Image Processing Report

Module Name: <Image Processing>
Submitted as part of the degree of BSc Computer Science to the
Board of Examiners in the Department of Computer Sciences, Durham University

1 METHODOLOGY

After examining the photographs, it was determined that there were basically three issues with them: excessive noise, images that did not spread throughout the screen, and poor contrast and brightness. As such, the solution will be centered around resolving these issues. The approximate procedure is shown in the Figure 1.

1.1 Algorithm Selection

The focus of this section is the process in which the algorithms for this task were chosen As a consequence, two algorithms for noise removal and brightness and contrast will remain, along with one method for dewarping.

1.1.1 De-warping

As can be seen from the original image, the image distortion is not severe. For the majority of cases, the issue is that the image does not expand throughout the screen. As a result, the warp perspective approach in OpenCV was used. The four points [[20, 20], [949, 9], [19, 387], [961, 373]] were identified manually. Figure 2 compares performance before and after implementing the procedure. It is plain to notice that there is no longer any pointless black region.

1.1.2 Noise Removal

Three algorithms were tested: the medium filter, the Non-local Means filter, and the Bilateral Filter. The difference between them is obvious in Figure 3; the median filter produces an image with acceptable quality but with too many details lost. For the others, they pay attention to detail and maintain a high standard of quality. As a result, the comparison of the Non-local Means filter and Bilateral Filter was maintained while the median filter was eliminated.

1.1.3 Brightness and Contrast

Gamma Correction, Histogram Equalisation, and CLAHE were all evaluated. The difference between them is illustrated in Figure 4; Histogram Equalisation introduces more noise into the image than the other two. As a result, the Gamma Correction and CLAHE continue to be used.

