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# Optimal Image Selection for Segmentation with Particle Swarm Optimization

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***Abstract*—Calcium is an ion that acts as messenger in the cells. An important step to analyse and to study the Calcium ($Ca^{2+}$) using images to consist on localization the cells inside the images. Sometimes this process can be difficult because of environmental factors. In this work, the PSO (Particle Swarm Optimization) algorithm is introduced in order to obtain the best image to segment, reducing the time of processing.**

***Keywords*— Optimization, segmentation, PSO.**

## I. Introduction

Many process performed by cells are highly related with the levels of calcium that contains, where the calcium act as an altern messenger [1]. Producing, haematological problems as muscular diseases, hormonal disorders and another more specific like injury and cell death [2]. The Ca2+ can be analysed through substances that generates the movement or activation of calcium [3]. In the literature, different authors have developed different methods to watch stimulating cells cause that calcium has a fluorescence effect as shown in Fig. 1.

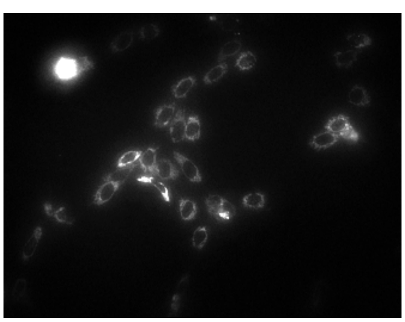

Fig. 1: Images with fluorescence of calcium.

The segmentation allows to locate the cells in the images to evaluate the fluorescence of calcium. Hence, it is possible to analyse the variations.

Image segmentation allows automatically locate objects of interest, hence it is possible graphically represent the significant information, partitioning it into a region of interest. There are many algorithms and it have been developed different techniques to solve this kind of problems [4]. In order to get an image segmentation is necessary execute two important process:

1) Pre-processing. This stage consists on removing noise to avoid the over-segmentation,

2) Segmentation. This stage consists on extracting the information of interest, Particularly, the objects are localized with the edges detection.

To obtain a good segmentation different techniques can have been applied Particularly, in a first stage is necessary to homogenize the background and to remove loss particles that does not comply with the particular characteristics of the objects to analyse, adding them to the background of the images. Frequently, images can have minimal changes across the time. Hence, it is important select one image to segment it to analyse the rest of images. This image represents the global optimum.

The paper is organized as follows. The next section presents a review of the foundations of Bio inspired algorithms. In Section 3, the PSO method is presented to detect the cells. Finally, in section 4 we present and discuss the results and the conclusions.

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## II. Theoretical Fundamentation

### A. *Sequential Search*

Sequential search consists in verify element by element until find the information. Basically the search space is analysed from the beginning to end until to find the item or the data set is over, whichever occurs first. Normally when the algorithm comes to the end, the position of the element is what we want to know in case of being found [5].

Then for this case every pixel from the first image is evaluated, to verify the level of noise that every one of it contains so we can take the best, but this requires processing and time to do so. This method offers some advantages in this kind of problems, always find the optimum global, never get stock on optimum locals of search space, it is trustworthy, among others. Its disadvantage is that in some process is necessary get the solution satisfying certain requirements reducing the processing level. The algorithm starts evaluating all the pixels of every image in the bank of images, keeping just the one who has less noise than the others. If an image *i* is the actual solution, and when you compare it with *i+1* exist an improvement the solution now will be this one, finishing only with the optimum global. This require evaluate every possible solution.

### B. *Bio Inspired Algorithms*

The bioinspired computer systems emerged as a set of models based on the social and cooperative behaviour of some biological species to solve their needs on the searching place. The computer solutions (algorithms) bio inspired reside in the field of optimizations, artificial intelligence, data mining, among others. Particle Swarm Optimization by its initials PSO is one of many bioinspired algorithms that has been used for optimization problems [6][7]. The algorithm act with certain guidelines among particles, like personal and global experience [7][8].

PSO is a practice tool where each particle moves aleatory through velocity and inertia. Each iteration of the algorithm makes one personal solution updating the global if this came out with better than actual one. The erratic movements obtain solutions that may not be the best but they can be a possible optimum local case [9][10]. Reducing the execution time and processing level. The PSO process is described in Fig. 2.

