Sensors & Transducers, Vol. 169, Issue 4, April 2014, pp. 282-287

Sensors & Transducers

http://www.sensorsportal.com

Iris Acquisition Auto-focusing System and Diagnostic Research

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Received: 22 April 2014 /Accepted: 29 April 2014 /Published: 30 April 2014

Abstract: The auto-focusing method is described in this article based on image processing technology, and of an automatic iris image acquisition system is designed by the application of the principles. By using infrared lighting, the camera lens moving is control by computer, and in the human eye images are constantly collected in the process. First, the iris region is positioned in each image, and on the contrast of the area, we determines whether the iris image is a clear. By auto-focus, the captured image is used finally for identifying. Experiments proved that auto-focus is more accurate, iris images are captured with high contrast, and its texture features are rich significantly, and the requirements of subsequent processing and use are meet. Focusing mechanism is relatively simple, easy to implement the control system. It is applied to medical diagnostics to good effect. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Iris acquisition, Auto-focusing, Contrast, Phase method, Iris diagnostic.

1. Introduction

In the photographic camera technology, the focus is key step to ensure that the recorded images of the photosensitive media are made with clear effect. Focusing mechanism is used to adjust the distance between the imaging lens and the photosensitive medium so that the image plane falls on the surface of the photosensitive medium [1, 2]. At present, the auto-focus is used in the common automatic cameras, camcorders and digital cameras, and according to the subject target distance, the lens are directed to the appropriate position by back and forth moving from the IC, so that the subject goal is imaged automatically and clearly. In the late 1970s, auto-focus technology was developed [3, 4], and now it has matured and has achieved wide application, so that automation is more perfect in the cameras, photographic equipment [5, 6].

Iris formation is determined by genetics, and the form, physiology, color and overall appearance of the human iris are determined by the gene expression. Static identification is used currently in close iris recognition devices, and the lens has no auto-focus function in the iris medical equipment, when the human eye is not in the standard sampling distance, the image is not clear, the iris is not recognized in the system.

Iris Diagnostics is proposed by the Ignatz von Peezely [11, 12]. The whole body can be bent into circular, and is projected in the iris. Particularly the head projection is large, the representative district of internal organs are in the close area of the iris central portion. And other representatives of the external skin is surrounding area in the iris, the iris is divided into seven zones from the edge direction of the pupil to ciliary body. A high-definition image is required in iris medical diagnosis. For this reason, an automatic

Article number P_RP_0119

iris image acquisition system is designed. In the system, an average contrast of the iris region is as a criterion of the focusing accuracy, and thus the real-time focus is made by the feedback control actuators.

2. Several Major Auto-focus Mode

According to the basic principles, the auto-focus can be divided into two categories: one is based on the measuring method of the distance between the lens and the subject target, and the other is based on the image clearer focus detection method of the focusing screen [7, 8].

2.1. Ranging Method

There are triangulation method, infrared distance ranging method and ultrasonic one in the main ranging method of automatic focusing.

1) Triangulation. Ranging principle is shown in Fig. 1. The left side mirror Is a partial coated reflector, and light reflected from the right by a small intermediate mirror, the most field of the rest is directly to the front of light transmission, as shown in the lower left corner, the image is focused on a plane. The rotation of the mirror at the right side is controlled by the circuit. There is Optoelectronics detect in the focusing plane. When the two images in transmission and reflection are coincided, there is the following relationship in the distance D between the movable mirror rocking angle α / 2 and the object point A:

$$\alpha = arctg\ (\frac{b}{D})\ , \quad (1)$$

where b is the base line length.

Thus, the distance of the system can be calculated between the subject goals and lens, and the lenses are driven to run the right place and to complete focus.

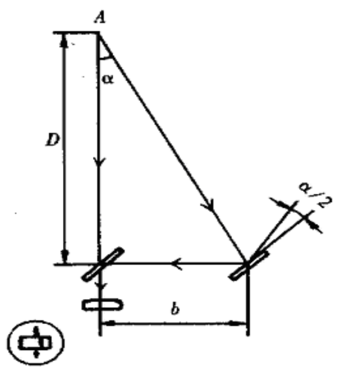


Fig. 1. Triangulation method principle.

2) Infrared measuring distance method. This method is similar to the principle of triangulation, the difference is that the infrared light is initiatively launched by the camera as the measuring distance. And the rotation of the infrared emitting light diode is used instead of the rotation of the movable reflector.

