Vigorous Iris Segmentation Algorithm

Weam Farhan[1], Ebtesam N. AlShemmary[2*]
[1, 2] Department of Computer Science, Faculty of Computer Science and Maths.,
University of Kufa, Najaf, Iraq
*dr.alshemmary@uokufa.edu.iq

Abstract:

The accuracy of the iris system recognition is greatly influenced by the partition stage. In this paper, a vigorous iris segmentation algorithm is proposed to deal with iris segmentation challenges. The algorithm overcomes the problems occur at the image taken stage such as specular reflection, iris and pupil are not on the center of the eye, and the iris is partially occluded by the eyelid, eyelashes, glasses, and shadow. A hybrid method that combines Chan-Vese and GrabCut methods have been implemented. The complement and region full methods used for image preprocessing stage, then to identify the external bounds of the iris, Chan-Vese is applied for active contour which is a strong and flexible method to segment iris region. The segmented image of the iris region is smoothed by applying GrabCut which is an energy minimization algorithm of graph cuts family. The inner boundary pupil localized by the Hough transform. Finally, the eyelid and eyelashes are detected and removed from the iris. The experimental results of the proposed algorithm on the UBIRIS V2 iris data basses indicate how the segmentation accuracy affects the recognition system. The proposed method is able to segment the iris texture from the input images correctly.

Keyword: Iris Segmentation, Chan-Vese Algorithm, Graph Cut.

I. INTRODUCTION

Iris recognition biometric systems have several advantages over other biometric systems, for instance, most iris patterns have not been altered over the life span, cannot be easily falsified or modified, and each individual possesses individual iris pattern with a high grade of fluency [1, 2]. Biometric research used iris recognition to determine high dependability and this led to overall studies in the development of iris techniques in an unrestricted environment, off-angles, noise, vagueness, and obstruction by eyelashes, eyelid, glasses, and hair. These causes lead to the likelihood of gaining a non-ideal iris image is very high [3, 4]. Most of the preceding research on the iris segmentation is concentrate on the exact detection of the iris images which are captured in closely controlled condition compared to the new trend of the research that applies different approaches to reduce the error percentage even in the presence of types of noise include iris obstructions and specular reflection.

In this paper, we proposed a hybrid method, active contour and grab cut are used to accurately localize the structure of the iris in the eye image. While many methods of segmentation based on heavily in some away on the edge detection, the “Active Contours Without Edges” method by Chan and Vese ignores edges completely. Chan-Vese active contour is a powerful and flexible method which is able to segment many types of image and used extensively in the medical fields.

The structure of the paper as follows: in the next section, related work is presented. Section 3 presents the proposed algorithm. Section 4 the technical details of the vigorous algorithm are described. Section 5 shows the experimental results and finally, Section 6 gives the most important conclusion of the proposed algorithm.

II. RELATED WORK

The concept of the iris is defined as a specific area bounded from the inside by the pupil and from the outside by the hard part and the eyelids. Most studies detect these two areas and remove the eyelid, lashes and light reflection.

Daugman was the first one who exhibits a total iris recognition system [5]. To divide the iris he defined the so-called Daugman Integro-differential factor. This factor seeking for the circle with the topmost alteration in values by changing both positions, radius and center (x,y) of the outline curvature. The two top value congruous to the both gained circles that locate the iris. Daugman does not employ any threshold on the image gradient, which applies the information of each image. However, the factor is significant to the outrageous value that might progress to misconception discovery in the iris. Daugman uses a duplicate agent for the eyelids, then the factor searches the parabola curvature shapes the eyelid. Finally, eyelashes reflexion results from isolation of severing threshold.