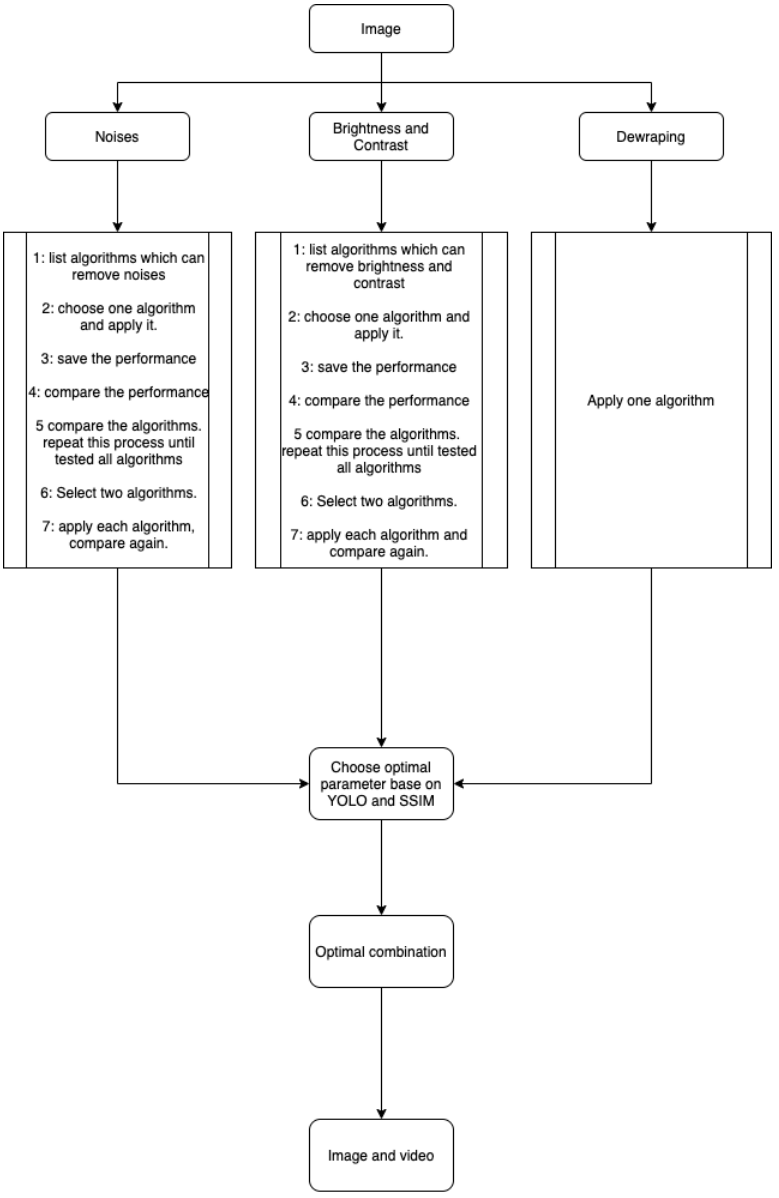


Fig. 1. Procedure

1.2 Tuning Parameters

While awareness of the algorithm is necessary, the algorithm's parameters are crucial. After modifying the

Fig. 2. Dewarping comparison

Fig. 3. Noises comparison

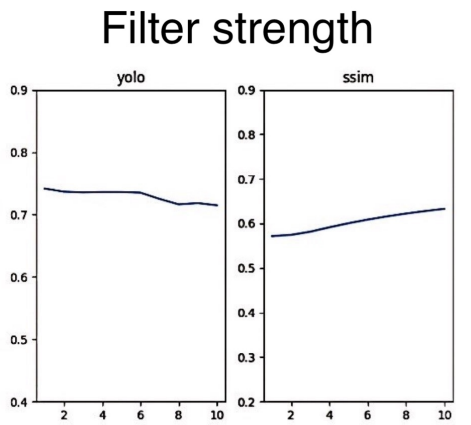
settings, we will compare the SSIM scores to the YOLO scores on the validation set. Finally, chose the optimal parameters and combined them to determine the optimal

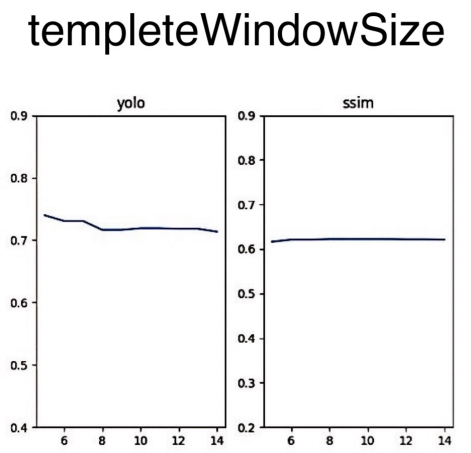
Fig. 4. Brightness and Contrast comparison

algorithm combination. Figure 5 to 8 shows the example process to tune parameters, as high yolo score does not mean the high SSIM score, thus finding a balance is crucial. For example, in non-local mean tuning process, decide to use 8 as filter strength but not 1 as 8 has higher ssim score and reasonable yolo score. Applying the same process on each parameter in each algorithms, getting the optimal parameters for each algorithm, shown in table 1.

1.3 Final approval of Algorithm

After confirming optimal parameters in the tuning section, which was done on the validation data. The YOLO score for each pair of algorithm is shown in Table 1. As can be observed, the YOLO score has been reduced by around 5% when compared to the validation set. The most likely explanation is that the test set differs in brightness and contrast from the validation set, necessitating a re-tuning of the brightness and contrast algorithm parameters, as seen in figures 9 to 12. And table 3 has the final parameters for each; the rationale for not selecting the greatest YOLO score is that a high YOLO score equates to a low SSIM score; so, to balance them, the median value is chosen as





