Iris Localization Using Colour Segmentation and Circular Hough Transform

Nor'aini Abdul Jalil, Rohilah Sahak, Azilah Saparon
Faculty of Electrical Engineering,
Universiti Teknologi MARA,
40450 Shah Alam, Selangor, Malaysia
nonie183@yahoo.com

***Abstract* - This paper presents the enhancement technique of iris localization using circular Hough transform and colour segmentation. Circular Hough transform localized the inner and outer boundaries of the iris using images from each colour channels namely; R, G and B and H, S and V. Combination of the colour channels was also experimented. The experiments were conducted on the iris images obtained from healthy women free from Human Papilloma Virus (HPV). The result from the enhancement technique shows that when images of gray scale and combination of S and V channels are used, both outer and inner boundaries of the irises able to achieve 100% correct localization.**

Keywords – Iris; iris localization; circular Hough transform; gray; RGB; HSV

I. INTRODUCTION

Recently, iris localization has been the focused by many researchers since the impressive analysis of iris pattern. Iris pattern has been proven as a tool to recognize person identification [1-2], health status and types of disease [3-5]. Previous researchers analyzed the texture and colour of iris and relate the analysis with cases.

To extract iris pattern, circular iris is segmented first by localizing boundaries of inner (pupil-iris) and outer (iris-sclera) iris as shown in Fig. 1. The segmented iris is unwrapped into polar form in normalization process. Then, features are extracted and analyzed.

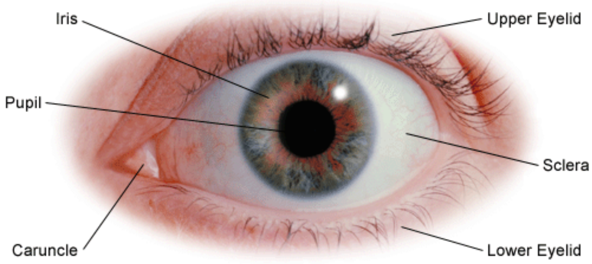

Fig. 1: The anatomy of eye

Of these processes, localization is a crucial process. Miss localization of inner and outer boundaries of iris causes inaccurate iris segmentation and then failure in further analysis. The most common algorithm used in iris localization is Circular Hough Transform (CHT). It has been proven as the best algorithm in localizing iris [6-7].

The authors would like to extend their sincere gratitude to MOHE and RMI of Universiti Teknologi MARA for awarding the Fundamental Research Grant of Science (FRGS).

Q. C. Tian et al. [8] employed modified Hough transform to localize the iris. The modified algorithm has been proven successful to localize iris with short computation time.

A. E. Yahya and M. J. Nordin [9] proposed a new technique for iris localization. To detect the inner boundaries of iris, they employed direct least square fitting of ellipse and Hough transform for outer boundaries of iris. The correct rate of the proposed method is 96.7%.

A new technique for iris localization also has been proposed by [10]. The researchers' localized pupil and iris using combination of thresholding and CHT. The experimental results obtained accuracy of 98.62%.

J. Cui et al. [11] proposed an iris localization algorithm based on texture segmentation. The researchers used information of low frequency of wavelet transform of the iris image and modified Hough transform to segment pupil and iris. They achieved accuracy of 99.54%.

Initially, CHT generates edge image using Canny edge detection, then detects the radius from the values in accumulator array and finally detects circles of inner and outer iris. To generate edge image, most of the researchers [6-11] employed gray scale image instead of colour image. Normally, pupil area is darker than iris. After colour image is transform to gray scale, high intensity is obtained in the pupil area. With the large difference of intensity between pupil and iris area, Canny edge detector can simply generates edge map.

However, this is not always true since it depends so much on the colour of the iris and pupil especially for Asian people where the boundary of iris and pupil is not easily distinguished due to close colour intensities. The problem arises when the algorithm is applied on the samples of iris images of a group of these people in a study. When the images of the eye obtained are transformed to gray scale, small difference of intensity between pupil and iris is produced. This happens due to dark brown of the iris in most of the eye images. Minimal difference of intensity between pupil and iris causes detection of the edge between pupil and iris to be less accurate and some may fail.

