FAST AUTO-FOCUS CONTROL ALGORITHM USING THE VCM HYSTERESIS COMPENSATION IN THE MOBILE PHONE CAMERA

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ABSTRACT

A practical real-time auto-focus algorithm for a digital camera is presented in this paper, and it improves the reliability and speed of the auto-focus process, especially suitable for a 2mega-pixel high definition camera. The proposed algorithm divides auto-focusing process into several modes and finds the focus by the different control current in the each mode. Additionally, an adaptive step size searching and a hysteresis compensation of the voice coil motor increased searching speed. The experimental result shows the proposed algorithm is faster auto-focusing than conventional algorithm in the VCM camera system.

1. INTRODUCTION

The mobile phone makes rapid progress in short period than the some digital appliances by new technology and consumer's purchase. Specially, the camera phone is played the important of multimedia communication. The low cost, high definition and compact digital camera will be interested in camera phone's market. Auto-focus is an essential function in mega-pixel phone camera. There have been researched in auto-focus techniques of phone camera [1]-[3].

The step motor and the voice coil motor (VCM) are employed in control the lens position of the camera phone. The VCM is preferred to the step motor in miniaturization, rectilinear movement, fast response characteristic, and minuteness position control of lens. Therefore, the VCM is used much to control position of focusing lens of camera for the mobile phone.

The fundamentals of auto-focus are introduced in part 2. The proposed algorithm and its experiment results are described in part 3 and part 4.

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2. FOCUS VALUE AND CLIMBING SEARCH ALGORITHM

The auto-focus technique for cameras maximizes the high frequency components of an image by adjusting the focusing lens. In general, focused image have higher frequency components than defocused image. One of measures for finding the best focusing position in the focus range is an accumulated high frequency component of an image. This measure is called the focus value. The best focusing position of the focus lens is obtained at the maximum position of the focus value.

2.1. Focus value

The focus value is a performance parameter to measure the focus degree of an image. The focus value is generally based on edge of an image. It often refers to the sum of the absolute edge of pixels in an image as following

$$FV = \sum_x \sum_y \left| \phi(x, y) \right| \tag{1}$$

where FV is the focus value and $\phi(x, y)$ is the sobel edge at point (x, y).

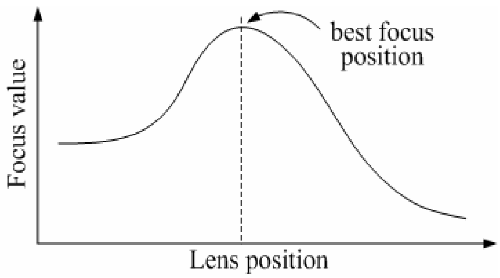

Fig. 1. The focus value versus the lens position.

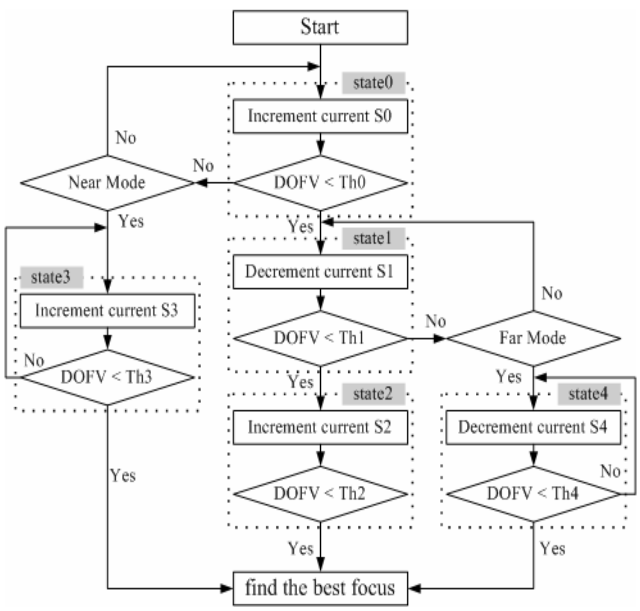

Fig. 2. Fast autofocus algorithm flow chart

2.2. Climbing search algorithm

The climbing search algorithm is split to two different searching stages in order to obtain fast speed. Generally, in the first searching stage, a large step size is used for lens moving. When the mountain peak is found, it enters into the second searching stage, and the smallest step size is used for lens moving toward the best focus position. Fig. 1 is known as focus value curve, which indicates the relationship between the focus value and the lens position. The peak of this curve is referred as the best focused position.