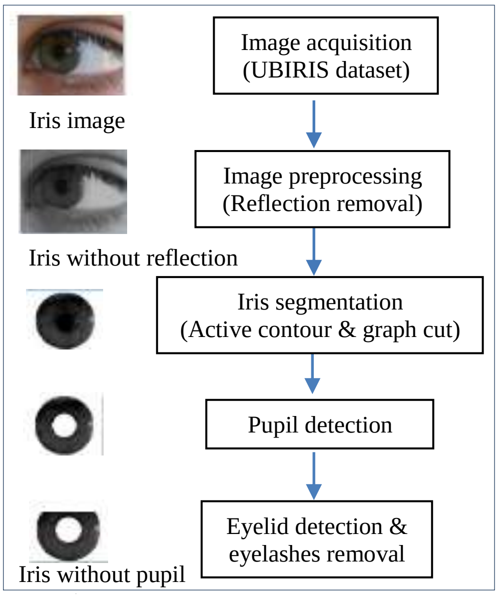
Wilds established the circular Hough transform to locate the iris [6]. The tendency of the images is calculated by this algorithm and makes a brink-maps to transform it to Hough. The voting is then calculated to recognize both the given circles which are represented the potential radius. The external iris boundaries are discovered prior to the internal boundaries; the outcome is agreeable for the image of the particular gradient and the predetermined domain of the radius of the potential circle [1].

Iris localizing is done by the use of Morphological factor such as density thresholds opening and closing [7, 8]. More specifically speaking in [7] a square region that's fully besetment the pupil it discovered by using the intensity information. The region is thereafter binaries to educator a brink-maps out of it. It using a reiterated morphological factors algorithm locating the iris internal boundaries. The mechanism for determining external tires is going along with the outer boundary is separated into left and right sides in which they are detected by arched Hough transform and finally consolidated together. Attractive results obtained which show development on the accuracy of the iris localization. In any case, it must be taken into an account that the database used to experience the system (CASIAV4) is considered as a simple unchallenging database.
Chan and Vese [9, 10], suggest a new level set model. This model has large properties for global optimization because it employs all the information in the full image area. Instead of, this method optimally fits a two-phase piecewise constant.model to the given image. The border segmentation is represented implicitly with a level set function the levelset effects on handle segmentation, it make more easy than explicit snake.
Jahangiri and Heesch [11], prepare an unattended GrabCut algorithm configured with a rough segmentation acquired by active argument. However, they are solitary fit to segment the front-end objects from a clear background and not use any category-specific information.

III. THE PROPOSED METHOD

This section reviews the proposed hybrid method which integrates two techniques used in cutting the picture which is the active contour (Chan-Vese) and GrabCut, thus we get more accurate and efficient results in cutting the iris. Figure 1 shows the steps for the proposed method of iris segmentation.

Figure 1: The proposed method



IV. TECHNICAL DETAILS

Iris segmentation is to isolate the iris part from other parts in the iris recognition system that's find the limits of the iris in term of pupillary and limbic, locating the top and lower eyelids if they occurred, or detected eyelashes, shadow and reflection. In this section, we will explain the approaches used at each stage of this algorithm.

A. Specular Reflection Removal

This section presents the iris image quality enhancement through reflection removal steps.

1. Remove Reflection from Pupil Region

The interpolation method (bicubic method) is used to deal with this problem. Bicubic interpolation, also known as crossover curing interpolation, (4×4) adjacent pixels are considered. It is different from linear double interpolation which is only (2x2) pixels into account, using this equation [12]:

$$v\,(x,y) = \sum_{i=0}^{3}\sum_{j=0}^{3} a_{ij}\, x^{i}\ y^{j} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Where:
v (x, y): the coordinates.of the resulting point.
a_{ij}: the coordinates of the adjacent

For more illustration of the above equation, the chromatic value of the coordinate is the sum of the color values of sixteen contiguous [12]:

$$v(x,y) = \begin{bmatrix} f(i-1,j-2) & f(i,j-2) & f(i+1,j-2) & f(i+2,j_2) \\ f(i-1,j-1) & f(i,j-1) & f(i+1,j-1) & f(i+2,j-1) \\ f(i-1,j) & f(i,j) & f(i+1,j) & f(i+2,j) \\ f(i-1,j+1) & f(i,j+1) & f(i+1,j+1) & f(i+2,j+2) \end{bmatrix} \ldots\ldots(2)$$

Where:
F(i,j): the coordinates.of the sixteen contiguous.