This paper presents the enhancement technique of iris localization using CHT combined with each channels of colour namely R, G and B and H, S and V. Combinations of these channels were also experimented. Gray scale intensity, which is commonly used with CHT was also employed to compare with the proposed method.

II. Theoretical Background

A. Circular Hough Transform (CHT)

CHT has been recognized as robust technique for curve detection whereby it can detect object even in noisy image [12]. It is also good at extracting geometrical components from any given object [13].

Fig. 2 shows the process of CHT in localizing the iris. The steps involved in this process are generating edge image, detecting radius of pupil and iris and lastly, detecting circle of pupil and iris.

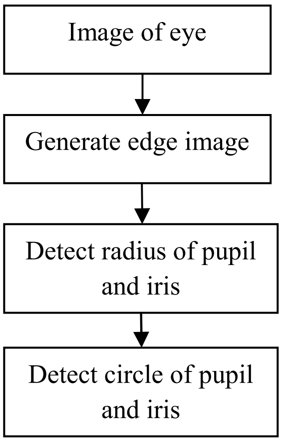

Fig. 2: Block diagram of the procedures in CHT for iris localization

To generate edge image, a common method called Canny edge detection is used to detect edge pixels. It has been proven as the best edge detector in iris recognition system [14-15].

After generating edge image, each edge point is taken as a centre of a circle of radius, r drawn onto an accumulator array. Many constructed circles intersect leading to a large intensity peak in the accumulator array at, or near, the centre of the circle. This statement is illustrated in Fig. 3.

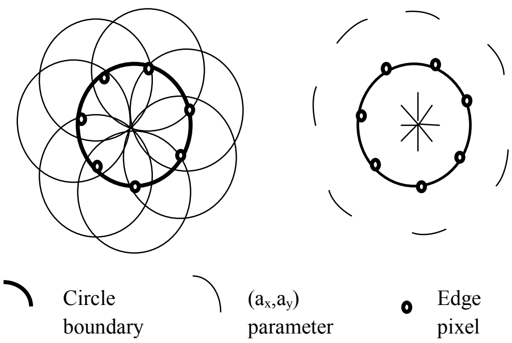

Fig. 3: The CHT showing the edge points and accumulator

The CHT as described above may be carried out for a range of different radius. This leads to an accumulator array, or parameter space, consisting of three dimensional; the position of the centre and the radius, (a, r), where $a = (x_o, y_o)$. The values in the array will be accumulated and increased every time a circle is drawn with the desired radius over every edge point. The accumulator keeps count of how many circles pass through the coordinates of each edge point and continue to find the highest count. The coordinates of the centre of circles are the coordinates with highest count [16].

Once the radius of circle is detected, the local maxima in the region of interest are assumed as the centre of the circle. If the linear indices among the minimum value of qualified pixel forming the circular shape, then that area is the pupil-iris region detected on the image. Every area of interest is tested with this process for it occurs as an element of the circle component which is the iris-sclera region identified in the image [17].

The circular shape of the iris is detected using the equation of circle as in (1).

$$(x - x_0)^2 + (y - y_0)^2 = r^2 \tag{1}$$

where, (x_0, y_0) is the coordinate of the circle centre, r is the radius of the circle.

B. Colour Image

Colour image is represented as an image with three matrices from some colour model. The common colour models used in image processing are RGB (red, green, blue) and HSV (hue, saturation, value).

RGB colours are known as primary colours and are additive. RGB expresses colours in terms of red, green and blue presence. By changing RGB colours, other colours can be achieved. Fig. 4 shows the RGB colour space.

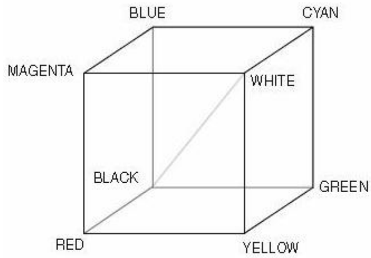

Fig. 4: The RGB colour space

HSV can be derived from RGB space [18], as shown in Fig. 5. Hue signifies as colour type. Hue can be illustrated as angle, ranges from 0 to 360 degrees. The angle varies from red, yellow, green, cyan, blue, magenta and back to red as shown in Fig. 5.

