Depth Estimation through Combining Chebyshev moments with Bezier-Bernstein polynomial

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Abstract— This paper combined the chebyshev moments and Bezier-Bernstein polynomial of cubic degree to obtain detailed depth estimation. Chebyshev moments are used as an image focus measure operator. It is measured as the ratio of higher spatial component to lower spatial components by using chebyshev order. And Bezier-Bernstein polynomial for interpolation for constructive 3D shape retrieval. It is tested on various image sequences of distinct focus images.

Keywords—focus measure operator, interpolation, depth estimation.

I.INTRODUCTION

Estimating depth is an integral part in computer vision, astronomical imaging, and microscopy [1-4]. In the process of projecting 3D real object in to 2D image one dimension is lost. It is impossible to project light model. Image depth can be estimated by using stereo imaging system or by taking sequence of images with a single camera whose external or internal settings are changed for every fabric [5]. Shape from focus is a passive method by which depth of the object can be recovered; we can estimate 3D shape [6]. Consider object distance *u*, focal distance *f* and image distance *v* the relation between *u*, *v* is 1/u + 1/v = 1/f. the supreme focus will be reach when there is exact correspondence in to the focal plane location v and object distance u. So assessment of focal level is demand in shape from focus.

In this method change the level of focus by varying the camera position and obtain sequence of images of the same object. With these sequences of images we can able to calculate the high frequency image details, by calculating the better focused images from the image sequence taken at distinct focus [7]. Shape from focus is mainly used in many applications like robot control, colonoscopy. The first stage in shape from focus is to calculate the keenness quality for each pixel in the image sequence. The best focus points are calculated using focus measure to estimate the depth map. Number of focus measures is recommending in the previous counting [8]. The wide spread gray level variance, modified laplacian and tenenbaum-gradient etc.

Shape from focus methods use isolated focus measure. Numerous elements, including window size, illumination, and noise level infect the rendering of focus. Focus measure is an amount which calculates quality of an image. When the image is best focused then the focus measure is high, and it decreases as the blurring increases. In this method the important interpretative properties of an image can be captured by using chebyshev moments. The image data stored in each moment is independent and the data redundancy between the moments is minimal. In the proposed method the depth map is calculated through Bezier-Bernstein polynomial [9] as an interpolation process applied on the chebyshev moment focus measure. The results are demonstrated

II. METHOD

First the chebyshev moment applied as focus measure operator in sequence of synthetic images to obtain the depth maps of different scenes. To get best focus levels of image. Secondly apply the interpolation polynomial for the reconstruction of depth map. In this method Interpolation is performed by cubic Bezier-Bernstein polynomial.



1) CHEBYSHEV MOMENTS (FOCUS MEASURE OPERATOR)

The chebyshev moment of order (m+n) for an image with intensity function $f(x,y),x \in \{0,1,...,N-1\}$ is defined as[10]

$$T_{mn} = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} t_m(x;M) t_n(y;n) f(x,y) \dots (1)$$

Where $t_n(x;N)$ and $t_n(y;N)$ are the normalized chebyshev polynomials defined by

$$t_m(x;M) = \frac{t_m(x;M)}{\sqrt{\rho(m;M)}}, \ t_n(x;N) = \frac{t_m(y;N)}{\sqrt{\rho(n;N)}}, \ \dots \ (2)$$

The new focus measure is based on the chebyshev moments. Given an *MXN* image f(x, y), we normalize it by defining

$$f(x, y) = \frac{f(x, y)}{\sqrt{\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f(x, y)]^2}} \qquad \dots \dots (3)$$

So that
$$\sum_{x=0}^{M-1} \sum_{y=0}^{N-1} [f(x, y)]^2 = 1$$

Note that this does not affect the spatial frequency contents of the image. Based on f(x, y) we have the corresponding set of chebyshev moments, $T(f; M, N) = \{T_{mn}^f\}$ where m=0, 1...M-1, n=0, 1...N-1. We take the lower-order moments to be moments of order less than $p(\leq M + N - 2)$. Hence, if we denote the set of low and high-order chebyshev moments with L(f:P) and H(f;P), respectively, we have

$$L(f;P) = \{T_{kl} | k+l \le P\};$$

$$H(f;P) = \{T(f) | L(f;P)$$

Now we propose a chebyshev moments-based focus measure:

$$M_T = \frac{\left\| \mathbf{H}(f; P) \right\|}{\left\| L(f; P) \right\|} \dots \dots (4)$$

The focus measure is the ratio of the energies in the highpass band to the low pass band. For practical implementation we can write

$$M_{T} = \frac{\|f\| - \|L(f;P)\|}{\|L(f;P)\|} \dots (5)$$
$$= \frac{1 - \|L(f;P)\|}{\|L(f;P)\|}$$

We know that ||f|| = ||L(f;P)|| + ||H(F;P)||(6)

The focus measure becomes more sensitive to the high frequency components of the image .if the parameter P is increased.

2) BEZIER-ERNSTEINPOLYNOMIAL (INTERPOLATION)

The beginning depth can be comfortably calculated by increasing sharpness of the focus curve $P_z(i, j)$.We implement cubic Bezier polynomial to evaluate perfect depth by interpolating neighboring frames of the beginning depth. In Bezier curve we need to concentrate more about the selection of proper controlling points, range vector (parameter for the polynomial curve), and input curve and input curve. In our paper we select four control points $(bb_{k-a}bb_kbb_{k+a}bb_{k+2a})$. From these four control points we select bb_k is the maximum sharpness value from the focus curve $P_z(i, j)$ at location k and parameter 'a' defines the length of the input curve. The Bezier curve B (t) then in matrix form will be as [9]

$$\boldsymbol{B}(t) = (t^{3}t^{2}t\mathbf{1}) \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} bb_{k-a} \\ bb_{k} \\ bb_{k+a} \\ bb_{k+2a} \end{bmatrix} \dots \dots \dots (7)$$

Where $0 \ t \ 1$ is the polynomial parameter. By using the Bezier curve we can calculate the position of the

maximum value. Then obtain the clear depth by adjusting the difference with respect to k^{th} position

III RESULT

The proposed method is also tested with synthetic images of different focus levels. We perceive that the proposed method can able to recover the depth maps are smother and finer than the previous methods. By using two statistical parameters root mean square error (RMSE) and correlation to assess the performance of the proposed method



Figure 2 sequence of images



Figure 3 sequence of images



Depth map of figure 2

Depth map of figure 3

Table 1. Performance evaluation through statisticalparameters

S.no	Parameter	Figure 1	Figure 2
1.	RMSE	0.1957	0.1296
2.	MSE	0.0383	0.0168
3.	PSNR	62.2983	65.8806
4.	Normalized Cross correlation	0.3965	0.5513
5.	Average difference	0.0798	0.1052

IV CONCLUSION

In this paper a new depth evaluation technique developed by hybridizing the chebyshev moments with Biezier-Bernstine polynomial. In traditional methods use local summation of focus values because of this it will get disfigure effect this can be avoided by using this method. The results show that the lucidity and productiveness of the proposed depth evaluation method is more useful in 3D world.

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