Development Of Non Circular Iris Segmentation Using Modified Snake Algorithm

Z Zainal Abidin1*, Z Abal Abas1, N A Zakaria1 and Z Z Shaharin1

1Fakulti Teknologi Maklumat dan Komunikasi
Universiti Teknikal Malaysia Melaka 76100 Durian Tunggal Melaka Malaysia

*E-mail: zaheera@utem.edu.my

Abstract. The importance of this study is to identify a human’s almost round iris shape since the existing technique of iris recognition detects human iris using a circular segmentation method. However, the circular segmentation has limitations to detect and acquire iris in non-ideal conditions. In the non-ideal condition, the location of the iris is situated at a different angle and the information acquired may not be about the iris template. Thus, the non-ideal condition produces less accurate information about the iris template and creates a “not match” situation during verification since the information of the iris template acquired is not similar to the previous iris template. To overcome the problem, this paper proposes the development of the Modified Snake algorithm. The experiment results show that the Modified Snake algorithm reduced the influence of noise in iris images, good execution in learning the edge of images since the number of iteration reduced or maintain based on the iris image since iris image contains high noise. As a conclusion, the experiment used the public iris image database from the Center for Biometrics and Security Research for non-bias evaluation and demonstrates an efficient performance.

1. Introduction
Human iris image contains high noise due to several factors such as the iris shape itself, obstacles (i.e.: eyelids, eyelashes, pupil, and retina), aging and source of light. The boundary between iris and pupil is oblong [1], which is not really in a round shape. The information about iris is hidden by obstacles and sources of light, which produce a non-accurate data template [2]. The aging factor creates new features inside the iris image such as pigment and crypt [3]. However, the existing technique in circular segmentation produces a mismatch during non-ideal situations or successful conditions for ideal iris. As iris has unique characteristics and the algorithms of circular segmentation unable to acquire accurate information, the information of the iris template attained is not similar to the previous iris template. Therefore, due to the unique characteristics of iris, an algorithm in non-circular segmentation is demanded to study the features inside the iris template and in non-ideal conditions [4]. Thus, techniques of non-circular segmentation are snake [5], greedy [6] and RANSAC [7], which is the active contour model and it is useful to produce a better image solution for iris recognition. The objective of this study is to explore an algorithm based on the non-circular segmentation method and develop the application. Figure 1 illustrates the idea of non-circular segmentation.
Figure 1. Techniques of Active Contour in Non Circular Segmentation.

The snake algorithm has the ability to detect the complex outline and good results are obtained in the feature extraction algorithm of the iris image. In fact, the Snake algorithm locates the iris outside edge successfully but snake only great at the same shape of the iris image, which is useful at matching for a person (verification phase), not more than one. Moreover, the energy function is high. Another technique is the Greedy algorithm that always makes the selection of an image that looks best at the moment, which is intuitive and fast, but typically it is not optimal. Greedy algorithm is an iterative method used for minimizing the energy functional of active contours, snakes. On the other hand, a technique called Random Sample Consensus (RANSAC) is used for iris segmentation. RANSAC is good at accurately and efficiently detects the precise pupil contour and localizes the limbic boundary. Nonetheless, RANSAC’s computational process is high and consumes energy usage. Based on the three main techniques discussed, the advantage and disadvantage of each technique is summarized in table 1.

| Method     | Advantages                          | Disadvantages                                      |
|------------|-------------------------------------|----------------------------------------------------|
| Snake      | Reduced the influence of noise in the images | The parameter has to be adjusted for a new type of image |
| Greedy     | Converges faster than the other algorithms | Cannot be used to segment a variety of different shapes |
| Ransac     | High performance in iris segmentation | The parameter to be computed needs some time because no upper bound and number of iteration executed is limited |

Due to the winning criteria of the snake algorithm, it motivates the researcher to implement the snake algorithm for iris segmentation. The goal of this paper is to develop using MATLAB programming using a modified snake algorithm and measure the snake’s number of iteration. The rest of the paper is organized as follows: Section II explains the modified snake algorithm in iris segmentation. Section III describes the results and findings. Section IV concludes the study on the snake algorithm.