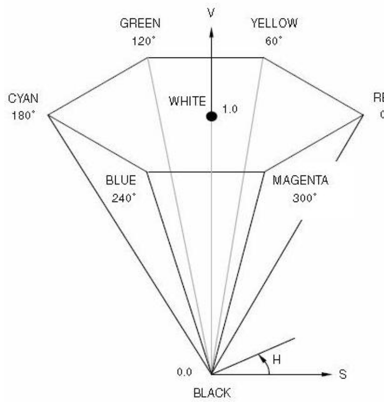

Fig. 5: The HSV colour space

Hue can be calculated as ,

$$H = \arccos \frac{\frac{1}{2}(2R - G - B)}{\sqrt{(R-G)^2 - (R-B)(G-B)}} \tag{2}$$

Saturation represents the vibrancy of the colour, ranges from 0 to 255. 0 indicates presence of gray in the image. The calculation can be expressed as,

$$S = \frac{max(R,G,B) - min(R,G,B)}{max(R,G,B)} \quad (3)$$

Value indicates the brightness of the colour. It ranges from 0 to 255, with 0 being completely dark and 255 being fully bright. Value can be calculated as,

$$V = max(R, G, B) \quad (4)$$

III. PROPOSED TECHNIQUE

The overall process used to localize inner and outer boundaries of iris is shown in Fig. 6. Initially, images of eye were cropped and resized from 3888 x 2592 pixels to 601 x 501 pixels.

The pre-processed images were transform to different space of colour channels, red (R), green (G), blue (B), hue (H), saturation (S) and value (V) before generating edge image.

In addition, gray image and combinations of colour channels, (R+G), (R+B), (G+B), (H+S), (H+V), (S+V) were also employed. Then, radius and boundary of pupil were calculated.

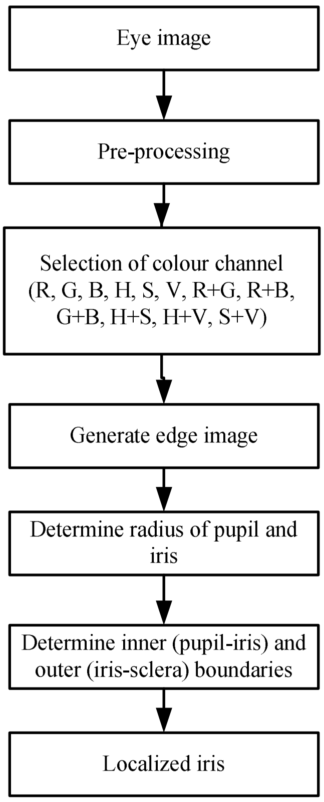

Fig. 6: The overall process in localizing iris

IV. RESULTS & DISCUSSIONS

The database of iris images for this study is obtained by the research team using iridology digital camera. 40 eye images (left and right) of healthy married women free from HP virus were used in this study. Fig.7 shows edge image generated using Canny edge detector at different channels.

Obviously, clearer edges of inner and outer iris are obtained in Fig. 7 (a), (d), (g) and (j) while Fig. 7 (b), (c), (e), (f), (i), (l) and (m) show incorrect detection of inner iris (pupil), but successful detection of outer iris. Incorrect detection of inner and outer iris causes miscalculation of pupil and iris radius and further fail in determining inner and outer iris boundaries.