3) Ultrasonic Ranging method. This method is that the ranging is carried out according to the time of ultrasonic transmission between the camera and the subject. Transmitting means and receiving ones are respectively provided with an ultrasonic wave on the camera. When the ultrasonic vibration generator works, there is the ultrasonic wave with a continuous period of about 1/1000 second, covering 10% of the entire screen. After ultrasonic reach the subject, these are returned immediately and perceived by the receiver, and then the focusing distance is determined and calculated by the integrated circuit according to the ultrasonic round trip time.

Infrared and ultrasonic autofocus is the use of active transmit light waves or sound waves for ranging, they are called active autofocus.

2.2. Focus Detection Method

Focus detection methods are mainly the contrast method and the phase method.

1) Contrast method. The method is that the automatic focusing is realized by the detection of the image edge outline. The sharper the image contour edge is, the greater the gradient of its brightness, or the contrast is the greater between the subject and the background of the edge. Conversely, as the defocus images and contours edges are blurred, the brightness gradient and contrast are decreased, and the farther the defocus is, the lower the contrast [9, 10].

By using this principle, the two photodetectors are put in the position with equal distance before and after the film, the photographic object is transmitted through the splitter and into the two detectors, the image contrast is respectively outputted. When the contrast of the two detector output is equal, the focus image plane is described exactly in the middle of the two detectors, i.e., the position is coincided with and the backsheet, so focusing is completed.

2) Phase Method. This method is that the auto-focus is achieved by the image offset detection. In Fig. 2, the grid plate is placed in the position of the photosensitive film, which is consisting of parallel lines, and the lines have the transmittance and no light. The two light components are positioned in the appropriate location which is on the back of the grid board, and they are symmetrically to the optical axis. The network board vibrates reciprocally in the perpendicular direction of the optical axis.

As can be seen from Fig. 2, when the focal plane is coincided with the network board, light transmits through a grid plate, while it reaches two light receiving elements behind. When defocused, light beams can reach the two light receiving elements successively, so that there is a phase difference between the output signals. The phase difference of the two signals is processed by the circuit, and the actuator can be controlled to adjust the position of the objective lens, so that the focal plane is coincided with the plane of the grid plate.

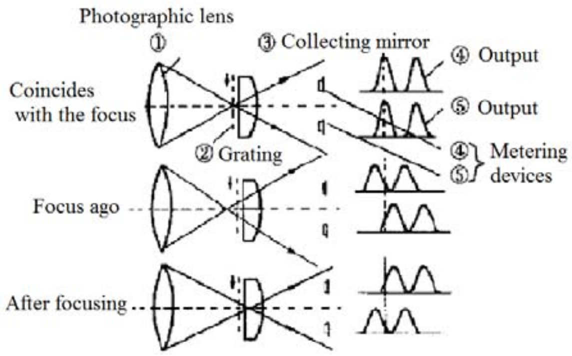


Fig. 2. Phase method autofocus.

Various Automatic Focus (AF) methods have their limitations. Such as focusing distance methods of infrared ranging and ultrasonic ranging, when the measured target has strong absorption to infrared light or ultrasound wave, the ranging system will be failure or focus is inaccurate; rather in contrast method, focus detection is restricted by lighting conditions. When the light is dim or contrast between subject and background is very small, the focus will be difficult or even useless.

3. Automatic Focusing on Image Processing

Automatic focusing method for focus detecting is based on an optical image of analytes. When the computer is used as a digital image acquisition, processing of digital signals can take advantage of the computer's speed and flexibility, auto-focus is made for digital image. With the rapid development of computer hardware and digital image technology, real-time image processing has become possible. A series of digital images are captured by computer through the lens and CCD, and each frame image is processed in real time, we determine whether focusing is accurate, whether image is clear, and give a feedback signal to control the operation of the lens until the image acquisition to meet the requirements, and to complete automatic focusing.

There are the following two advantages according to auto-focus of image processing:

First, the focus is more intelligent, focus criterion is more flexible and diverse. Focus detection method is based on simulated images, using only the contrast (contour edge gradient) between the measured object and the background as a criterion, and to determine whether image is clear. The gradient information can be not only used in digital image processing, and a variety of other useful information can also be extracted in the image, e.g., frequency and phase. For an image with high frequency information, in general, the focusing is more accurate, the higher the frequency of the image signal, the more sharp the edges. If defocused the frequency is reduced, edges is relatively smooth. In addition, because of the flexibility of the computer image processing, the different criterions are chosen to focus for different requirements. For example, sometimes we are concerned only with the target, which it is one part in image, and is not the clarity of the whole image. At this point it should be that the image is processed and the criterion is extracted in this part, and the local contrast (edge gradient) is used as a basis for focusing.

