The Potential Use of Bioinspired Algorithms Applied in the Segmentation of Mammograms

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Abstract: In this article, we present the potential use of bioinspired algorithms for segmentation. The comparison is done with 3 bioinspired algorithms and Otsu method, which is an algorithm currently used to perform image segmentation. The vast majority of bioinspired algorithms were designed for optimization, however in this work, an adjustment is done to use the function to be optimized as a function that allows us to segment an image. The results in this work showed that the bioinspired algorithms are a good alternative to perform the task of segmentation in medical images, specifically mammography.

1 INTRODUCTION

Breast cancer is a global problem and one of the cancers that has caused more than 410,000 deaths until 2002 (Ferlay et al., 2010). An early diagnosis of breast cancer will result in more opportunities and treatments which will reduce death risk of the patient.

This is the reason that there are mammography segmentation techniques, which aim to detect small abnormal regions within the breast. This segmentation process allows us to detect regions of interest in the medical image and, in case of being necessary, to carry out a subsequent treatment by the medical specialist.

In this work we explore the possibility of using bioinspired algorithms for the segmentation of mammographies. These algorithms are based on a biological process used to find an optimal solution to a problem.

Although many of the bio-inspired algorithms are mainly designed to solve optimization problems, in this paper we propose to use a function that allows us to transform the optimization process into a segmentation process.

Nowadays, the use of segmentation algorithms in medical areas has allowed the early diagnosis of many diseases including breast cancer.

This paper is organized as follows, In section 2, some of the previous works are presented. In section 3, the tested algorithms for segmentation are explained as well as the materials used. The results and comparison of the segmentation algorithms are presented in section 4. And finally in section 5, we present the conclusions and future work related to this area.

2 PREVIOUS WORKS

In the existing field called Evolutionary Computation, there has been many approaches such as evolutionary methods and swarm intelligence which have showed good performances solving problems in computer vision (Vite-Silva et al., 2007), clustering (Abraham et al., 2008), network routing (Kassabalidis et al., 2001), among others.

Related to swarm intelligence, some algorithms have been used in optimization of classifiers (Ramirez et al., 2015), instance selection (Derrac et al., 2012) and optimal parameter values selection (Friedrichs and Igel, 2005).

Catarious et al. proposed a system to identify suspicious masses in mammograms (Catarious et al., 2004), similarly in 2006, Scharcanski and Jung (2006) proposed a method to improve the contrast and eliminate noise in mammographic images.

Related to bioinspired algorithms, Brodić and

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Milivojević (2011) proposed a modified version of the water flow algorithm which they applied to the segmentation of texts.

Other approaches (Bevilacqua et al., 2009) have been used to detect blood vessels in retinal fundus using artificial neural networks.

Other works presented by Frausto-Solís et al., (2013)in 2013 and, Rad and Lucas (Rad and Lucas, 2007) in 2007 showed the use of bioinspired algorithms (simulated annealing algorithm and IWO algorithm respectively) showing good performances.

Although there are many algorithms to perform the segmentation, there is not yet a perfect algorithm that allows its use in all segmentation problems, that is why this work presents modified bioinspired algorithms that allow us to perform this task.

3 MATERIALS AND METHODS

Many of the bioinspired algorithms were mainly designed for optimization tasks. However, in this work, we propose the possibility of using these algorithms for segmentation by using the Dunn index and using each individual component as if it were a gray level of the gray scale. In this work we made a comparison of the Otsu method (Otsu, 1975) against 3 bioinspired algorithms (Novel Bat Algorithm (Meng et al., 2015), Invasive Weed Optimization (Mehrabian and Lucas, 2006) and Particle Swarm Optimization (Kennedy and Eberhart, 1995)).

Given that the bioinspired algorithms used in this work have as their main component Individuals, it is necessary to present the representation that they will have in the system. The composition of an individual will be given by a vector composed of values that represent gray levels as presented in figure 1.

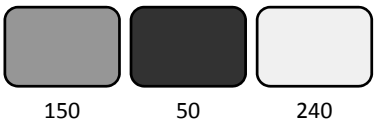

Figure 1: Representation of an individual.

3.1 Novel Bat Algorithm (NBA)

Bat algorithm was proposed in 2010 by Yang (Yang, 2010), as an optimization algorithm based on the behavior of bats and, specifically, the techniques they use to identify food using echolocation.

Later, Meng (Meng et al., 2015) propose a modification of the algorithm proposed in 2010, which he called Novel Bat Algorithm (NBA), this algorithm includes among other novelties, the Doppler Effect and the ability to search the global solution in different habitats. The implementation of this latest version was the one used for this work.

3.2 Invasive Weed Optimization (IWO)

This algorithm of numeric optimization was introduced by Mehrabian and Lucas (2006) in 2006 and is based on weed colonies and how they adapt to the environment to spread their seeds. Unlike other metaheuristics, this algorithm allows all individuals (plants) to participate in later generations. This aspect gives the opportunity to plants with better performance to produce more seeds and plants with lower performance, will produce fewer seeds. Another notable difference of this algorithm is that individuals produce seeds autonomously, that is, the mating process does not occur.

3.3 Particle Swarm Optimization (PSO)

This algorithm proposed by Kennedy and Eberhart (1995), is based on the movement of the particles. The search and refinement of candidate solutions is based on a social swarm model (such as birds or fishes) that pretends to find food.