Figure 2 display the result of removing reflection from the pupil region using interpolation method.

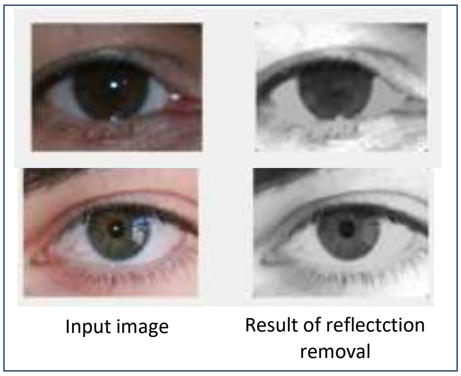


Figure2: The result of the pupil reflection removal.

2. Iris Reflection Removal

Morphological filter operation is used to iris reflection removal, region fill algorithm, and complement image. The region fill of the image can be selected in two ways: (i) inner region and (ii) boundary region. The inner region is characterized by specifying an identical value to all the pixels inside that region. The algorithms exercised to change the values of all pixels in the interior regions to new values are FLOOD-FILL algorithms [13].
The boundary regions are characterized by the similar incentive to each pixel on the regions. The pixels of the regional boundary and the inner once should not have identical values. BOUNDARY-FILL algorithms are used to change the value of all pixels in boundary regions to new value [13].
The algorithm for region filling based on set of dilations, complementation, and intersections. The main idea is filling the entire region with 'black' starting from a point "p" inside the boundary. If we adopt the convention, the first step is that all the non-boundary (background) points are labeled 'white' and then assigned a value of black to point "p". Filling the region with 'black' executed by the following procedure [14]:
$x_k = (x_{k-1} \oplus B) \cap A^C)$ ……………………….(3)

Where:
k=1,2,3,…
B: is the symmetric structure element
A^C : is the complement of the set.
When k=0 then x_0 will equal to the point "p" in Eq. 3. Figures 3 shows the results of the iris reflection removal steps.

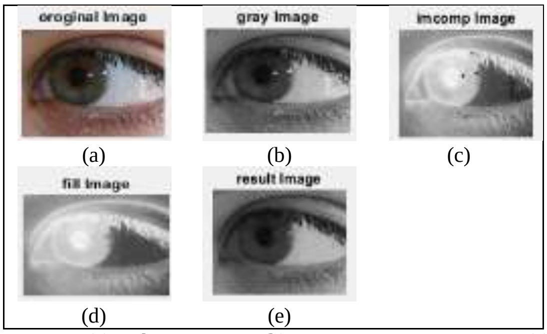


Figure (3): The outcomes of preprocessing stage. (a) authentic image, (b) RGB image to gray image, (c) complement image, (d) fill image, and (e) the resulting image without reflection.

B. Iris Segmentation

The iris segmentation is one of the most important stages in the recognition system of the iris. This stage includes the separation of iris from the rest of the other parts. Iris is a part that contains the unique characteristics of the eye in which the recognition rely on. Chan-Vese active contour and graph cut is a hybrid method that used for the segmentation in the proposed algorithm.

1. Chan Vese Active Contour

Chan-Vese active-area model [15] is a strong and soft method to segment many types of image, in particular some images which are complicated to segment suitably by "classic" segmentation technique using a gradient-based [16]. This pattern is established on Mumford-Shah functional [17] and is extremely used in medical imaging, particularly for brain, heart, and tracheal dissection. This model is firstly based on the power decrease problem, which can be reformulated in the form of the level groups, resulting in problem-solving.

Let f mark the given eye.gray image in a domain Ω to be segmented. The Chan–Vese strategy is inlivened by the Mumford–Shah model. Mumford and Shah functional [17] approaches the image *f* by a soft segment function *u*, as a result for the minimizing case [18]:

$$\underset{u,c}{\arg} c1, c2 \min \mu\, length(C) + \lambda \int_{\Omega} \big(f(x) - u(x)\big)^2 dx + \int_{\Omega\setminus C} |\nabla u(x)|^2\, dx \quad \ldots\ldots\ldots\ldots(4)$$

While C is the edge range curved, u is permitted to be sporadic. The first term secure regularity of C, the second term support u to be near to *f*, and the third term ensure that u is differentiable on Ω\C. The Mumford–Shah approximation suggests Selecting this edge set C as the segmentation limit.