3. PROPOSED FAST AUTO-FOCUS ALGORITHM USING THE VCM HYSTERESIS COMPENSATION

Fig. 2 shows the flow chart that the proposed fast autofocus algorithm. The proposed algorithm extracts sobel edge from CCD image and calculates the focus value by sum of the total edge value. To adjust optimal focus, move focus lens

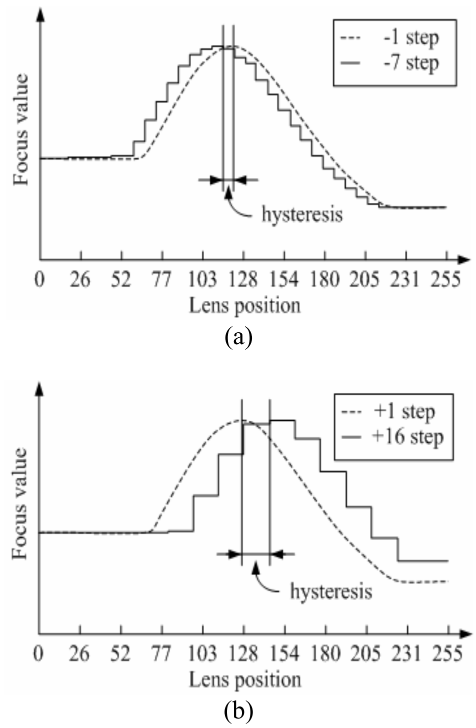

Fig. 3. The focus value curve is extracted from (a) -7 step size and (b) +16 step size.

by the separating mode and state using the focus value (FV) and difference of the focus value (DOFV). Thn is the threshold value which is used to decide changing state. Sn is the current value for moving the focus lens. To move focus lens, control the input current and to remove a redundant search, hysteresis compensation of the VCM. By this way we can get faster auto-focus operation time and more accurate image.

Fig. 3 shows the focus value curve which is extracted from a different step size control in the same image. The mountain peaks vary according to the step size in the lens position, if the focus lens is moved by using the VCM. This problem is the result of hysteresis error of the VCM. Conventional methods in the VCM camera module have redundant searching region about 5~10 frames when step size changes [4]. To improve the demerits, we proposed the algorithm that compensates hysteresis error of the VCM.

The process of our auto-focus algorithm explains as following: In the first searching stage, +16 step size is used for lens moving. If the slope of mountain is changed, it enters into the second searching stage (-7 step size). When the mountain peak is found, it enters into the third searching stage (+1 step size). After third searching stage finished, it find optimal focus. Our auto-focus algorithm improves focusing time for compensating hysteresis of the VCM, when stage changes from first to second or second to third.

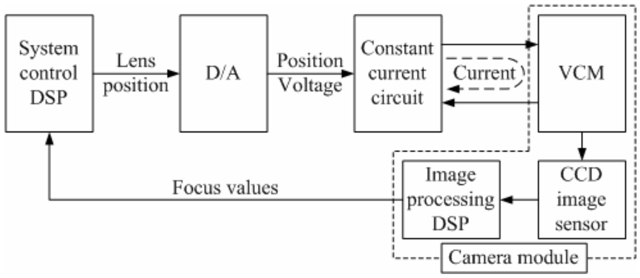

Fig. 4. System construction.