3.4 Error Measures

According to Zhang et al., (2008), it is possible to determine the quality of a segmentation by calculating two error measures (F and F'). F measures the average squared color error while F' is a modification of F that penalizes segmentations with small regions.

$$F = \sqrt{N} \sum_{j=1}^{N} \frac{ej^2}{\sqrt{Sj}} \quad (1)$$

$$F' = \frac{1}{1000 * SI} \sqrt{\sum_{b=1}^{MaxArea} N(b)^{1+\frac{1}{b}}} \sum_{j=1}^{N} \frac{ej^2}{\sqrt{Sj}} \quad (2)$$

3.5 Dunn Index

Since the bioinspired algorithms used in this work were designed for optimization, in this work, the possibility of using them for segmentation is proposed changing the function to be optimized as the division of the minimum outercluster distance between the maximum intercluster distance. This

relationship is called the Dunn index (Dunn, 1973) and is used as a function to be maximized since it is intended to have the greatest distance between clusters and the smallest distance between the elements on the same cluster.

4 RESULTS

In this work, 362 images of real patients were segmented, which belong to the Breast Cancer Digital Repository database (Moura and López, 2013). This dataset contains the segmentation of said images, carried out by a group of radiological experts.

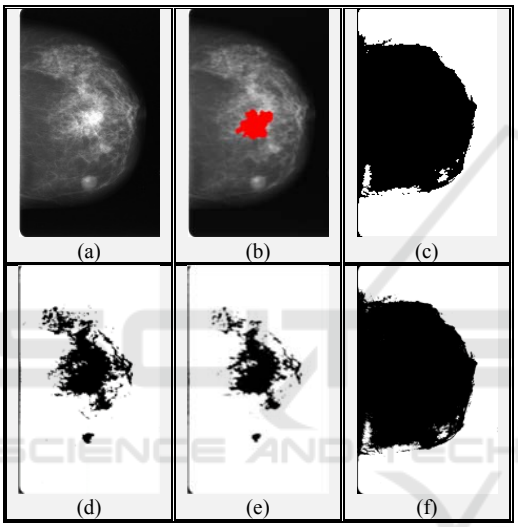

Figure 2: (a) Original image, (b) Overlap of the ROI segmented by expert radiologist over original image, (c) Image segmented by Otsu method, (d) Image segmented by NBA, (e) Image segmented by IWO, (f) Image segmented by PSO.

In Figure 2, we present a mammographic image taken at random from the 362 images of the dataset. This image was segmented by the 4 segmentation algorithms and the image results are presented in the image.

The values presented in Fig. 3, are expressed in $x\,10^{6}$ for F mean, and $x\,10^{-3}$ for F' mean. These values were calculated for the 362 images and the average is presented in Fig. 3 for each algorithm.

In Figure 3, it is observed that IWO obtained a lower error than the other bioinspired algorithms. The other bioinspired algorithms obtained lower errors than Otsu method, which at the present time remains as an algorithm widely used to segment.

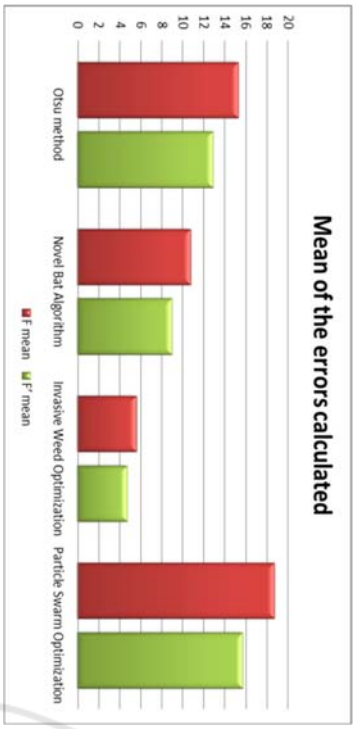

Figure 3: Mean of the errors calculated for the segmentation of the 362 mammographies.

Table 1: Mean time in seconds per image segmented.

Algorithm	Mean Time per image (seconds)
Otsu method	0.051
Novel Bat Algorithm	53.83
Invasive Weed Optimization	412.71
Particle Swarm Optimization	36.93

362 images were processed with each algorithm and the processing times were calculated for each image. Later, the average time was calculated, these times are presented in Table 1. It is observed that Otsu method got a very small time to process each image. It is relevant to mention that the Matlab implementation of this algorithm was used. The other algorithms were implemented and modified to be used as segmentation algorithms.

5 CONCLUSIONS

In this work, a comparison of the bioinspired algorithms applied to segmentation is presented, something relevant given that most of these algorithms are mainly designed for optimization.

We compared the errors calculated for each segmentation performed by each bioinspired

algorithm against the Otsu method, which is widely used to perform image segmentation.

IWO algorithm got the lowest average error, although it also got the highest time to process each image.

It is important to clarify that, in the medical field, there must be a balance between time and quality, since we are dealing with real patients and the incorrect classification of a disease is a very important factor.

The results presented in this article show a good performance of the bioinspired algorithms in the task of segmentation, so it is a good alternative to carry out a more detailed analysis in this field.

As future work, we intend to carry out a more detailed study and explore the possibility of automatically adjusting the parameters of the algorithms.

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