Fast Auto-focus Control Algorithm Using the VCM Hysteresis Compensation in the Mobile Phone Camera

Taekyu Kim¹, Heechul Hwang¹, Chanho Han², and Dukgyoo Kim¹
¹ School of Electrical Engineering and Computer Science, Kyungpook National University
1370, Sankyug-Dong, Buk-Gu, Daegu 702-701, Korea
Tel: +82-53-940-8625, Fax: +82-53-950-5505
² Han Innovation Technology Co. Ltd., Inauguration and Incubator Center
1370, Sankyug-Dong, Buk-Gu, Daegu 702-701, Korea
Tel: +82-53-953-4579, Fax: +82-53-953-4579
E-mail: {neoncrom, heeyaa, chhan, dgkim}@ee.knu.ac.kr

Abstract: A practical fast auto-focus algorithm for a digital camera is presented in this paper, and it improves the reliability and the speed of the auto-focusing process. The proposed algorithm divides auto-focusing process into several modes and finds the focus by the different control current in the each mode. Additionally, the adaptive step size searching and the hysteresis compensation of the VCM increase the searching speed and the reliability. The experimental result shows the proposed algorithm is faster auto-focusing than conventional algorithm in the voice coil motor (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. 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. The auto-focus is an essential function of the mega-pixel phone camera. There have been researched in the auto-focus techniques of the phone camera [1]-[3].

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

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

\[ FV = \sum \sum |\phi(x,y)| \] (1)

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

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
The proposed algorithm extracts the sobel edge from CCD image and calculates the focus value by sum of the total edge value. To adjust optimal focus, the proposed algorithm controls the focus lens by separating the mode and the state. To move the focus lens, the input current is controlled. The hysteresis error of the VCM is compensated to remove a redundant search. Due to this way, we can perform rapidly the auto-focus operation time and get the accurate image.

Fig. 2 shows the focus value curve which is extracted from a different step size control in the same image. If the focus lens is moved by using the VCM, the mountain peaks vary according to the step size in the lens position. This problem is caused by the hysteresis error of the VCM. Conventional algorithms in the VCM camera module have the redundant searching region about 5~10 frames when step size changes [4]. To improve the demerits, the algorithm which compensate hysteresis error of the VCM is proposed.