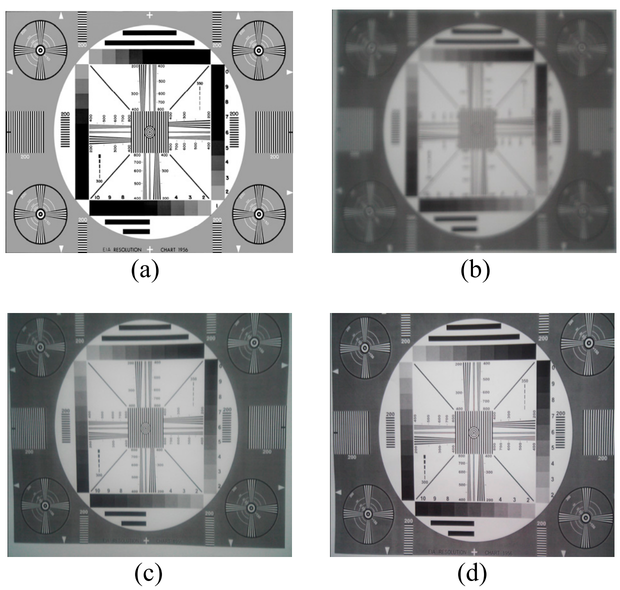

Fig. 5. Result images (a) original image, (b) non-focused image, (c) conventional method, and (d) proposed method.

4. EXPEREMENTAL RESULTS

Fig. 4 shows the system construction, the proposed autofocus algorithm implemented in camera system composed by camera module, image processing DSP, and system control DSP. In order to verify the effectiveness of the presented method, an experiment was performed on taking a photograph of test pattern of EIA RESOLUTION CHART1956, the focus value, the position of focus lens, and operating time for focusing. Fig. 5 shows the result image which the proposed algorithm is more accurate than conventional method. Fig. 6 shows the requirement time which bring the test pattern into focus at different distance. As shown Fig. 6, the proposed algorithm can rapidly adjust the focus than the conventional algorithm. Adaptive step size searching and hysteresis compensation of the VCM increased searching speed and reliability.

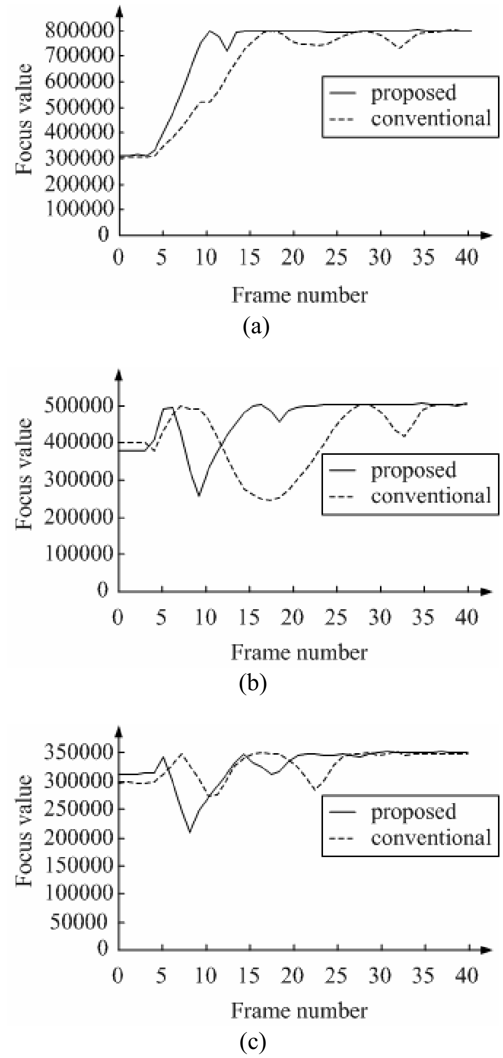

Fig. 6. The experimental result of focusing time according to the distance between camera and test pattern (a) 10cm, (b) 30cm, and (c) 50cm.

A practical real-time auto-focus algorithm for a digital camera is presented in this paper, and it improves the reliability and speed of the auto-focus process, especially suitable for a 2mega-pixel high definition camera.

5. CONCLUSION

The proposed algorithm implemented in camera system composed by LZ0P3731 camera module, LR38660 DSP for image processing and TMS320DM270 DSP for system control. The experimental result shows the proposed algorithm is faster auto-focusing than conventional algorithm in the VCM camera system.

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