To simplify the equation (4), Mumford and Shah also looked at a fixed intermittent model [18]:

$$\underset{u,c}{\arg} c1, c2 \min \mu\, length(C) + \lambda \int_{\Omega} (f(x) - u(x))^2 dx \quad \ldots\ldots\ldots\ldots(5)$$

Where *u* desired to be fixed on each linked element of Ω\C. In this case, C is the limit of a closed set necessarily, i.e. C is collected from closed curves. Contrast to th e Mumford Shah's model, the main variation with the Chan-Vese model is an extra item that penalizes a closed area and furthermore simplifica tion that *u* is permitted to have two values only [18]:

$$u(x) = \begin{cases} c_1 & where\ x\ inside\ C \\ c_2 & where\ x\ outside\ C \end{cases} \quad \ldots\ldots\ldots(6)$$

Where C represents the boundary of a closed set, while c1, c2 represents both inside and outside the values of C respectively. Chan–Vese model finds through all *u* of this formula the one that best convergent *f* [18]:

$$arg_{c1,c2,C}\, \mu\, length(C) + vArea\big(inside(C)\big) + \lambda 1 \int_{inside(C)} |f(x) - c_1|^2\, dx + \lambda 2 \int_{outside(C)} |f(x) - c_2|^2 dx \quad \ldots\ldots\ldots\ldots(7)$$

The first term monitoring minuteness by correction the length. The second term correct enclosed C area to dominate its size. The third and fourth terms complete th e contradiction “piecewise constant model” u and the input image *f*. Figure 4 display the application results of the Active Contour method (Chan Vese) on the iris image. The implementation started with the initialization of mask curve (initial contour location close to the object that is to be segmented), then segment the image using the method with 150 iterations and finally boundary determination of the segmented image.

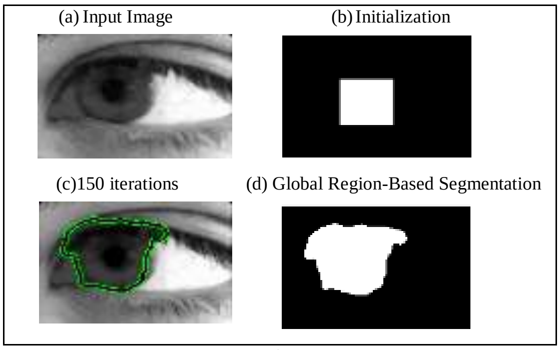


Figure 4: Show the results of Chan Vese algorithm, (a) input image, (b) initialization of mask curve, (c) segmentation with 150 iterations and (d) boundary of the segmented image.

2. *GrabCut method*

Boykov and Jolly 2001 [19], proposed a technique of repeated image segmentation established on the GraphCut algorithm. There are algorithms for returns the cut with minimum cost in a graph. It is beneficial for segmentation if the energy can be expressed as a cost of a cut in a special graph builds from the image. This is the situation of the Chan-Vese model.

GrabCut expansion images can be colored by Graph cutting and more over the deficient developments are extremely raise the advantage of graph cut. This process of user interaction can be simplified by drawing a rectangle around the desirable foregrounding, followed by a small amount of modifying editing. The color information module in the algorithm of graph cut and the refined learning process raises its hardness. Consequently, GrabCut is a modifying tool of a hopeful image for foreground extraction [20]. Figure 5 shows the selection of nodes according the segmented region for foreground and background [21]. The results of GrabCut algorithm and segmentation are fully illustrated in Figure 6.