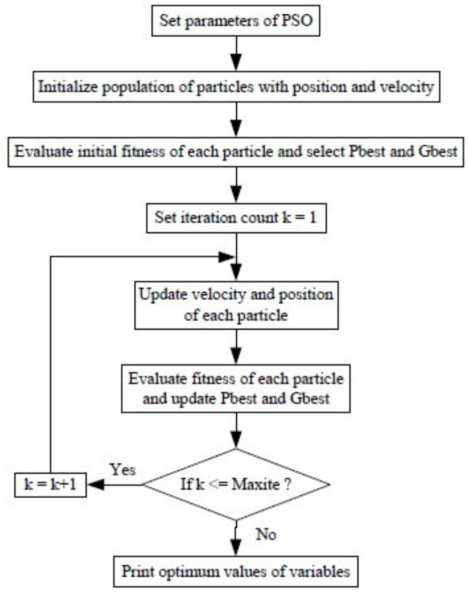


Fig. 2. PSO algorithm flowchart.

### C. *Bio Inspired Algorithms*

## III. Materials and Methods

All the tests were made in a computer with an Intel(R) Core(TM) i7-6500U 2.5GHz processor.

The natural selection consists in evaluate every image, in order to get an optimum global. Particularly 892 images of 256x332 pixels were analysed, with intensities from 0 to 255.

The bio inspired algorithm was applied to optimize and to reduce the time of processing, making easier future work and then use that time on another task like noise removal and image segmentation. PSO was codified on Matlab.

To calculate the noise level in the image without known the objects of interest we propose a noise counting method through threshold. A threshold is applied, where it, makes possible split background from the rest, so we can group all the pixels that do not belong to the background, leaving the variations only in the noise, because the objects of interest remain almost invariant. The image i+2 is the best choice, it has less noise than the others two as it is shown in Fig. 3.

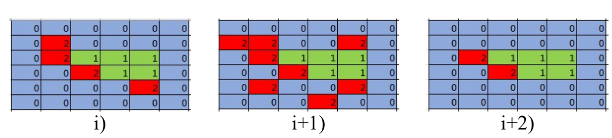


Fig. 3. Matrices 2 value is noise, 1 object of interest and 0 the background. i) image with 9 pixels higher than 0 and therefore they don't belong to the

background, i+1) Matrix with 13 pixels that do not belong to the background, i+2) Matrix with 7 pixels that do not belong to the background.

First, 20 periods (iterations) with 25 particles are defined, the velocity of 1.5, inertia of 0.5 and the actual position of the particles we could obtain those solutions presented previously. Each particle evaluates an image selected from the set randomly doing a noise counting, therefore, having 25 particles working together with 20 periods we only verify 500 images instead the 892 that sequential search does.

Six tests were carried out with sequential search, covering the 892 with a total of 343 noise pixels in 3.799458167 seconds. Then another 30 test were done but with PSO method to verify if it reduce the time on the same 892 images trying to get the same solution.

## IV. Results

As it can be seen, the 892 images show a very similar behaviour in different threshold levels (See Figs. 4-7). Therefore, optimal solutions are found.

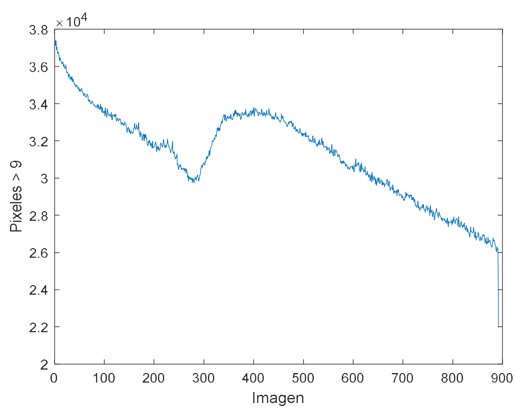

Fig. 4: Pixels higher than a 9 threshold.

