2.1 Segmentation of Glove

According to the snippet (**Error! Reference source not found.**), here are the steps for segmenting the glove.

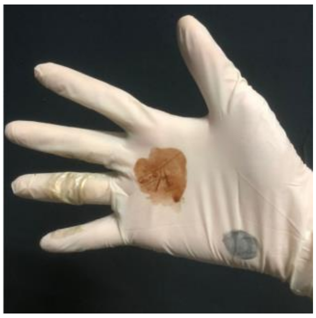
Figure 1

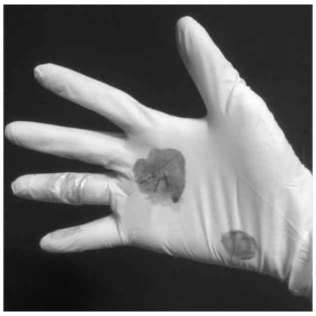
Figure 2

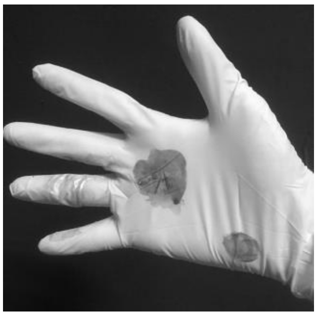
Figure 3

The above three figures from left to right, shows the original, then greyscale, then sharpened image.


Figure 4


Figure 5


Figure 6

As clearly shown, there is a big difference from Figure 3 and **Error! Reference source not found.**, because it has undergone thresholding using the Otsu's method and is now a binary image. The next two figures, however, shows morphological operations, closing then open operations to close the holes and remove imperfections.


Figure 7


Figure 8

Error! Reference source not found. and Figure 7 are closely related as Figure 7 is a copy of **Error! Reference source not found.**. However, the difference is that, Figure 7 has converted into a double precision image, replacing all zero pixels values with NaN values for removal. With that, the background is removed as shown in the last sample, known as glove segmenting.

This project aims to detect defect from gloves and not the background of gloves. Therefore, it is crucial for the glove be segmented out from its background so as to prevent interference from unrelated areas of the image, ensuring accurate and reliable detection results as the focus is now on the glove and the glove only.

2.2 Hole & Undersized Detection

Holes in gloves represents that the skin is exposed. Therefore, under that assumption, this algorithm primarily attempts to detect skin colour within the image.

Figure 9

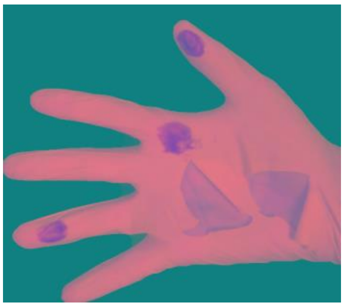

Figure 10

Figure 11

To start it off, the image is converted into YCbCr colour space. The reason for this conversion is to extract the skin colours by thresholding the Cb and Cr channels using the pre-defined ranges, which has resulted in producing Figure 11.

Figure 12

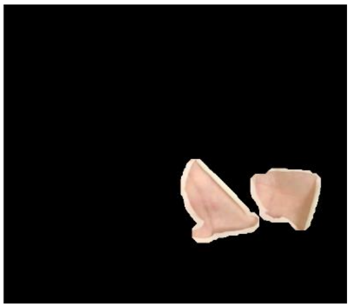

Figure 13

Figure 14

Morphological operations are then done on Figure 11 to close the gaps of the desired area and remove small white noises. Next, like in glove segmenting, the desired portion is segmented out from the original image and sent off for identification whilst sending Figure 14 with the skin colour portion removed to the other detectors to detect other defects.

Skin detection is vital to detect holes or undersized gloves. This algorithm is created with the assumption that the gloves would be worn by a human hand with bright peach colour. Although it may be done with greyscale image, this technique offers more accuracy and is considered distinct from other techniques, hence limiting interference from other defect detections.

2.3 Stain Detection

Figure 15

Figure 16

Figure 17

Detecting stains is similar to glove segmentation with these three images representing grayscale, filtering and thresholding. In this specific case, Otsu's method is not used as the condition for each pictures varies, affecting Otsu's capability of securing the optimal threshold value.

