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Improved Depth Approximation through B-Spline Polynomial

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Abstract

Three-dimensional (3D) shape reproductions are a basic issue in robotic vision application. Shape from focus is one of the passive strategies for 3D shape recuperation that uses level of focus as a signal to appraise 3D shape. In this approach we present correct depth estimation from image focus by utilizing cubic degree B-spline polynomial. Exploratory outcomes exhibit its exactness and viability for 3D shape recuperation.

INTRODUCTION

3D cameras with depth detecting abilities are presently generally utilized as a part of numerous regions, for example, human movement estimation, web conferencing, computer games, surveillance and security systems, mobile and robotic technology gadgets and computer helped restorative systems. Mostly these cameras utilize dynamic depth estimation strategies like stereo or triangulation techniques utilizing laser scanner, 3D CMOS imaging sensor that is equipped for figuring depth through infrared light, and monocular scanner less procedures based on time of flight, image intensifier, and electro-optical crystal.[1] In any case, these strategies are costly. The cost can be decreased by applying optical passive techniques as they are reasonable and productive yet the precision of such passive strategies in processing depth maps still should be made strides.[2]

Shape from focus methods recover the spatial data from numerous images of a similar scene taken at various concentration levels.[3] In Shape from focus the goal is to discover the depth by measuring the separation of very much focused position of each object from the camera focal point.

When separations for all points of the objects are known, the 3D shape can be recouped. Fig. 1 appears the essential geometry of image arrangement of focused and de-focused objects through the convex lens. Assume the focal point is stationary what more is; the images are gotten on image plane by interpreting object along the optical axis. All light rays, which are emanated from the object, are blocked by the lens and converged at the image plane. A point P on the object is very much focused and its image is gotten at point P', in the Image detector. An all around focused point p fulfills the lens law:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{..............(1)}$$

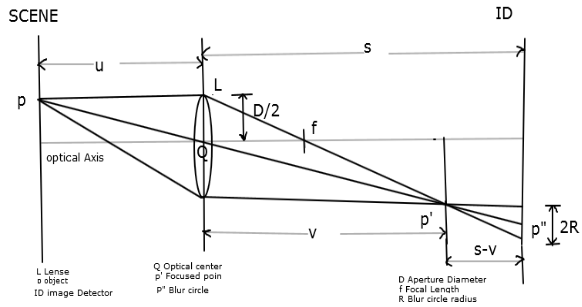

Figure 1: image generation in a convex lens

Where f is the focal length of the lens, u is the separation of the object point from the lens, and v is the separation between focal point and, image plane. At some other separation u'(u ≠ u') of the object point from the lens point won't be all around focused on image plane and, an obscure circle of span R is created [11].

The fundamental issue in Shape from focus conspire is to decide the specific separations of all object points from the camera for which they are very much focused at the image plane. The focus measure increments with the expansion of focus quality and it accomplishes the most extreme esteem at very much focused frame number. Along these lines, a very much focused image will have bigger measure of high frequency substance when contrasted with de-focused image of a similar scene. The fundamental issue in the development of exact depth map is to find the best-focused pixel utilizing the acquired image frames for each object point.

Many focus measures proposed in spatial and in addition in frequency domain have been accounted for in [5] the most well-known are sum modified laplacian (SML), Tenengrad focus measure(TEN), and gray level variance(GLV). From the acquired image frames at each object point, from the depth map, camera parameter esteems for this focus image frame are utilized to figure the separation of the related object point.

Prior, Malik and choi[2] examined different estimate techniques in view of Gaussian interpolation, neural network, piecewise curved surface guess and dynamic programming(DP),M.T. Mahmood and seong-o shim talked about precise estimate technique in view of Bezier-Bernstein polynomial to refine the outcomes acquired by a focus measure. In current work we apply B-spline polynomial on GLV focus measure to get high precise depth estimation.