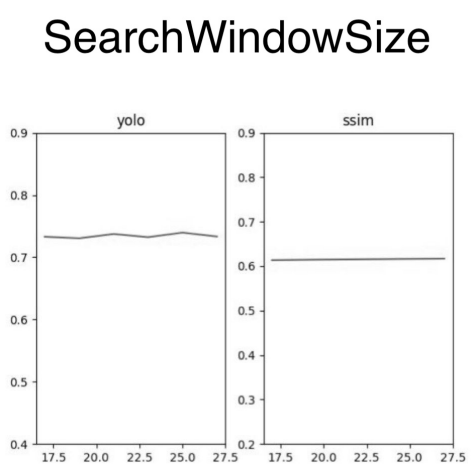


Fig. 5. Tuning non-local means parameter

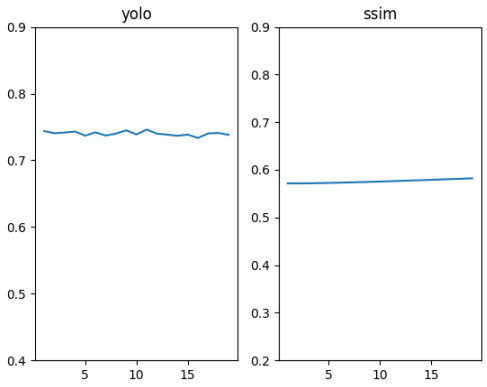


Fig. 6. Tuning Bilateral Filter parameter sigma

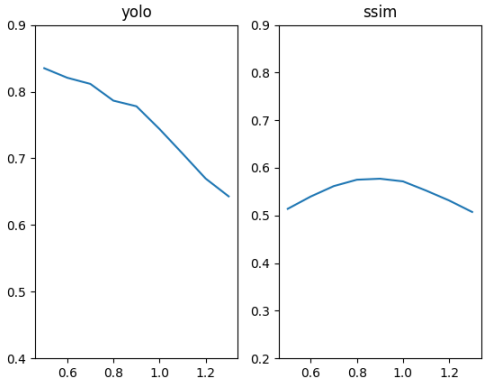


Fig. 7. Tuning Gamma Correction parameter

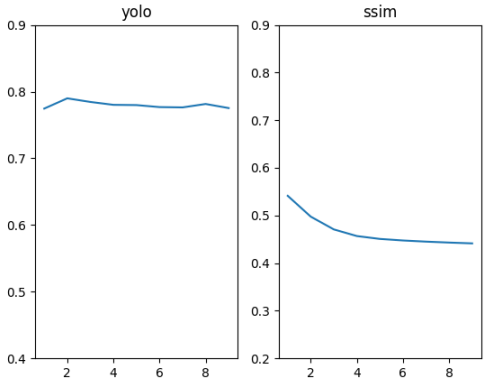


Fig. 8. Tuning CLAHE parameter clip-limit

the outcome. Finally, because they all received the same score, we must examine the real image and determine the best combination. As seen in figure 13, the combination of non-local mean and gamma correction provides superior performance.

Parameter list		
Algorithms	Parameters	value
Non-local Means filter	filter strength templeteWindowSize SearchWindowSize	8 5 25
Bilateral Filter	filter size sigma values sigma colour	5 11 11
Gamma Correction	Gamma	0.8
CLAHE	clip limit GridSize	1 (2,2)

TABLE 1
Parameter Result

First Algorithm Combinations		
Noise remove Algorithms	Brightness and Contrast Algorithms	yolo score
Non-local Means filter	Gamma Correction	0.69
	CLAHE	0.69
Bilateral Filter	Gamma Correction	0.70
	CLAHE	0.68

TABLE 2
First Algorithm Combination

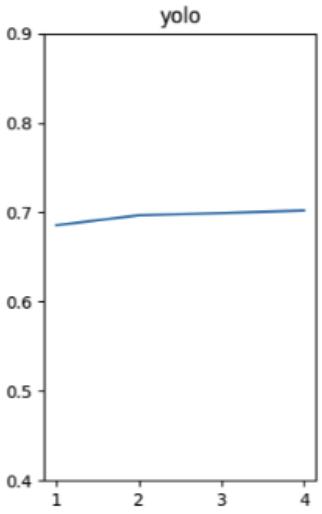


Fig. 9. Tuning CLAHE parameter with non-local

Second Algorithm Combinations and Tuning parameters			
Noise remove Algorithms	Brightness and Contrast Algorithms	parameter value	yolo score
Non-local Means filter	Gamma Correction	gamma = 0.8	0.69
	CLAHE	clip size = 2	0.70
Bilateral Filter	Gamma Correction	gamma = 0.8	0.70
	CLAHE	clip size = 2	0.68