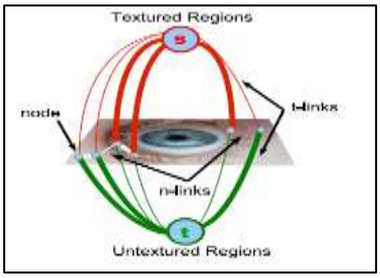
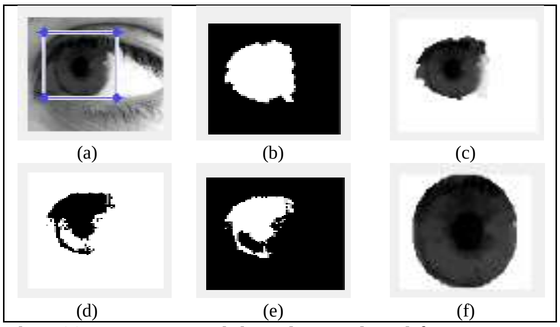


Figure 5:- shows t-links between terminals and nodes and n-links between two nodes [21].

The algorithm of GrabCut uses Gaussian Mixture Models (GMM) to lump the RGB pixel values from the image. There are two GMMs, one foreground and one for background pixels. Each GMM.is defined to have 5 clusters (K = 5, set to be constant).



Figure(6): The results of grab cut algorithm, (a) gray image with boundaries selected from previous step (Chan Vese), (b) applying grab cut function, (c) masked image, (d) binary mask image, (e) full complement binary image, and (f) result of segmentation.

There is an inflexible segmentation of the pixels between the foreground and background GMMs performs by n = 0 (background) 0 or 1 (foreground).

A Gaussian Mixture Model (GMM), the probability distribution used, is defined by sundry parameters [19].

$$\theta = \{\pi(\alpha, k), \mu(\alpha, k), \Sigma(\alpha, k)\} \;\ldots\ldots\ldots(8)$$

where:

- $\alpha = (0, 1)$, $k = 1$
- μ mean RGB value
- π weighting coefficient
- Σ covariance matrix (3x3)

The algorithm of GrabCut hard segmentation which is iterative image segmentation in GrabCut Colour data modelling can be shown as below [23]:

Initialisation

- User initialize trimap T by supplying only TB. The foregr und is set to TF = /0; T U = T B, complement of the background.

- Initialise αn = 0 for n ∈ TB and αn = 1 for n ∈ TU .
- Background and foreground GMMs initialised from sets αn = 0 and αn = 1 respectively.

Iterative minimization

1. Assign GMM components to pixels: for each n in TU , kn := argmin kn Dn(αn, kn,θ,zn).
2. Learn GMM parameters from data z: θ := argmin θ U(α,k,θ, z)
3. Estimate segmentation: use min cut to solve: min {αn: n∈TU } min k E(α.,k,θ, z).
4. Repeat from step 1, until convergence.

C. Pupil Detection

Pupil detection is the process of separating the pupil from the iris image because it is not necessary. The pupils may have difficulties in the selection because they may be unclear and may not be in the center of the iris. First, filtering the iris image with 2-D median filters and then specify the small value of the pixels of the image of the iris Imin, aftar that switching the resulting image to binary by using threshold (25+ Imin). There are other uses of a 2-D median filter is used on the dual images to dismiss the comparatively smalle regions related to the eyelashes [22]. Generally, the largest boundary of the remaining regions of the eye corresponds to the pupil. However, when the pupil is constricted, it is very likely that the boundary of the detected region correspo nding to the eyelashes which is larger than that of the pupil. A circle-fitting procedure is executed on all detected regions. Finally, the circle whose circumference contains the maximum number of black pixels is deemed to be the detected pupil. Regions with diameters more than half the image size are not considered [22].

D. Eyelids and Eyelashes Detection

An iris segmentation is a basic unit in the recognition of the iris in order to determines the active area used to extract the parameters, therefore, the accuracy of recognition is directly related [23]. Of particular importance, the issue involved in iris segmentation is the localization of the eyelids important. The iris is almost partially unknown by eyelids and eyelashes which will increase the rate of false acceptance and false rejection if it isn't properly excluded. A morphological will use the laws of the circuit and subtracting the upper portion of them by comparing the color intensity of the iris image.