2. Non Circular Segmentation based on Modified Snake Algorithm

Figure 2 illustrates the implementation of the modified snake algorithm in the iris segmentation. The modified snake algorithm detects and segments iris using deformable curves to match the iris shape. It starts with open and closed the curve using the curve parametric model. At the initial state, the open and closed are the same, $\gamma(a) = \gamma(b)$. To create a contour function, named as $\gamma(s)$, which describes the behaviour of an iris image.
The external energy function describes the deformable curve match with features of an iris image, which described as $E_{\text{ext}} = P(\gamma(s))$, where $P$ is the potential attraction field to the edge of a feature. Thus, this energy reaches the whole contour, $C$ and to close the contour is represented as $E_{\text{ext}} = \oint_C |\nabla I(\gamma(s))| \, ds$, where $I$ is the input image and $\nabla$ is the spatial gradient function defined as $\nabla I = \frac{\partial I}{\partial x}, \frac{\partial I}{\partial y}$. Moreover, to minimize the energy, the Gaussian smoothing is introduced to assist for convergence to a local minimum, as shown as $E_{\text{ext}} = - \int_A^B \nabla (G_n \ast I)^2 (\gamma(s)) \, ds$, where $G_n$ is a Gaussian weighted kernel of dimension $n$. A and B is a non-closed contour moving from A to B. Thus, a weighting parameter on the external energy allows to increase the visibility of the gradient field by the snakes and shown as in equation (1).

$$E_{\text{ext}} = - \delta \int_A^B \nabla (G_n \ast I)^2 (\gamma(s)) \, ds \tag{1}$$

The internal energy is the component of the behaviour function, which describe the physical properties such as continuity and curvature that represents in equation (2).

$$E_{\text{int}} = \int_A^B (\alpha (\gamma'(s))^2 + \beta (\gamma'(s))^2) \, ds \tag{2}$$

Where $(\alpha, \beta) \in \mathbb{R}^2$. Thus, the contour energy function is expressed as in equation (3).

$$E_{\text{snake}} = E_{\text{int}} + E_{\text{ext}} = \int_A^B (\alpha (\gamma'(s))^2 + \beta (\gamma'(s))^2) \, ds - \delta \int_A^B \nabla (G_n \ast I)^2 (\gamma(s)) \, ds \tag{3}$$

Therefore, to find the $E_{\text{snake}}$ at minimal energy usage, the parameters need to be optimised. The formulation of optimization energy is elaborated at equation (4).

$$X^{m+1} = X^m + t^m \, d^m \tag{4}$$
Where \( t \) is time step used and \( d \) represents the direction that modification of time step is accomplished. Moreover, the energy function is minimized based on time growth. Moreover, the optimal direction growth is formulated as in equation (5).

\[
\forall X^m d < 0 \rightarrow d = -X^m 
\] (5)

If the following condition in equation (6) is fulfilled.

\[
f(X^{m+1}) < f(X^m) 
\] (6)

3. Results and Discussion

Figure 3 shows the Graphical User Interface (GUI) of the prototype development of a modified snake algorithm in iris segmentation. The prototype consists of four main parts such as image screen, buttons, settings, and result. Firstly, the iris image needs to be loaded in the image screen. This is done by click the “Load Image” button. Secondly, click “Set Initial Points” button. As the “Begin” button is clicked, select the iris image in the folder. The result of modified snake development in iris segmentation after ten times execution for testing and evaluates the proposed algorithm based on the threshold value to obtain the number of iteration and time of computation. Based on the computation of the modified snake algorithm, the increase of convergence is minimum and the user could initiate at only interesting contour. For testing the modified snake convergence activity, the number of iterations based on threshold values is executed according to user A from the public iris database. The public iris database available in the Center for Biometrics and Security Research in the Institute of Automation Chinese Academy of Sciences (CASIA) iris database as shown in figure 4.

![Figure 3. Development of Modified Snake Algorithm for Iris Segmentation with results.](image)

The outcome from Figure 4 indicates that the number of iteration of artificial snake is decreasing due to minimal energy usage in learning features in the iris image. The result from the experiment is
based on iteration versus threshold. Thus, the less the number of iteration, the less energy used for convergence since the snake recognizes the object faster for each iteration executed. The result has proven that, even though the User A captured the iris image at several sessions and different time slots, the modified snake can recognize User A as the same person. The indicator of the graph revealed that the modified snake full converged and time spent on learning the feature is 0.5 second and the average iteration is 10.5.

![Graph showing No. of Iteration versus Threshold Values](image)

**Figure 4.** Number of iteration versus threshold for user A

4. **Conclusion**
   As a conclusion, the development of a modified snake algorithm produces better performance in terms of convergence and achieve faster time in searching for features of iris image in the segmentation stage. Based on the result, the number of iteration has been reduced and the use of energy in convergence has been optimized.

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