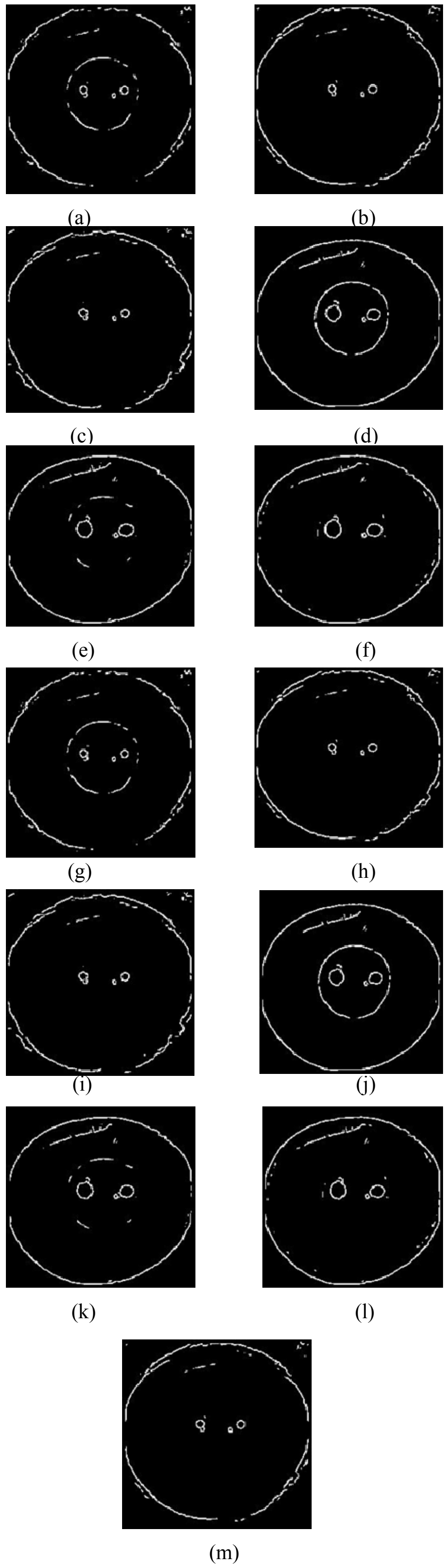

Fig.7: Edge image using Canny edge detection with image of (a) R channel (b) G channel (c) B channel (d) R+G channel, (e) R+B channel, (f) G+B channel (g) H channel (h) S channel (i) V channel (j) H+S channel, (k) H+V channel, (l) S+V channel and (m) gray image.

Fig. 8 shows circle drawn on the inner (pupil) and outer (iris) boundaries of iris. The circle is drawn based on edge image in Fig. 7. Incorrect pupil localization is obtained when images of channels G, B, R+B, B+G, V and gray scale are employed. However, localization of iris is correct for these images. Incorrect iris localization can also be found using channels S, H+S and H+V as shown in Fig. 8.

The performance of CHT depends on the edge image. The localization of iris is considered fail once the CHT is not able to detect edge of the outer and inner iris correctly. The determination of correct localization of the iris is based on visual examination.

Table I shows the percentage of correct iris localization for both right and left eye images. Most of the outer boundaries of the irises were successful localized but failed for inner iris boundaries. The highest correct localization is the inner boundary at 100%. This is obtained when combination of S and V channels is employed as input images.

Of these input images, gray scale image provides the worst accuracy in localizing the inner iris boundary. However, it provides the highest accuracy (100%) in localizing iris outer boundary. From table 1 it is also observed that combination of S and V channels is able to achieve 90% localization for both inner and outer boundaries of the irises.

TABLE I
PERCENTAGE OF CORRECT IRIS LOCALIZATION

Eye image	Localization of		
	Inner boundary	Outer boundary	Inner and outer boundaries
Gray	0	100	0
R channel	20	97.5	35
G channel	0	97.5	0
B channel	5	92.5	5
R channel + G channel	17.5	60	15
R channel + B channel	2.5	55	2.5
G channel + B channel	7.5	55	10
H channel	97.5	35	40
S channel	97.5	52.5	50
V channel	20	97.5	22.5
H channel + S channel	42.5	15	12.5
H channel + V channel	42.5	17.5	15
S channel + V channel	100	90	90

