned above that with higher magnification, we need to increase the illumination. Therefore, we apply the histogram equalization to enhance the intensity of images taken under $40\times$ and $60\times$. As a result, the output images has been improved in the intensity. We also investigate the effect of Otsu's segmentation methods on these image. The cells is highlighted from the environment, even some noise is still included. Regarding the FLIR images, the HSI conversion is again applied. We now apply conversion only on top-half of the image to see the contrast.

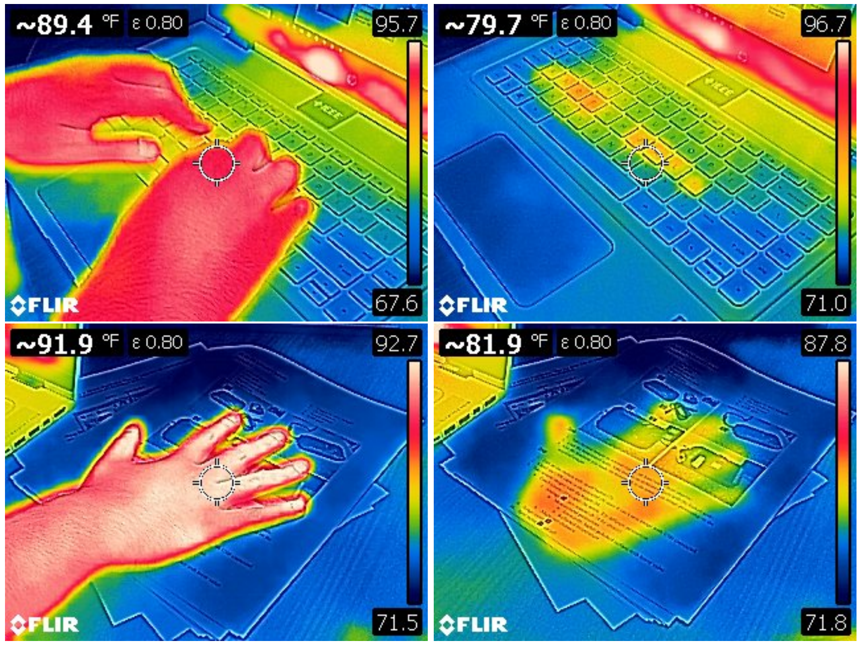

Figure 11: Images captured by FLIR camera from different object. The temperature scale is showed on the right.

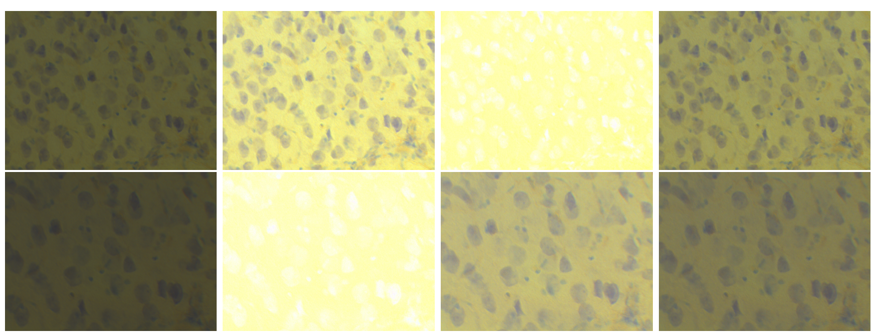

Figure 12: Histogram equalization on the microscope images using increasing range from 50, 100 and 150.

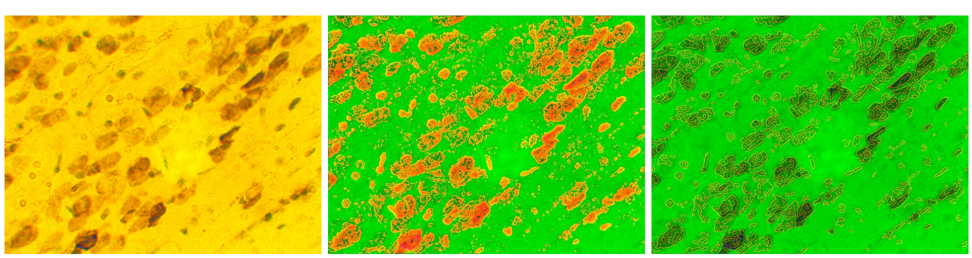

Figure 13: Edge detection using Otsu's algorithm and canny edge detection after histogram equalization.