V. EXPERIMENT RESULT

This algorithm is proposed to be applied on UBIRIS V2. UBIRIS database has over (11000) images (and continuously growing) where this dataset contains the normal cases and noise cases in which noise are intended by (non ideal iris, reflection, eyelid, eyelashes, blurring). The accuracy of this algorithm in the normal cases up to 99% and in the critical cases up to 97%. Table 1 shows the accuracy of different iris segmentation methods. Table 2 displayes the results through the steps for the proposed method of iris segmentation.

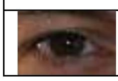
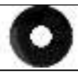
Table 1: The accuracy of various iris segmentation methods.

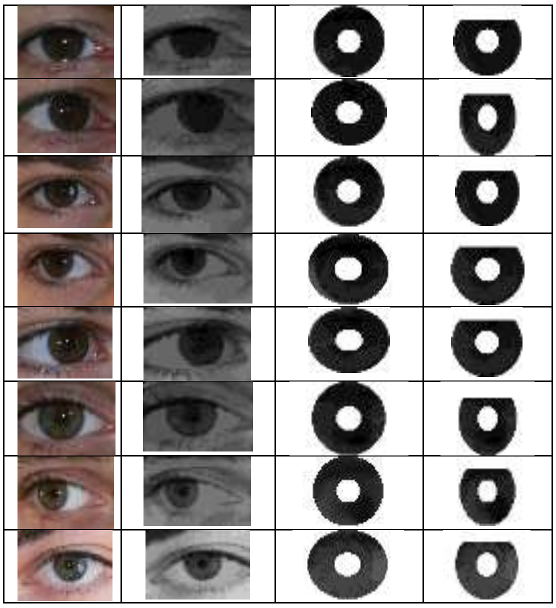
Algorithm	Precision
Suggested algorithm	97.3%
Integro-diferential factor	90.5%
Hough transform with edge detection	95.7%

VI. CONCLUSIONS

The present paper offered a new algorithm that proceeds a hybrid method that combines Chan-Vese and GrabCut methods in case of minimal forced situations, consisting variety in the average of closure, lighting and different positions of the iris. The reasons that made robustly are the validity of the proposed algorithm is due to for reasons: dealing with non-ideal iris, spectral reflection, the pupil is not center, remove eyelid and eyelashes. The accuracy of the algorithm range between 99% for the normal cases and 97% for the critical cases. A possible continuation of this work may be to think of a good automated initialization of the generalized Chan-Vese model. The original method with constant regions can be initialized with a well chosen threshold. For the polynomial regions, the problem is more complicated. For example, using the Otsu thresholding as an initial segmentation .

Table 2: The proposed algorithm results.

Input image	Preprocessing	Segmentation	Eyelid removal
			



REFERENCES

[1] R. S. Shubhika Ranjan, Prabu Sevugan, P.Swarnalatha, Magesh Gopu, “Iris Recognition System,” vol. 4, no. 12, pp. 354–356, 2017.

[2] T. Kazakov, “by A thesis submitted to University of Birmingham School of Computer Science University of Birmingham,” no. May, 2014.

[3] N. Zainal and M. J. N. , Abduljalil Radman, Mahamod Ismail, “Iris Segmentation for Non-ideal Images Jurnal Teknologi Iris Segmentation for Non-ideal Images,” *J. Teknol. (Sciences Eng.*, vol. 74:3, no. May, pp. 39–43, 2015.

[4] P. V. L. Suvarchala, S. S. Kumar, and B. C. Mohan, “Iris recognition under non-ideal imaging conditions and CCD noise,” *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 8251 LNCS, pp. 319–326, 2013.

[5] J. G. Daugman, “High Confidence Visual Recognition of Persons,” *Intelligence*, vol. 15, no. 11, 1993.

[6] R. P. Wildes, “Iris recognition: an emerging biometric technology,” *Proc. IEEE*, vol. 85, no. 9, pp. 1348–1363, 1997.

[7] HamedGhodrati ; MohammadJavadDehghani ; MohammSadegh Helfroush ; Kamran Kazemi “Localization of noncircular iris boundaries using morphology and arched Hough transform,” in *2010 2nd International Conference on Image Processing Theory, Tools and Applications*, 2010, pp. 458–463.

