COMP2271 Data Science – **Future Medical Data Analysis through Data Cleaning and Image Processing**

Image Processing Report

Date: **27/04/2023**

Abstract — This report describes methods used to enhance the quality of 256x256 images using 'opencv' in Python. The image processing techniques used and their contribution to improving an eye clinic's ai classifier using a test dataset are discussed.

Index Terms — Image Processing, Glaucoma, Noise, Classifier, Inpainting

A sample set of 40 corrupted images need to be enhanced so they can be classified by the eye clinic. The images are distorted in the following ways:

1. Noise - Gaussian and salt+pepper
2. Warping - perspective warping
3. Contrast/brightness - High and low brightness/contrast
4. Colour channel imbalance - some channels are brighter/darker than others
5. Missing region - ellipse shaped hole missing on each image

First, remove salt + pepper noise and then Gaussian noise. A median filter is used to remove salt + pepper noise. This is a non-linear smoothing filter which replaces each pixel with the median of its neighbouring pixels, removing outliers and preserving edges. Apply a non-local means filter to remove Gaussian noise. This combination of filters was more effective than a bilateral filter.

Larger grid size for the median filter increases blur therefore it is important to balance noise reduction against smoothing. I will use non-local means to remove Gaussian noise so the median filter only needs to remove salt + pepper noise. I found a grid size of 3 to be appropriate.

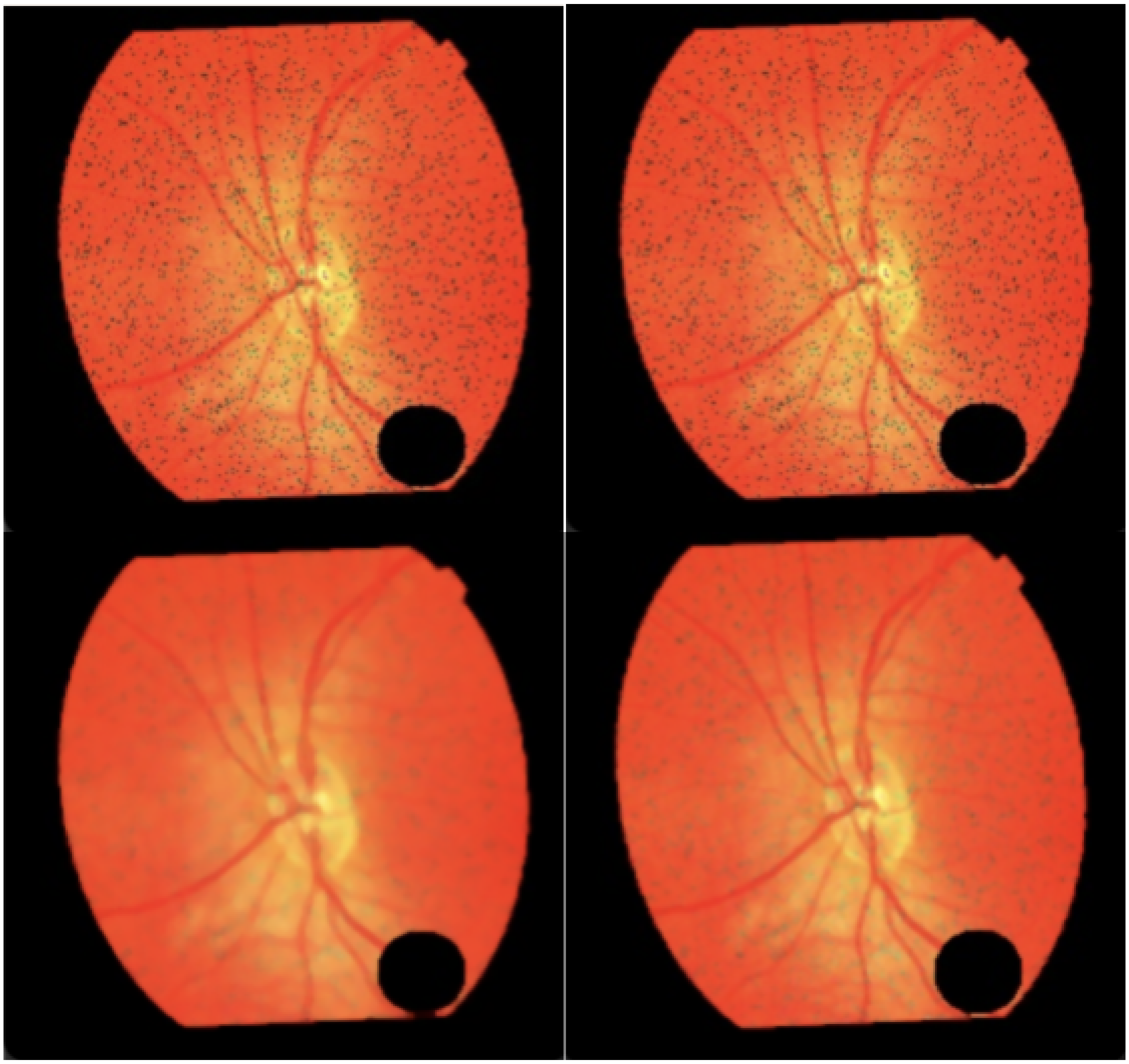

Figure 1. Median filter varying grid size.