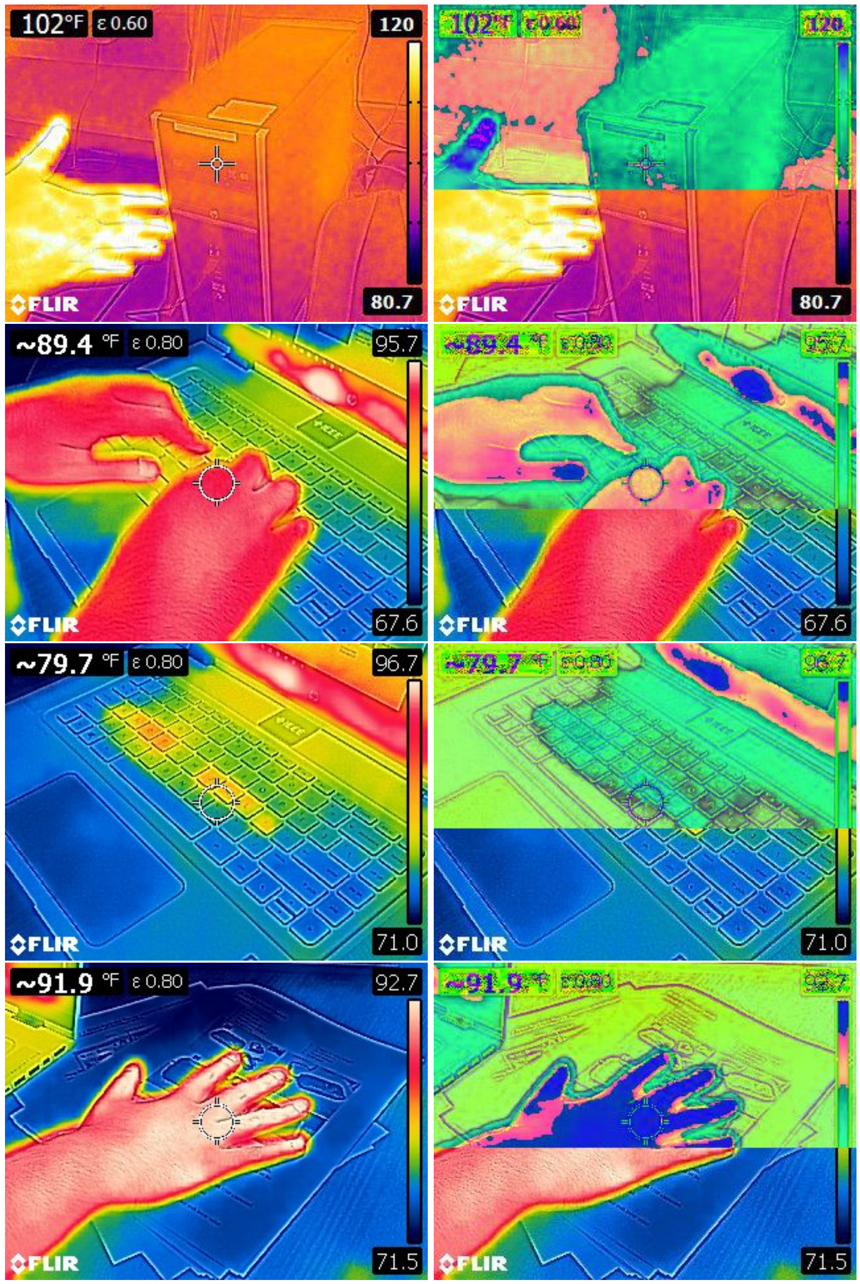

Figure 14: Color conversion to HSI applying only on top-half of the original images.