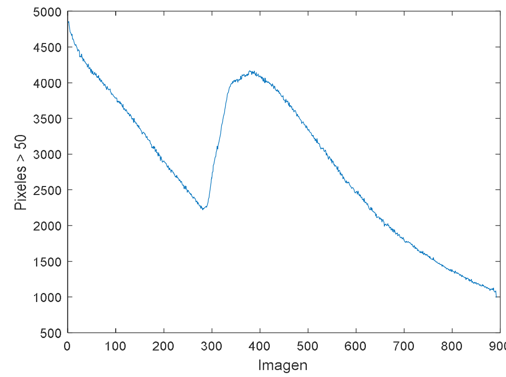

Fig. 5: Pixels higher than a 50 threshold.

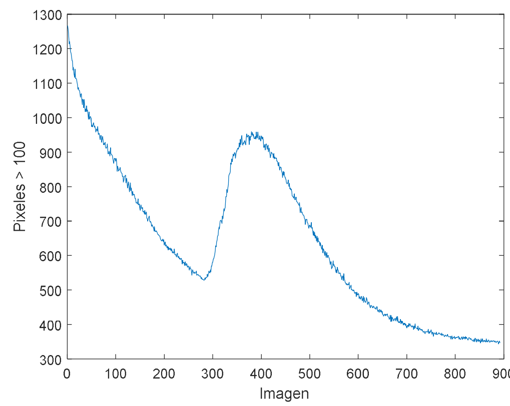

Fig. 6: Pixels higher than a 100 threshold.

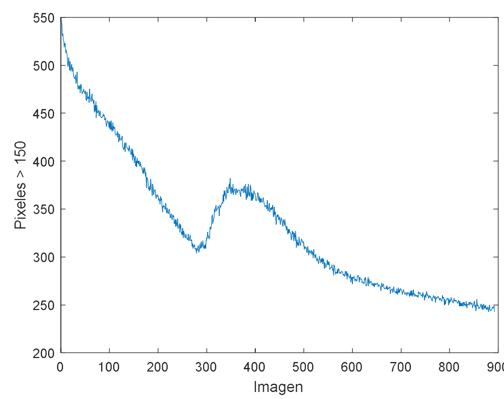

Fig. 7: Pixels higher than a 150 threshold.

In both methods, the time was measured In order to have a reference of it as shown in Fig. 8, 9, 10, 11. We make zoom at the part of the solutions on figures 4,5,6,7

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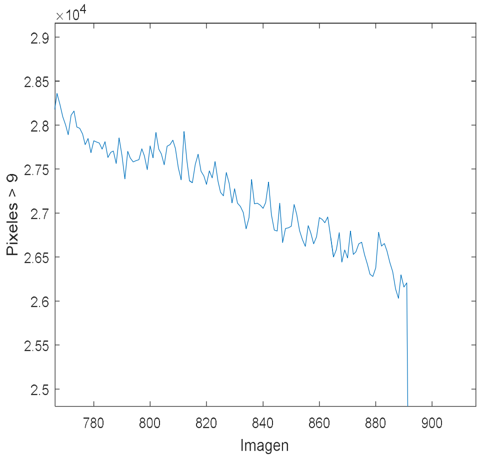