Figure 1 Shows how salt and pepper noise is removed with a median filter.

Local means filter also has parameters to tune. These change the degree of noise and colour smoothing and the grid size to search for similar pixels. I found lower values to be better, they preserve more detail and are less computationally expensive. Noise from almost all images was effectively removed using these methods without a large loss of detail.

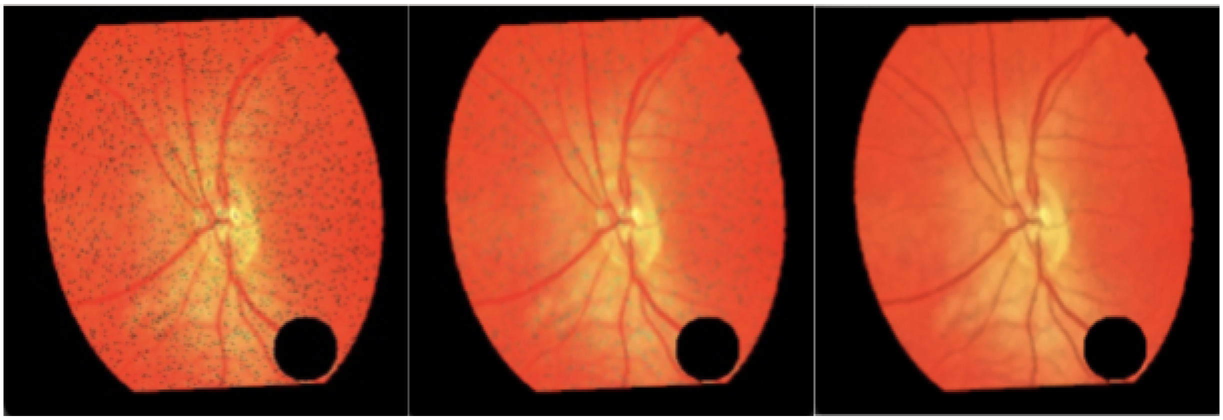

Figure 2. Image enhanced with median filter then non-local means filter.

I used a contrast stretching method next. I decided to use Contrast Limited Adaptive Histogram Equalisation (CLAHE). Contrast stretching increases the pixel range to increase the contrast between bright and dark colours. This is particularly useful for these images as most colours fall within a small dynamic range with a red/orange hue. CLAHE is a method of controlled equalisation with tunable parameters, unlike most other contrast stretching methods. It is called localised histogram equalisation and makes CLAHE the most appropriate contrast stretching method for these images. The best value I could find for 'clipLimit' is 2 and 'tileGridSize' in the range 6-10.

I used a dynamic gamma correction method utilising the power law. Some of the images are underexposed and some overexposed. I accounted for this using the power law to choose appropriate values of gamma. When the image is dark and underexposed, gamma is < 1 and weights intensities towards higher values and when the image is overexposed, gamma is > 1 and intensities are weighted towards lower values. CLAHE and gamma correction distinguished between similar shades of red/orange/yellow in most images and greatly improved the detail.

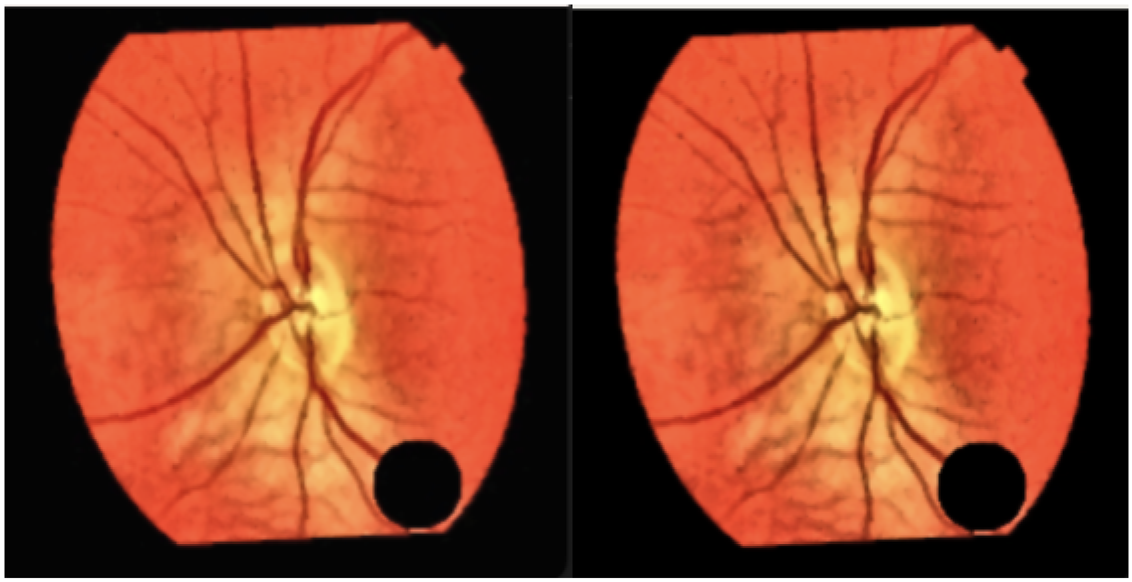

Figure 3. Contrast stretching and gamma correction.

