

# Enhancement of Biopeckle Laser Samples Using Algorithms Based On Histogram Equalization

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The biospeckle laser is a non-invasive technique. This technique helps to monitor changes and measure activity in biological samples [2]. In the generation of high quality food this technique allows us to inspect the quality and safety of food. Speckle pattern images have problems of saturation, low contrast, among others. These problems can be mitigated using image enhancement techniques [4]. This work presents a methodology for correction and enhancement of details in the biospeckle output image using image processing techniques. First, the algorithms will be applied to the sequence to minimize the loss of information. Then, the graphical method of speckle AVD is used with the modified images to finally obtain the activity map. Finally, the obtained result is evaluated objectively. The numerical and visual results show that contrast enhancement techniques can help to better visualize bioactivity in seeds.

The tests were performed on a total of the 32 biospeckle output images. The evaluation metrics used were: Contrast (C) [1] which measures the overall contrast of the biospeckle output image. Entropy (E) [1] which determines the richness of detail in the resulting image. Structural Similarity Index (SSIM) [3] provides us with a coefficient that measures the structural similarity between two images.

The HE and CLAHE [5] were developed using Python 3.7 and OpenCV 4.5.0. The tests were executed on a computer running Windows 10 Home OS, with an Intel Core i7 8750h Processor, a 16 GB Ram Memory and a Nvidia GTX 1060M GPU. The parameters used for the CLAHE were: a window [8,8] and a Clip Limit equal to 2.5.

Table 1 shows the average of the metrics of each algorithm and the original output image (ORI) in the first row. CLAHE technique performs better than HE by enhancing contrast and detail.

Table 1: Average results obtained by the algorithms

Algorithms	C	E	SSIM
ORI	28.276	5.677	1
CLAHE	<b>36.528</b>	<b>6.066</b>	<b>0.844</b>
HE	26.059	5.731	0.604

Figure 1 shows the results of each algorithm for a sample of bean seed. Bioactivity is better visualized in the enhanced images.

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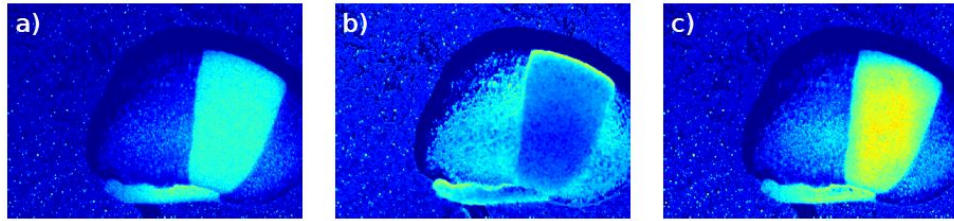


Figure 1: AVD of a sample with polarized and unfiltered. (a) Original output image (b) HE-enhanced image (c) CLAHE-enhanced image. Source: From the authors.

As future work we intend to apply more contrast enhancement techniques. Subsequently, it is intended that a subjective evaluation by physical professionals will be performed.

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## References

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