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A Video Camera System with Adaptive Zoom Tracking

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Abstract— **This paper presents an advanced auto focus camera system using the adaptive zoom tracking method. The proposed system can achieve an accurate zoom tracking with significantly reduced system memory.**

I. Introduction

With the popularization of consumer video cameras, the adjustment functions of video cameras such as autofocus (AF), auto exposure (AE), auto white-balance (AWB), and zooming have accomplished high image quality under various shot conditions [1]. The zoom tracking is the continuous adjustment of a camera's focal length to acquire a expanding or contracting image of the object [2]. The zoom tracking technique can be implemented using a simple table look up method [3]. The table look-up method, however, requires a large system memory. Moreover, it is difficult to select a proper curve when the zoom lens moves toward the tele-angle.

In order to solve these problems, we propose a robust AF method using adaptive zoom tracking. The proposed adaptive zoom tracking algorithm uses the curve interpolation method to move the focus lens toward the in-focus position during the zooming operation.

II. Proposed Camera System

A. AF algorithm

If both the camera and the object do not move, the flicker or abrupt changing of the light intensity causes searching the in-focus position although the scene is the in-focus state. This problem can be solved by normalizing the focus value with the exposure value. Fig. 1 shows the relation between focus and exposure values in various situations of in-focus states. Without the scene change, the focus value is proportional to the exposure value. The AF operation is resumed when the focus value is far from the linear approximation of Fig. 1.

B. Zoom tracking algorithm

The proposed zoom tracking algorithm uses the curve interpolation and estimation techniques. The curve interpolation method requires only the upper bound and lower bound curves stored in the system memory. Each curve is divided into the linear and nonlinear regions as shown in Fig. 2. In the linear region, the left and right end points are stored in the memory and the rest focus positions are calculated from the two points using the linear interpolation method. In the nonlinear region, the focus position at each zoom position is obtained from the stored sampled curve data. In Fig. 2, curves between the upper and lower bound curves are estimated as follows:

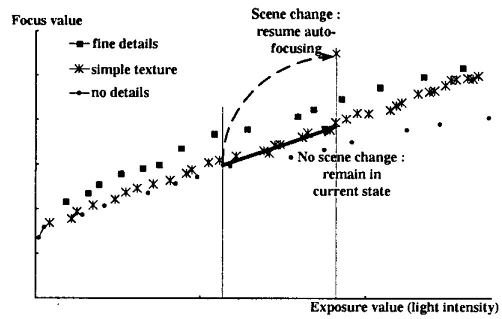

Fig. 1. The relation between focus and exposure values

$$F(k) = F_1(k) - R \times D_f, \quad (1)$$

where $F(k)$ and $F_1(k)$, respectively, are the focus positions of the estimated and upper bound curves at the zoom position k, R is the curve estimation factor of d_f/D_f where D_f is the difference between focus positions of the upper and lower bound curves at the zoom position k, and d_f is the difference of the focus position between the upper bound curve and the estimation curve at the same position.

Fig. 3 shows the procedure of the proposed zoom tracking algorithm. The proposed algorithm initially traces the upper bound curve since the difference between the focus positions of each curve is very small. The adaptive zoom tracking gradually moves the focus lens toward the in-focus position. The curve estimation factor is calculated when the in-focus position is

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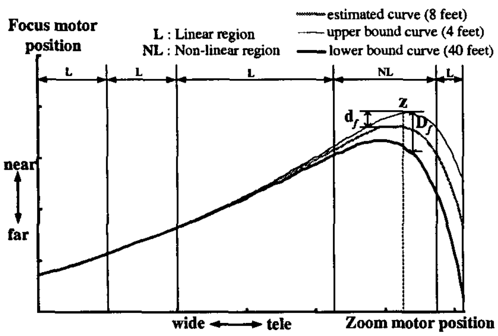


Fig. 2. The division and estimation of the zoom tracking curve

detected, and then the adaptive zoom tracking is finished. Finally, zoom curve interpolation and estimation are performed using the refined curve estimation factor.

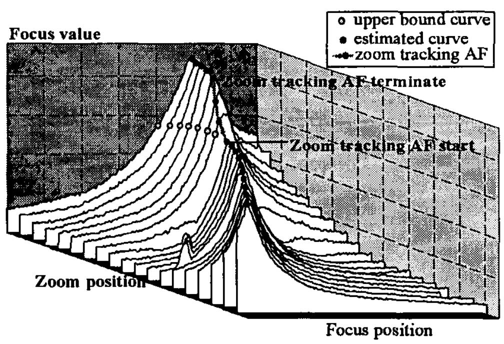
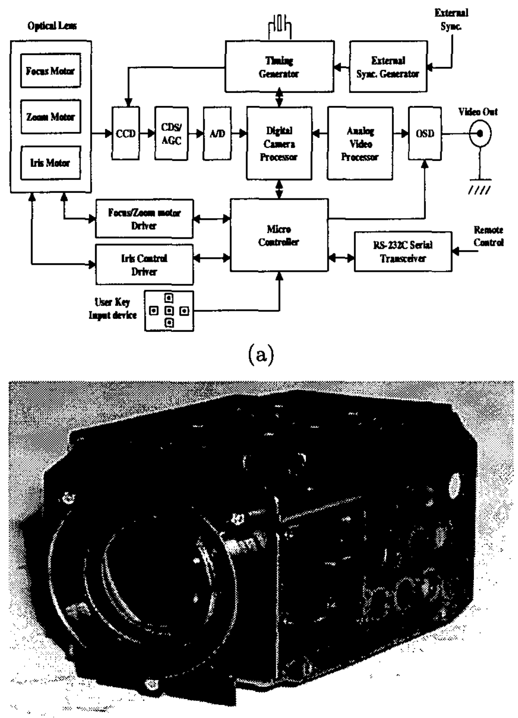


Fig. 3. The proposed zoom tracking procedure.

Fig. 4(a) and (b) show the functional block diagram and prototype of the proposed camera system, respectively. The proposed camera system utilizes a SONY digital signal processor (DSP) to process the digitized image. The DSP produces a focusing signal for AF, integrated luminance signal for AE, integrated RGB data for AWB. The microcontroller transmits a motor control signal to a motor driver so that the zoom tracking is performed.



(a)

(b)

Fig. 4. (a) Functional block diagram , (b) Prototype of the proposed system.

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