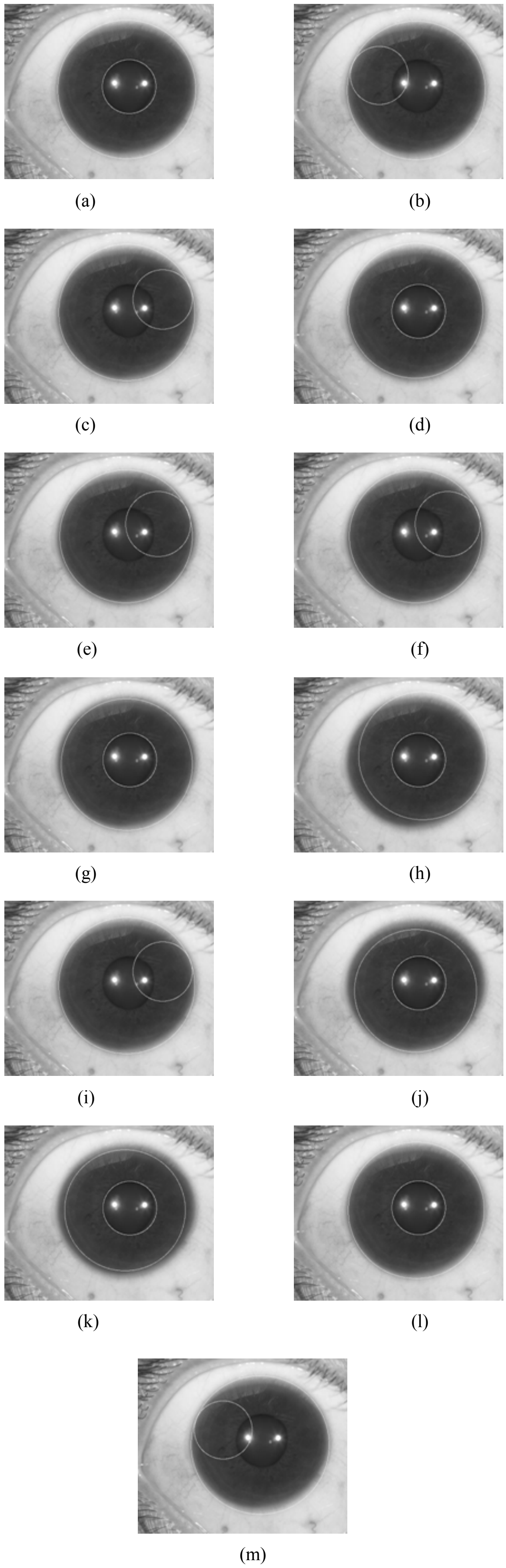

Fig.8: Iris localization using channels of colour; (a) R channel (b) G channel (c) B channel (d) R+G channel, (e) R+B channel, (f) G+B channel (g) H channel (h) S channel (i) V channel (j) H+S channel, (k) H+V channel, (l) S+V channel and (m) gray scale

Further experiment is conducted based on the results obtained previously by considering the combination of images S and V channels and gray scale. The result shows that the inner and outer boundaries of the irises achieved 100% correct localization. Fig. 9 shows eye images with successful iris localization. The outer iris boundary is detected using gray image while for inner iris boundary combination of S and V channels is employed.

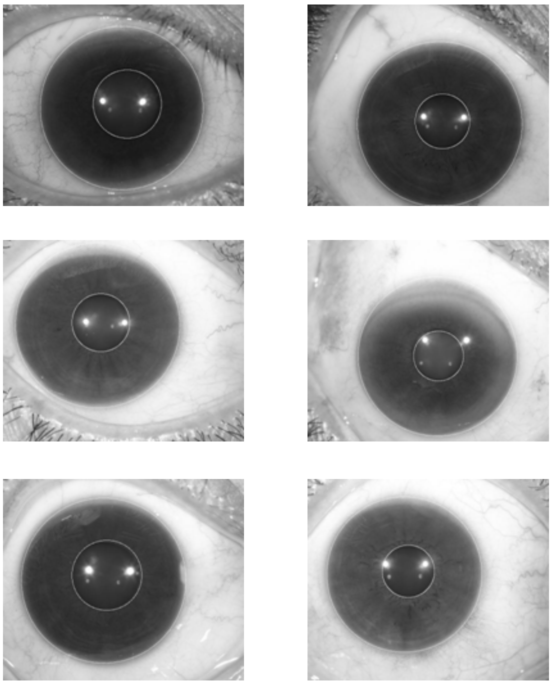

Fig.9: Iris localization using gray scale image and combination of S and V channels for outer and inner iris boundaries respectively

V. Conclusion And Recommendation

The enhancement technique of iris localization using CHT with channels of colour has been presented in this study. From the results obtained, most of the channels that have been experimented with CHT showed either poor localization of the inner or outer boundaries. However, using S and V channels, 90% correct localization is achieved for both inner and outer boundaries. It can also be observed that to achieve 100% correct iris localization for both inner and outer boundaries, combination of images S and V channels are used together with gray scale image to localize inner and outer iris boundaries.