The figure above shows how effective contrast stretching is. The dynamic range has increased showing more details of the image.

The perspective of the images has been warped. To combat this I used an 'opencv' method to inverse the warp. A transformation matrix is made using source and destination points which is then applied to the images. The image's shape was warped to a more circular shape, closely resembling an eye.

Finally, I used exemplar-based inpainting to fill in the missing pixels. I found that this was more effective than the other simple inpainting methods provided by 'opencv'. To perform this inpainting method a mask is needed which I created outside of Python. This mask, 'custom_mask.jpeg' corresponds to the missing hole in each image. I found that a radius of 10 was appropriate for exemplar inpainting. Most of the hole is filled up reasonably realistically without being computationally expensive. The edge of the missing section was not replaced effectively. More advanced inpainting methods should be used.

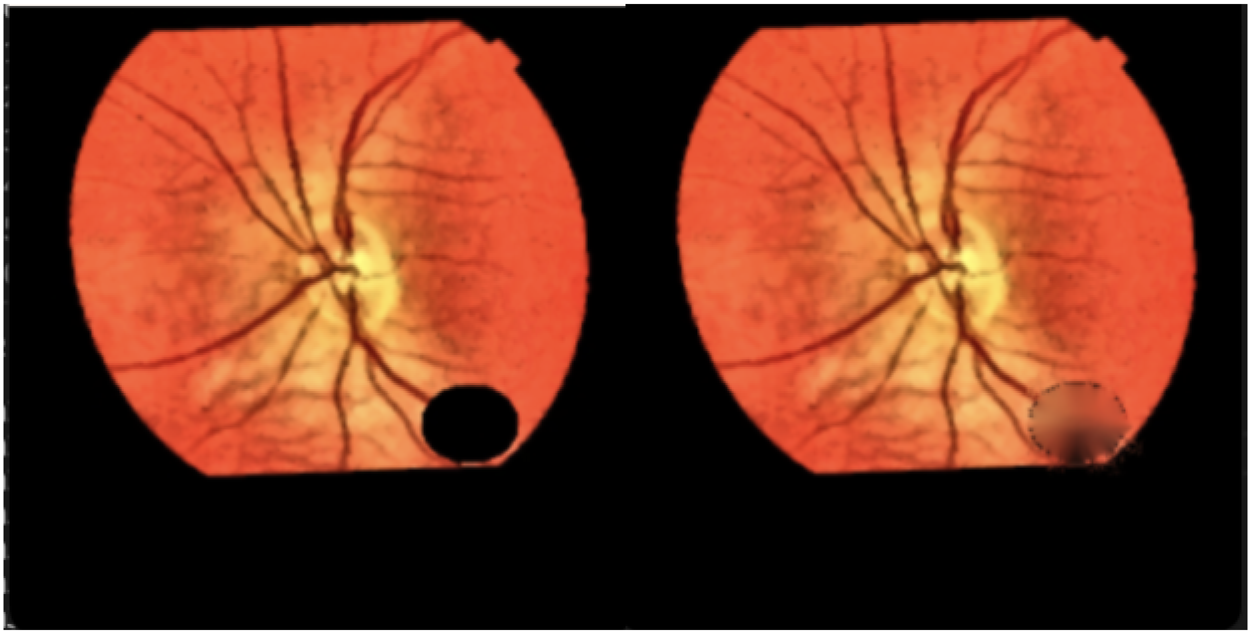

Figure 4. Warping and inpainting.

The figure above demonstrates the effectiveness of warping and exemplar-based inpainting.

Overall these methods improved the detail of most images while reducing noise and also improving colour contrast. The ai classifier performance was increased from 0.5 to 0.725.

```
im24-RET020OS.jpg: sick
im25-RET045OS.jpg: sick
im26-RET046OS.jpg: sick
im27-RET051OD.jpg: sick
im28-RET053OS.jpg: sick
im29-RET055OS.jpg: sick
im30-RET065OD.jpg: sick
im31-RET066OD.jpg: healthy
im32-RET069OD.jpg: healthy
im33-RET072OD.jpg: sick
im34-RET079OS.jpg: sick
im35-RET102OD.jpg: sick
im36-RET104OS.jpg: sick
im37-RET112OD.jpg: sick
im38-RET113OD.jpg: sick
im39-RET122OD.jpg: sick
im40-RET264OD.jpg: sick
Accuracy is 0.725
```

Figure 5. Final accuracy.