Figure 18

Figure 19

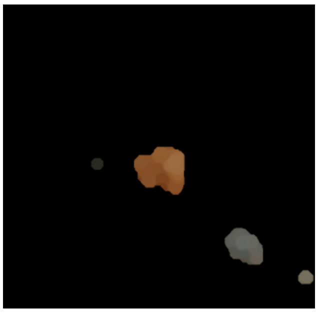

Figure 20

The image then undergoes various morphological operations to eliminate the outline of the gloves and highlight the stains.

Although crude, and less specific than the hole and undersized detection, it still works well and shows good results. Thus, this algorithm is chosen to be used for stain detection.

4.0 Obtained Results & Critical Comments

4.1 Latex

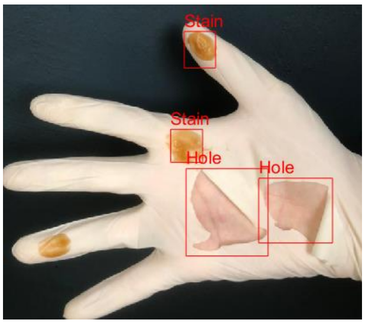

Figure 21: Latex Sample(1)

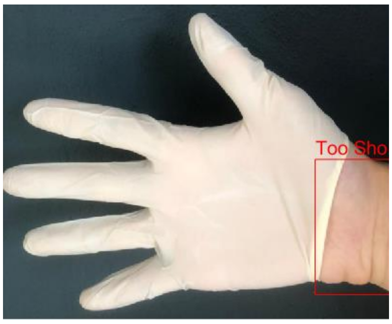

Figure 22: Latex Sample(2)

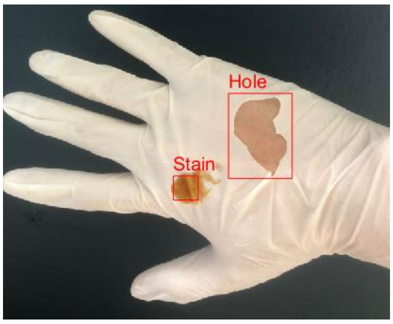

Figure 23: Latex Sample(3)

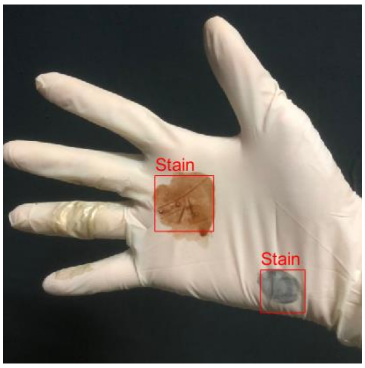

Figure 24: Latex Sample(4)

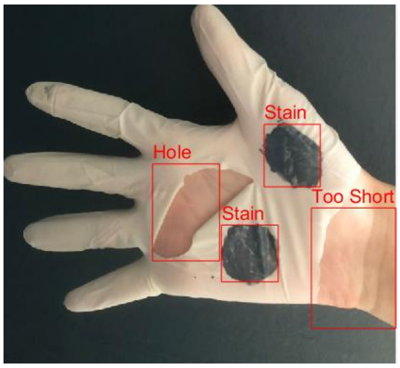

Figure 25: Latex Sample(5)

For latex, the detection system only identifies three defects; hole, stain and undersized. As seen in the result above, the detection system successfully detected and identified 13 out of 16 defects, an accuracy of approximately 81%. When the stains are too small like in Figure 25 or too shallow like in Figure 21 or possess similar colour to the glove, the system fails to perceive those defects. Additionally in terms of precision, stain outlines are more-or-less spot on while skin colour related defects like hole and undersized requires further precision, as it is evident in Figure 25 that the defects are outside of the boxes.

The detection of defects for latex has been successful. However, for detecting stain defect, it requires the user to manually configure the threshold value. Unlike glove segmenting, Otsu's method is not compatible in defects detection as images have various attributes such as lighting, contrast and intensity, making it hard for Otsu's method to determine the optimal threshold value.

Moreover, using colour to discern defects has its cons as well, despite its accuracy in the results above. In the situation where the colour of the defects is similar to skin colour, it would be perceived as a hole. Likewise, when the skin colour is of darker colour, the system would not perceive it as a hole, but instead, a stain. Therefore, the input is equally important to obtain the desired output.

Last but not least, intensity is the core value in images that greatly affects the image processing operations. Thus, pre-processing procedure such as image procuring is just as important as the processing itself. An image with uneven intensity and brightness can be the cause of inaccurate results. For instance, despite the same location and same background, the sample above clearly shows different lighting, thus requiring distinct threshold value differentiate the glove and the defects.