Acknowledgment

The authors would like to extend their sincere gratitude to MOHE and RMI of University Teknologi MARA for awarding the Fundamental Research Grant of Science (FRGS). Without this fund the research work is impossible to be conducted.

References

[1] A. Harjoko, S. Hartati, and H. Dwiyasa, " A Method for Iris Recognition Based on 1D Coiflet Wavelet", *World Academy of Science, Engineering and Technology 56,* 2009.

[2] R. T. Al-Zubi and D. I. Abu-Al-Nadi, "Automated personal Identification System Based on Human Iris Analysis", *Pattern Analysis Application*, 2007, 10:147–164.

[3] L. Berggren, "Iridology: A critical review", *Acta Ophthalmoligica*, vol. 63, pp. 1–8, 1985.

[4] R. S. Worrall, "Iridology: Diagnosis or delusion", *The Skeptical Inquirer*, pp. 23–35, Spring 1983.

[5] R. A. Ramlee and S. Ranjit, "Using Iris Recognition Algorithm, Detecting Cholesterol Presence", *2009 International Conference on Information Management and Engineering.*

[6] C. H. Daouk et al., "Iris Recognition", *Proceedings of the 2nd IEEE. International. Symposium on Signal Processing and Information Technology*, 2002 pp. 558-562.

[7] L. Masek, 2003, *Recognition of Human Iris Patterns for Biometric Identification*, Thesis School of Computer Science and Software Engineering, University of Western Australia.

[8] Q. C. Tian, Q. Pan, Y. M. Cheng, Q. X. Gao, "Fast Algorithm and Application of Hough Transform in Iris Segmentation", *Machine Learning and Cybernetics, 2004. Proceedings of 2004 International Conference on* , 26-29 Aug. 2004.vol.7, no., pp. 3977- 3980.

[9] A. E. Yahya, M. J. Nordin, "A New Technique for Iris Localization", *International Scientific Conference Computer Science'2008, Information Technology Journal,*7(6):924-929, 2008

[10] Y. R. F. Ng, Y. H. Tay, K. M. Mok, "An effective segmentation method for iris recognition system", *Visual Information Engineering, 2008. VIE 2008. 5th International Conference on* , vol., no., pp.548-553, July 29 2008-Aug. 1 2008.

[11] J. Cui, Y. Wang, T. Tan, L. Ma, Z. Sun, "A Fast and Robust Iris Localization Method Based on Texture Segmentation", *Proceedings of the 3rd Iberian conference on Pattern Recognition and Image Analysis*, Part II, Pages 162 - 169.

[12] M. Rizon et al., "Object Detection Using Circular Hough Transform", *American Journal of Applied Sciences* 2(12), pp 1606-1609, 2005.

[13] S. S. Shylalaja et al., "Feed Forward Neural Network Based Eye localizaation and Recognition using Hough Transform", *International Journal of Advanced Computer Science and Applications*, Vol. 2, No.3, March 2011.

[14] S. Marcin and D. Ignacy, "Circular Object Detection Using a Modified Hough Transform", *International Journal of Applied Mathematics and Computer Science*, Vol. 18, No. 1, pp85-91, 2008.

[15] Canny Edge Detection,http://www.cvmt.dk/education/teaching/f09/VGIS8/AIP/canny-09gr820.pdf, retrieved on 26 March 2012.

[16] T. J. Atherton and D.J. Kerbyson, "The Coherent Circle Hough Transform", *Proceedings of the British Machine vision conference, Guildford, UK*, 1993, pp269-278.

[17] Simon J. K. P., "Circular Hough Transform", Aalborg University, Vision, Graphics and Interactive Systems, November 2007.

[18] Unpublished notes, Chapter 3: Color spaces, "http://compression.ru/download/articles/color_space/ch03.pdf".