TABLE 3
Second Algorithm Combinations and Tuning parameters

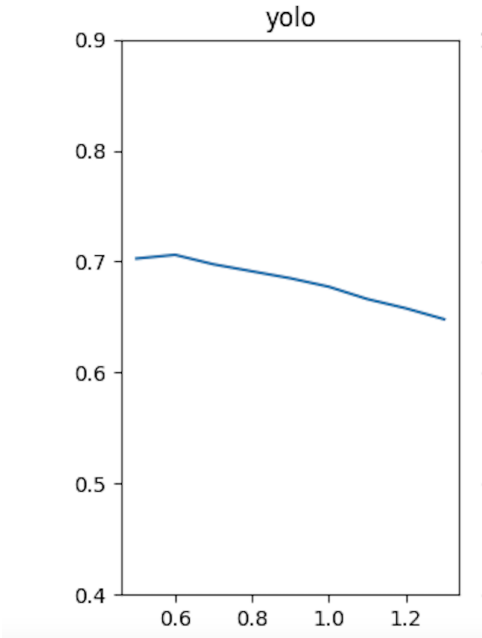


Fig. 10. Tuning Gamma parameter with non-local

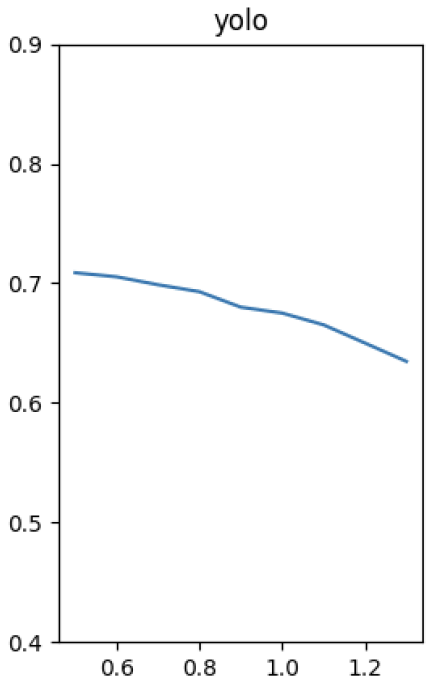


Fig. 11. Tuning Gamma parameter with Bilateral Filter

2 Result

The final algorithms used are shown in Table 4, followed by de-warping, non-local mean, and gamma correction, after which the pictures are converted to video and the YOLO score is calculated.

3 Conclusion

The objective of the project is to enhance the quality of real-world pictures. It has been proven that Warp Perspective,

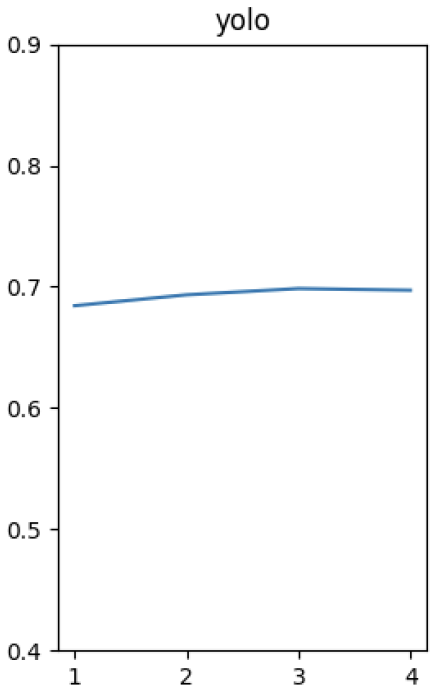


Fig. 12. Tuning CLAHE parameter with Bilateral Filter

Result			
Algorithms	yolo score	mean confidence	total objects detected
Warp Perspective Non-local Means filter Gamma Correction	0.69	0.63	1110

TABLE 4
Final Result

Non-local Means, and Gamma Correction have the most balanced performance, with a SSIM score of 0.62 and a YOLO score of 0.78 in the validation set, and a YOLO score of 0.69 in the test set. The SSIM score in the test set is estimated to be about 0.60. However, there is still room for improvement in this project, even after cleaning, certain photos are brighter or darker than the norm. The solution is to apply several algorithms to various photos in order to improve performance.

Fig. 13. Final comparing images