COMP2271: Data Science2023/24

Image Processing Coursework – Report:
A discussion of my solution’s design and choices made.

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1- Introduction

My task in this image processing assignment was to enhances the visual quality of the 100 given X-ray images. Due to faulty equipment, the X-ray images had various issues. The purpose of this task was to maximise the quality of the images, to ensure that a machine learning algorithm could be used on it to test whether a patient had pneumonia from their X-ray image. This report will provide a detailed summary of my approach to this problem and the results obtained.

2- Approach and Methodology

The original image had various faults and issues, as seen in *Fig1,* due to faulty equipment. This included excessive noise, warping of the images, issues with brightness and contrast, colour channel imbalances and missing regions.

Since the order of the transformations makes significant differences in results, I chose to start with inpainting of the missing region. This is because if done early, I can use all the available detail before it is lost in the smoothing process. I used a function to create a mask of the black areas. The masked areas are then dilated, and inpainted using ***cv2.dilate*** and ***cv2.inpaint***. The fill isn’t perfect, so further transformations are needed.

The images contain a lot of gaussian, salt and pepper noise. So, I used Bilateral Filtering to reduce gaussian noise and median filtering to remove salt and pepper noise. This alone isn’t enough to completely remove the noise because further increasing the blurring with these methods would remove too many fine details. So, I used non-local means deionising, ***cv2.fastNlMeansDenoisingColored***, to remove the last of the gaussian noise. According to the paper ***Image denoising with morphology- and size-adaptive block-matching transform domain filtering***[1], using this method achieved better deionising by effectively balancing between noise reduction and detail preservation. Using intuition, I adjusted the parameters of these 3 functions to generate an optimal set of images. The disadvantage of using these methods has been that a lot of fine detail has been lost in the process. So, I aimed to reintroduce as much detail as possible later.

The original images were distorted due to perspective of the machine. To tackle this, a perspective matrix is calculated to apply a transformation on the image. The paper ***Perspective Transformation Layer***[2] discusses how the function ***cv2.warpPerspective()*** works, and the mathematics behind it. I ensured the transformed images were all 256x256 pixels.

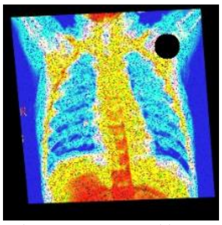
Fig 1: pre-processed image (image 44)

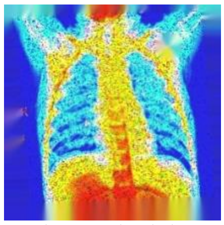
Fig 2: post inpainting

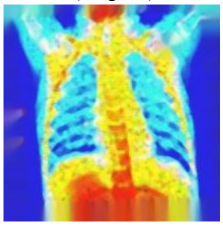
Fig 3: image after bilateral and median filtering

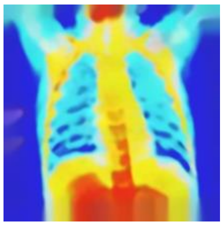
Fig 4: Image after non-local means deionising

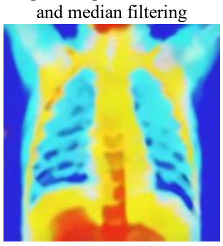
Fig5: Apply perspective transformation


Fig6: Apply unsharp mask

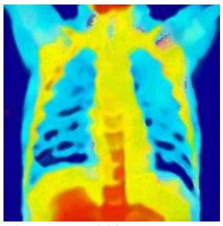
Fig 7: Hue shift

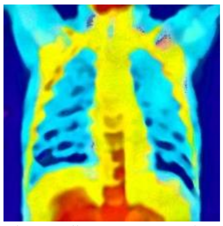
Fig 8: Adjust contrast and brightness

A colour channel imbalance was present, the images included spots of white, which shouldn’t be included. Furthermore, the background was a bright blue colour, it was hard to differentiate between the X-Ray and the background. I got inspiration for my solution from ***Open CV’s Changing Colorspaces***[3]. To fix these issues I hue-shifted the images to the redder end of the EM spectrum. I also, darkened the background by targeting the background hue using a threshold of 180. At this point, it's very difficult to see that there was originally a hole in the images.

To tackle brightness, blurring and contrast, 3 methods were used. The first was to apply an unsharp mask. This is a method of subtracting a blurred version of the image to sharpen it. The second method was to apply Contrast Limited Adaptive Histogram Equalization (CLAHE). This method enhances the edges while minimising the enhancement of noise, as discussed in the paper ***CLAHE Approach for Enhancement of the Microstructures of Friction Stir Welded Joints***[4]. The final method used was to increase brightness.

3- Evaluation of Solution Success and Conclusion

The final image achieved all the criteria of the specification and I've removed all the problems associated with the original images. The classifier gets an accuracy of 94% for my implementation. However, with a different model I achieved an accuracy of 97%. This implementation contained a caveat, and that's that the hole isn't filled in smoothly. So, I was happy to sacrifice the 3% for visual quality.

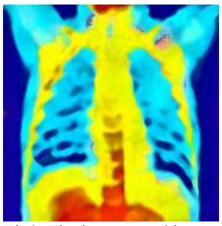

Fig9: Final, processed image

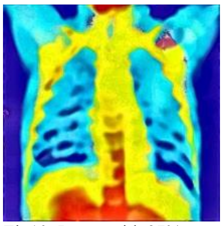

Fig10: Image with 97% classifier accuracy

However, comparing my results to *Fig11*(a real medical X-Ray image), I found that my images lack the detail required in the medical field. So, more advanced techniques should be used going forward.

If I was to do this assignment again, I utilise Wavelength Transforms to get fine detail, and then overlay the image with it. However, when I attempted to do so, the accuracy dropped to 84% and less.

Fig11: Real medical image[5]

References

[1] Hou, Yingkun, and Dinggang Shen. "Image Denoising with Morphology- and Size-Adaptive Block-Matching Transform Domain Filtering." EURASIP Journal on Image and Video Processing, vol. 2018, no. 1, 20 July 2018, https://jivp-eurasipjournals.springeropen.com/articles/10.1186/s13640-018-0301-y

[2] Khatri1, Nishan, et al. "Perspective Transformation Layer This Paper Has Been Accepted for Publication by the 2022 International Conference on Computational Science & Computational Intelligence (CSCI'22), Research Track on Signal & Image Processing, Computer Vision & Pattern Recognition." Ar5iv, ar5iv.labs.arxiv.org/html/2201.05706. Accessed 26 Apr. 2024.

[3] "OpenCV: Changing Colorspaces." *Opencv.org*, 2024, docs.opencv.org/4.x/df/d9d/tutorial_py_colorspaces.html#:~:text=Changing%20Color%2Dspace&text=For%20color%20conversion%2C%20we%20use.

[4] Mishra, Akshansh. "Contrast Limited Adaptive Histogram Equalization (CLAHE) Approach for Enhancement of the Microstructures of Friction Stir Welded Joints." *ArXiv.org*, 15 Aug. 2021, arxiv.org/abs/2109.00886. Accessed 5 Oct. 2023.

[5] Chouhan, Vikash, et al. "A Novel Transfer Learning Based Approach for Pneumonia Detection in Chest X-Ray Images." *Applied Sciences*, vol. 10, no. 2, 12 Jan. 2020, p. 559, https://doi.org/10.3390/app10020559.