Second, the actuator on the run can easily be controlled by the use of computers, thus the complex focusing circuit and institutions are avoided. Computer interface and bus technology has been very mature, and the control signals are gained by the use of software, the motor running is directly controlled with the objective, it is not only flexibility, the response speed is but also in line with the focus requirements, the circuit and sports organizations are greatly simplified. The disadvantage is that, because the image processing would take a lot of computer resources. In this automatic focusing method, the higher requirements are made for computer hardware. In addition, the contrast is as the previously described method, and there is also the limit of light conditions.

4. Auto Focus Technology in the Iris Image Acquisition

Iris is located between the sclera and the pupil, and it is a ring member surrounding the pupil, with brown or blue. Uneven folds, ridges and retraction are showed in the surface of the iris, its morphology appearance varies, and it does not change with time. These characteristics of the iris are as the basis for medical diagnosis, and therefore iris recognition identification technology is as a branch of biometric recognition technology, it has been the rapid development and application in recent years. Iris texture and morphological changes are observed, and the health of the human body is forecasted, diseases are projected, and rehabilitation process is peeped.

It is the most important issue of iris recognition that the clear, high-quality iris images are captured, but also it is one of the major difficulties which is faced by iris recognition simultaneously. Due to the small range of the iris and the more detail in its feature, in order to obtain high resolution images, a large magnification is required in the optical system, the same time a larger aperture is required to ensure the lighting effect. But generally the larger the aperture, the smaller the depth of field system, which auto focus specification is very precise.

Iris images are captured with a video camera, and they often contain the entire eye contour, and we are interested in only one part of the iris, which automatically corner is only for local iris, focus goal is to get a clear image of the iris section. Based on the above considerations, we have designed an automatic focusing system based on image processing for the iris image acquisition. Considering the visible to irritate the human eye, infrared light is used in the illumination. When the distance is reached within a certain range between the subject target (eye) and the camera lens, the motor-driven camera lens move a small margin, while CCD and image capture card capture images continuously, and image quality evaluation is assessed for a series image which is collected, to determine whether the iris section is a clear image. When the lens is moved to the right position, the iris image is clarity, while the subsequent processing and pattern recognition are in line with the requirements, auto-focusing process is completed, the image will automatically saved in the system.

Iris image is in real time, which includes the entire eye image of the human, the iris the annular region is found for addressing codes, i.e., to define inner and outer boundaries and the center position of the iris. Because there is a circular boundary with rules in the pupil, iris and sclera, the Hough transform is used for image segmentation, respectively, to achieve good results. Hough transform is a method to detect image edge by the use of the global characteristics. Under the conditions of the area shape which is known in advance, the boundary line can be easily obtained by using the Hough transform, and the no continuous edge pixel is connected. For circular boundary of the iris, the Hough transform edge detection operators can be expressed as:

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right|, \qquad (2)$$

In circle parameter space (r, x_0, y_0), and so that the maximum value be found from the said operator, the inner circular boundary and outer one can be found respectively in the iris. Wherein Gσ (r) (G_σ (r) $= \frac{1}{\sqrt{2\pi\sigma}} e^{-(\frac{(r-r_0)^2}{2\sigma^2})}$) is the Gaussian function, (σ factor operator can control the sensitivity of the edge gradient). I (x, y) is the pixel gray values of the coordinates (x, y). First the significant boundary is detected between the pupil and the iris, and the iris center coordinates are found at the same time, then by using the operator, the boundaries between the iris and the sclera are found in a smaller range.