Fig. 8. solution part zoom of Fig. 4

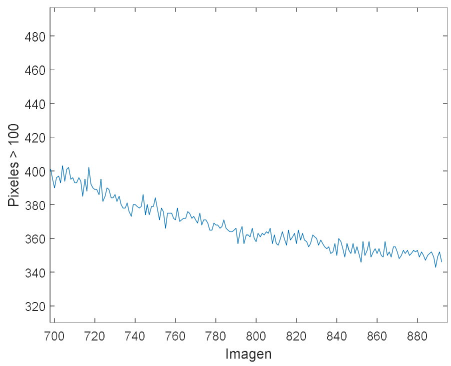



Fig. 9: solution part zoom of Fig. 5

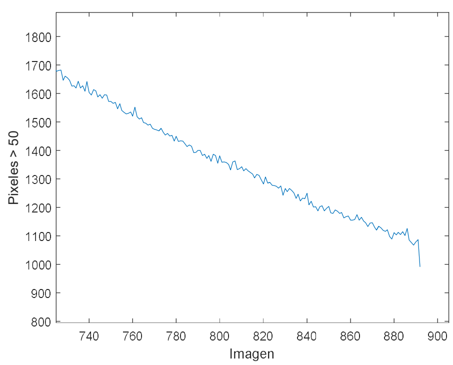



Fig. 10: solution part zoom of Fig. 6

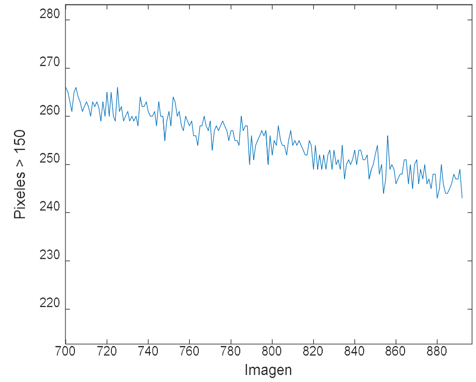


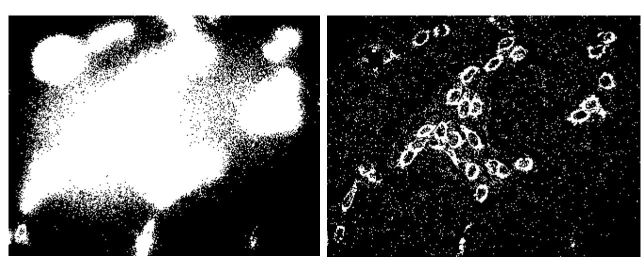

Fig. 11: solution part zoom of Fig. 7

Favorable results were obtained with 8 of 30 tests show the global solution. The others 22 obtained a local solution in the images 852 and 892 with 346 noise pixels which is a very close approximation to the global one. All this, in 2.072606133 seconds as shown in table 1.

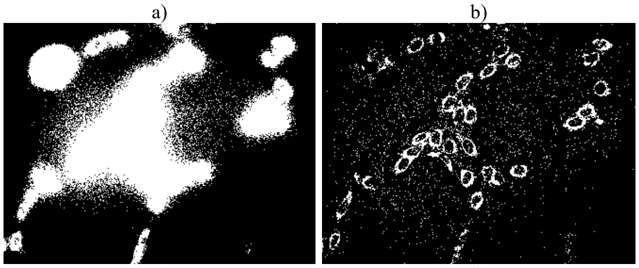
TABLE I
COMPARATIVE BETWEEN SEQUENTIAL SEARCH AND PSO WITH A 100 THRESHOLD.

| **Sequential Search** | | | |
|---|---|---|---|
| **Number of Tests** | **Image** | **Noise** | **Average Time** |
| 6 | 889 | 343 | 3.799458167 |
| **Particle Swarm Optimization** | | | |
| 8 | 889 | 343 | 2.072606133 |
| 5 | 852 | 346 | |
| 17 | 892 | 346 | |

There are some changes among the images that the human eye cannot distinguish, but with a simple threshold we can see that there are many difference in the intensities of their pixels as shown in the Fig 12.



a) b)



c) d)

Fig. 6. a) Image 1 from the set with a 9 threshold, b) Image 1 with withe tophat transformation, structural element of 2 and a threshold with 1976 object inside of the image, c) Image 892 of the set with a 9 threshold, d ) Image 892 with withe tophat transformation, structural element of 2 and a threshold with 1473 object inside of the image..

## CONCLUSIONS

Bio- inspired are algorithms that imitate simple and practical biological behaviors that can make numeric predictions or optimize search processes. For this investigation PSO was used in the optimization field, doing the image selection search for the segmentation. The time was optimized by reducing the total iterations and evaluations of the images. It is a good choise dedicate some time to tasks who make easier the future work, like select an image from the set that contain less noise than the others. Depending on the selection, the application of filters and transformations we get a filtered image with more or less noise making easier or harder the segmentation. A total of 1.726832034 seconds was reduced equivalents to almost 1450555708.56 operations that can be used in others tasks like noise removement or the segmentation.

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