[8] JOAQUIM DE MIRA JR. 1 , JOCELI MAYER2 “Image feature extraction for application of biometric identification of iris-a morphological approach,” in *16th Brazilian Symposium on Computer Graphics and Image Processing (SIBGRAPI 2003)*, 2003, pp. 391–398.

[9] T. Chan and L. Vese, “An Active Contour Model without Edges,” pp. 141–151, 1999.

[10] T. F. Chan, B. Yezrielev Sandberg, and L. A. Vese, “Active contours without edges for vector-valued images,” *J. Vis. Commun. Image Represent.*, vol. 11, no. 2, pp. 130–141, 2000.

[11] G. Christoph and J. Denzler, “Semantic Segmentation Using Grabcut,” pp. 597–602, 2012.

[12] P. R. Rajarapollu and V. R. Mankar, “Bicubic Interpolation Algorithm Implementation for Image Appearance Enhancement,” *Ijcst*, vol. 8, no. 2, pp. 23–26, 2017.

[13] C. Solomon and T. Breckon, “Morphological Processing,” *Fundam. Digit. Image Process.*, pp. 197–234, 2011.

[14] A. . Raid, W. . Khedr, M. . El-dosuky, and M. Aoud, "Image Restoration Based on Morphological Operations," *Int. J. Comput. Sci. Eng. Inf. Technol.*, vol. 4, no. 3, pp. 9–21, 2014.

[15] E. S. Brown, T. F. Chan, and X. Bresson, "Completely convex formulation of the Chan-Vese image segmentation model," *Int. J. Comput. Vis.*, vol. 98, no. 1, pp. 103–121, 2012.

[16] S. Jamaludin, N. Zainal, and W. M. D. W. Zaki, "Iris recognition based on the modified Chan-Vese active contour," *J. Teknol.*, vol. 78, no. 10–3, 2016.

[17] X.-C. Tai, K. Morken, M. Lysaker, and K.-A. Lie, *Scale Space and Variational Methods in Computer Vision: Second International Conference, SSVM 2009, Voss, Norway, June 1-5, 2009. Proceedings*, vol. 5567. Springer, 2009.

[18] P. Getreuer, "Chan – Vese Segmentation Simplified Mumford – Shah Model Level Set Functions," vol. 2, pp. 214–224, 2012.

[19] Boykov, Yuri Y, Jolly, M-P, "Interactive graph cuts for optimal boundary & region segmentation of objects in ND images," Proceedings eighth IEEE international conference on computer vision. ICCV 2001.

[20] B. Basavaprasad and R. S. Hegadi, "Improved GrabCut Technique for Segmentation of Color Image," *Int. J. Comput. Appl.*, no. March, pp. 5–8, 2014.

[21] S. J. Pundlik, D. L. Woodard, and S. T. Birchfield, "Non-ideal iris segmentation using graph cuts," *2008 IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. Work. CVPR Work.*, no. July, 2008.

[22] R. Kuck and K. Nadro, "GrabCut Iterative image segmentation through minimum graph cuts," *CS 445 Comput. Photogr. Final Proj.*, vol. 0, pp. 1–5, 2013.

[23] C. Rother, V. Kolmogorov, and A. Blake, "GrabCut' - Interactive Foreground Extraction Using Iterated Graph Cuts," *ACM Trans. Graph.*, vol. 23, no. 3, pp. 309–314, 2004.

[24] A. Ross and S. Shah, "Segmenting non-ideal irises using geodesic active contours," *Biometrics Symp. BCC 2006*, no. September, 2006.

[25] V. Artificial and N. Computation, "Chapter-3 IRIS SEGMENTATION," pp. 32–82.

[26] A. Basit, M. Y. Javed, and M. A. Anjum, "Eyelid detection in localized iris images," *Proc. - 2nd Int. Conf. Emerg. Technol. 2006, ICET 2006*, no. April 2015, pp. 157–159, 2006.