Image quality evaluation is based on the frequency gradient-based information of the local image (iris portion). In the iris area, texture features should be complex in a clear iris, which image contains high-frequency information, while there are differences between the surrounding tissue color and the blood vessels and pigment within the iris stroma, and a larger gray gradient is formed in the image. When there is the maximum gradient of the iris portion, the highest frequency becomes the large gray gradient. When the amplitude frequency of the iris portion is the maximum, and the frequency is the maximum, the focus is the most accurate. In fact, the texture features are distributed throughout the annular region of the iris, so that the average contrast of the area is use as the criterion of a clear image. Contrast ratio is calculated for the vicinity of each pixel, which the operator Δ is as follows:

$$\Delta = |I_{i,j} - I_{i-1,j}| + |I_{i,j} - I_{i+1,j}| + |I_{i,j} - I_{i,j-1}| + |I_{i,j} - I_{i,j+1}|, \qquad (3)$$

where $I_{i,j}$ is the pixel gray value of the coordinate (i, j), $I_{i-1,j}$, $I_{i+1,j}$, $I_{i,j-1}$ and $I_{i,j+1}$ are the adjacent pixel gradation value of the pixel (i, j) (see Fig. 3). Auto Focus program flow is shown in Fig. 4.

	$I_{i,j+1}$	
$I_{i-1,j}$	$I_{i,j}$	$I_{i+1,j}$
	$I_{i,j-1}$	

Fig. 3. Pixel contrast.

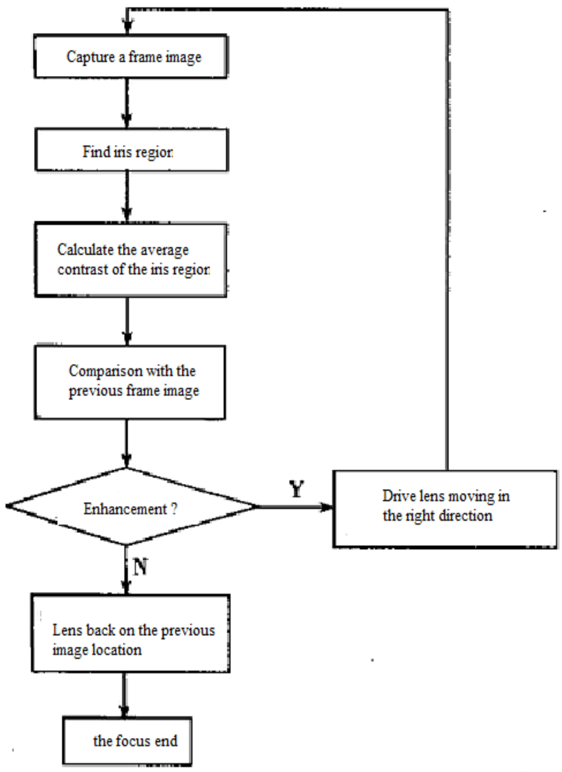
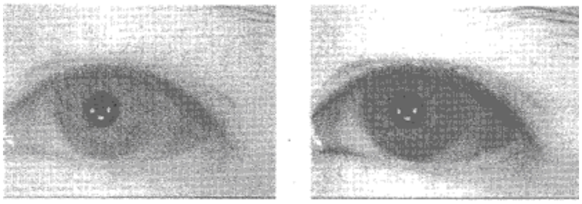


Fig. 4. Auto Focus program flow.

5. Experiment and Conclusion

Mintron 1132C type CCD camera is used as an imaging device, Boser BS602 frame grabber is used for digital image capture, using infrared light emitting diode array, PIII800 computer is used as a system control center. According to the method which is described above for image processing, automatic focus is made, when the iris image is clear, automatic photography is shooted. Experimental captured iris image photos are shown in Fig. 5 (a), the image enhancement is for the Fig. 5 (b).



(a) (b)

Fig. 5. Left is iris image captured, the right is an image enhancement.

From the point of view iris images which are captured in infrared light illumination, the iris portion of the imaging is clarity. Pupil outline is significant, and there is a higher contrast ratio in the iris portion, texture characteristics are significantly rich, these are indicating that auto-focus is more accurate, iris image acquisition can meet the requirements.

A set of colored iris diagnostic images are collected by autofocus in Fig. 6, they is with clear screen, the texture characteristics is highlight [13, 14].

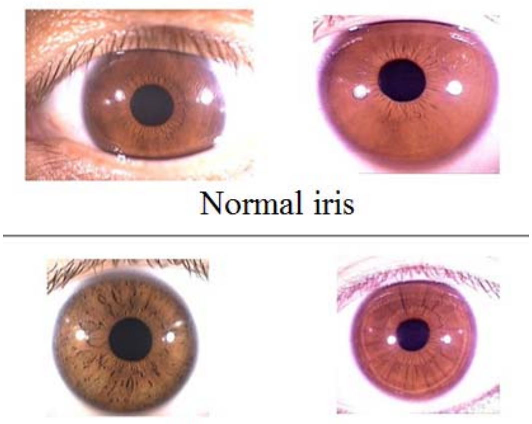


Fig. 6. A set of colored iris diagnostic images are collected by autofocus.

