Multi-objective optimization based on parameter tuning of CLAHE to achieve different contrast levels in medical images

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Introduction

Contrast of medical images show particular contrast features, because there might be notorious contrast differences because of the attenuation characteristics of X-Rays.

Local improvement approaches prove to be extremely useful when enhancing details in medical images. In our proposal a meta-heuristic for optimization will be used, in order to tune input parameters of the contrast enhancement algorithm.

Objective: Obtain images with different relationships between contrast and distortion, in order to highlight different features, which is useful for analysis performed by the specialist.

Method

The Figure 1 shows how Multi-objective PSO-CLAHE ($MOPSO-CLAHE$) based on $SMPSO$ is implemented to tune the parameters of CLAHE. The resulting images are automatically evaluated according to the metrics $Entropy$ ($\mathscr{H}$) and $SSIM$, and the best results measured by these shape a Pareto set for the image being processed.

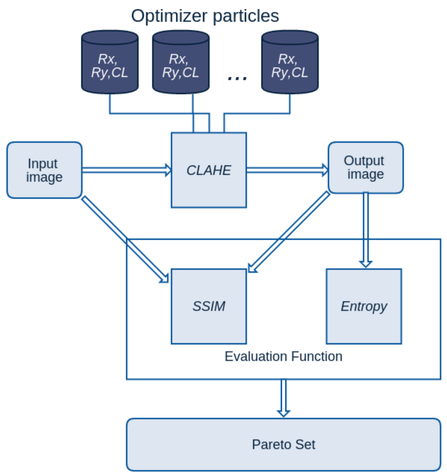

Figure 1: Interaction among $CLAHE$, $MOPSO$ particle and objective functions evaluation.

Results

- For every selected test image (http://openi.nlm.nih.gov/), 30 executions of $MOPSO-CLAHE$ were performed, with populations composed by 100 particles, and 100 iterations for every execution. Every particle (potential solution) is automatically evaluated by $MOPSO-CLAHE$ according to the metrics adopted.
- Approximately 300 non-dominated solutions were obtained for every image.
- Every non-dominated solution is an image with different compromise between *Entropy* and *SSIM*, as it can be seen in Figure 2(c) and Figure 3(c).
- Fine details of images are preserved, as in Figure 3(b), 3(c) and main characteristics are highlighted, as in Figure 2(b).

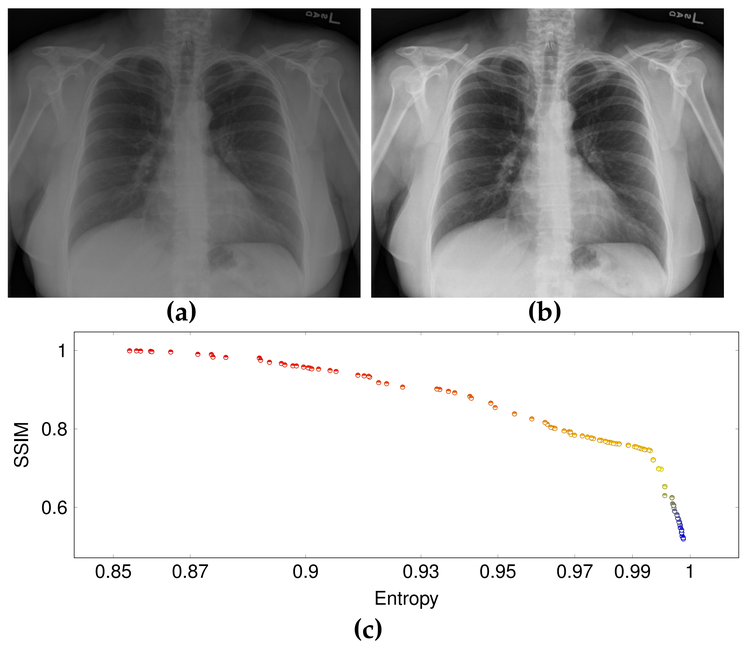

Figure 2: (a) Original Image. $SSIM$=1.0 $\mathscr{H}$=0.8536 (b) Resultant image. $SSIM$=0.9688 $\mathscr{H}$=0.7922 (c) Pareto set related to this image.

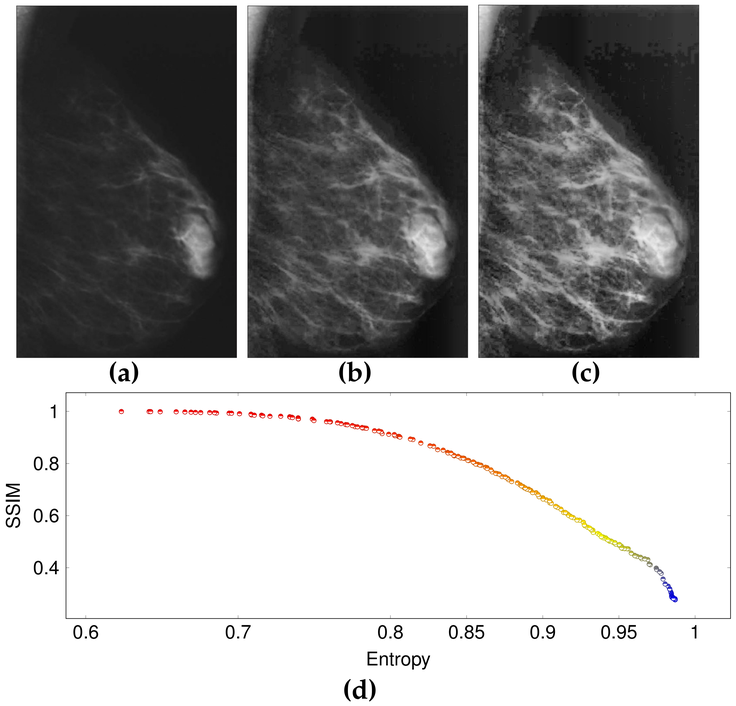

Figure 3: (a) Mammography. $SSIM$=1.0 $\mathscr{H}$=0.6235 (b) Resultant image. $SSIM$=0.8032 $\mathscr{H}$=0.8549 (c) Resultant image. $SSIM$=0.6121 $\mathscr{H}$=0.91393 (d) Pareto set related to this image.

Conclusions

- $MOPSO-CLAHE$ approach is successful at contrast enhancement, by tuning $CLAHE$ input parameters, and evaluating $Entropy$ (contrast) and $SSIM$ (Image quality assessment) simultaneously.
- The pareto sets show a compromise between $Entropy$ and $SSIM$ in terms of maximization, which indicates that both metrics are complementary.
- **Future work:** Test optimization-based contrast enhancement using new metaheuristics, IQA metrics, and public image databases. Establish new compromises between metrics, analytically and using pareto sets.