In Fig. 6 the l upper part is a healthy normal iris, ad the lower part is a patient's iris. Medical iris is based on the morphology, morphological changes are observed in the human iris, and by inference and analysis, to predict the health of the human body, the occurrence of the disease and physical rehabilitation [15, 16].

Acknowledgements

The project is funded by the issues NO.09C595 of Hunan Provincial Education Department.

References

[1]. Zhang Yanchao, Sun Qiang, Zhao Jian, Auto-focusing adjustment of multi-spectral imager by differential projection method, *Optics and Precision Engineering,* Vol. 21, Issue 8, 2013, pp. 34-40.

[2]. Shi Hongwei, Shi Yaowu, Yang Shuang, Evaluation and Selection of Estimating Function for Auto-focus System of Optical Microscope, *Journal of Computer-Aided Design & Computer Graphics,* Vol. 25, Issue 2, 2013, pp. 15-19.

[3]. Lu Zhenhua, Guo Yongfei, Li Hongfa, Li Yunfei, Auto-focus using LSF in aerial push-broom remote-sensing camera, *Infrared and Laser Engineering,* Vol. 41, Issue 7, 2012, pp. 51-56.

[4]. Lu Zhenhua, Guo Yongfei, Li Yunfei, Realization of auto-focus on APRC using CCD stitching, *Optics and Precision Engineering,* Vol. 20, Issue 7, 2012, pp. 3-47.

[5]. Fan Fuming, Cheng Lianglun, Xiao Lei, Quanmin Zhu, Establishment and analysis of auto-focus model for laser triangulation method, *Infrared and Laser Engineering,* Vol. 40, Issue 10, 2011, pp. 23-28.

[6]. Taillade F., Hoang N. N., Jumel J., Autofocusing system for a photothermal microscope, *Review of Scientific Instruments,* Vol. 5, Issue 1, 2003, pp. 543-544.

[7]. Liron Y., Patan Y., Zatorsky N. G., Laser autofocusing system for high-resolution cell biological imaging, *Journal of Microscopy (Oxford),* 2006, Part 2, pp. 145-151.

[8]. Obara T., Igarashi Y., Hashimoto K., Fast and adaptive auto-focusing algorithm for microscopic cell observation, *IEEE Computer Society Press,* Los Alamitos. CA, 2011, pp. 7-12.

[9]. Kuo F. C. J., Chiu C. H., Auto-focus control of a CMOS image sensing module, *Journal of Intelligent and Fuzzy Systems,* Vol. 3, Issue 4, 2007, pp. 405-415.

[10]. Lee J. H., Kim K. S., Nam B. D., Implementation of a passive automatic focusing algorithm for digital still camera, *IEEE Transactions on Consumer Electronis,* 1995, 03, pp. 449-454.

[11]. Xin Guodong, Wang Wei, Study on feature extraction in computer-aided iridology, *Computer Engineering and Design,* Vol. 27, Issue 18, 2006, pp. 25-30.

[12]. He Jiafeng, Ye Funian, Ye Miaoyum. A System of Computer-Aided Iridiagnosis, *Chinese Journal of Biomedical Engineering,* Vol. 23, Issue 5, 2004, pp. 8-14.

[13]. He Jiafeng, Ye Funian, Ye Miaoyum, The Automatic Iris Map Overlap Technology in Computer-Aided Iridiagnosis, *Chinese Journal of Medical Instrumentation*, Vol. 26, Issue 6, 2002, pp. 21-15.

[14]. Dong Feixia, Cheng Jinguo, Huang Weixia, On Iris Diagnosis and Chronic Kidney Disease Stage Classification and Syndrome Differentiation, *World Chinese Medicine,* Vol. 6, Issue 6, 2011, pp. 22-26.

[15]. Voicn Li, Myler Hr, Weeks Ar, Practical considerations on color image enhance using homomorphic filtering, *Journal of Electronic Imaging,* Vol. 5, Issue 1, 1997, pp. 108-113.

[16]. Lim Yw, Lee Su, On the color image segmentation algorithm based on the thresholding and fuzzy C-means techniques, *Pattern Recognition,* Vol. 7, Issue 9, 1990, pp. 935-952.