GRAY LEVEL VARIANCE WITH BEZIER-BERNSTIN POLYNOMIAL

Gray Level Variance focus measure registers the focus esteem by taking the variance of gray level esteems with in a little window. The distinction of each gray level from the mean μ is increased by the power function. This is connected on succession of pictures to evaluate best focused image. (6)

$$F_{VAR} = \frac{1}{N^2}\sum_{N}\sum_{N}(g(x,y)-\mu^2) \; \ldots\ldots \quad \ldots\ldots. (2)$$

To evaluate the depth map of an image we need to capture numerous sequence of image of the same scene, then applying the GLV focus measure operator on the sequence of images. From this focus measure operator, we can obtain best focused image frame to refine the results we can apply interpolation polynomials by using Bezier-Bernstein polynomial

The starting depth can be ascertained by expanding sharpness of the focus curve $R_Z(i,j)$. We utilize cubic Bezier polynomial to assess idealize depth by introducing neighboring frames of the starting depth. In Bezier curve we have to think more about the choice of legitimate controlling points, range vector (parameter for polynomial curve), and input curve. Select four control focuses. From these four control points we select one of the control point is the most extreme sharpness esteem from the focus curve $R_Z(i,j)$ at area 'k' and parameter 'a' characterizes the length of the info curve. The bezier curve B(t) at that point in framework shape will be as [7]

$$B(t) = (t^3 t^2 t 1)\begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} b_{k-a} \\ b_k \\ b_{k+a} \\ b_{k+2a} \end{bmatrix} \ldots\ldots\ldots (3)$$

GRAY LEVEL VARIANCE WITH B-SPLINE POLYNIMIAL

B-Spline curves are considered as a speculation of Bezier curves and all things considered offer numerous likenesses with it. Be that as it may, they have more wanted properties than Bezier curves. B-Spline curves require more data, for example, level of the curve and a knot vector, and in widespread contain include a more mind-boggling hypothesis than Bezier curves. They however have many preferences that offset this deficiency. Firstly, a B-Spline curve can be a Bezier curve at whatever point the programmer so wants. Promote B-Spline curve offers more control and adaptability than Bezier curve. It is conceivable to utilize bring down degree curves and still keep up an expansive number of control points.

In any case, one of points of interest in utilizing B-splines is that they do give relative invariance. This implies the organize framework it is spoken to in can change without influencing the relative geometry of the curve; this is seen when the geometry of curve stays reliable when it is turned, scaled, or translated.

B-spline curves additionally address the issue of neighborhood control. This implies changing one control point just influences the piece of the curve close to that control point, which is truly helpful when outlining shapes. It was said that the B-Spline curve is alleged after the customary spline utilized by sketchers to physically draw curves. These splines were basically long strips held around lead weights, which permit the sketchers to impact the state of the curve. In B-spline functions each control point is a lead weight that adjusts one bit of the general curve. The cubic B-Spline can be defined as (28)

$$B_{0,4}(t) = \begin{cases} \frac{t^2}{6} \; 0 \le t < 1 \\ \frac{-3t^2+12t^2-12t+4}{6} \; 1 \le t < 2 \\ \frac{4-t^2}{6} \; 3 \le t < 0 \\ 0 \; otherwise \end{cases} \quad \ldots \quad \ldots(4)$$

The positivity of the kernel is alluring for depth approximation. When utilizing part with negative lobes, it is conceivable to produce negative qualities while inserting positive information. Since negative intensity qualities are good to no end for demonstration, it is alluring to utilize entirely positive interpolation kernel to ensure the energy of the introduced image.

RESULTS AND DISCUSSION

To check exactness and adequacy of our proposed strategy, we performed experiments on database and real-time image sequences. A sequence of 30 images with 256 x 256 sizes is captured at different focus values. To get these real-time image sequences we utilized Logitech C920 web camera. The performance is evaluated by using eight statistical parameters, Root mean square error(RMSE), Mean square error (MSE), peak signal to noise ratio (PSNR), normalized cross correlation(NK), Average difference(AD), Structural content(SC), Maximum difference(MD), Absolute error(AE).

From table 1 and table 2 we can observe the statistical performance of both GLV beizer Bernstein and B-spline techniques on real time images captured by Logitech C920 web camera. From these tables we can conclude that on average GLV with B-spline polynomial depth estimation will gives lower the RMSE, higher the correlation, higher PSNR, lower Maximum difference, lower structural content, lower error values compared to GLV Bezier-Bernstein polynomial technique.

Real time image sequence captured by Logitech C920	Depth map Output by using GLV with Bezier Bernstein polynomial	Depth map output by using GLV with B-Spline

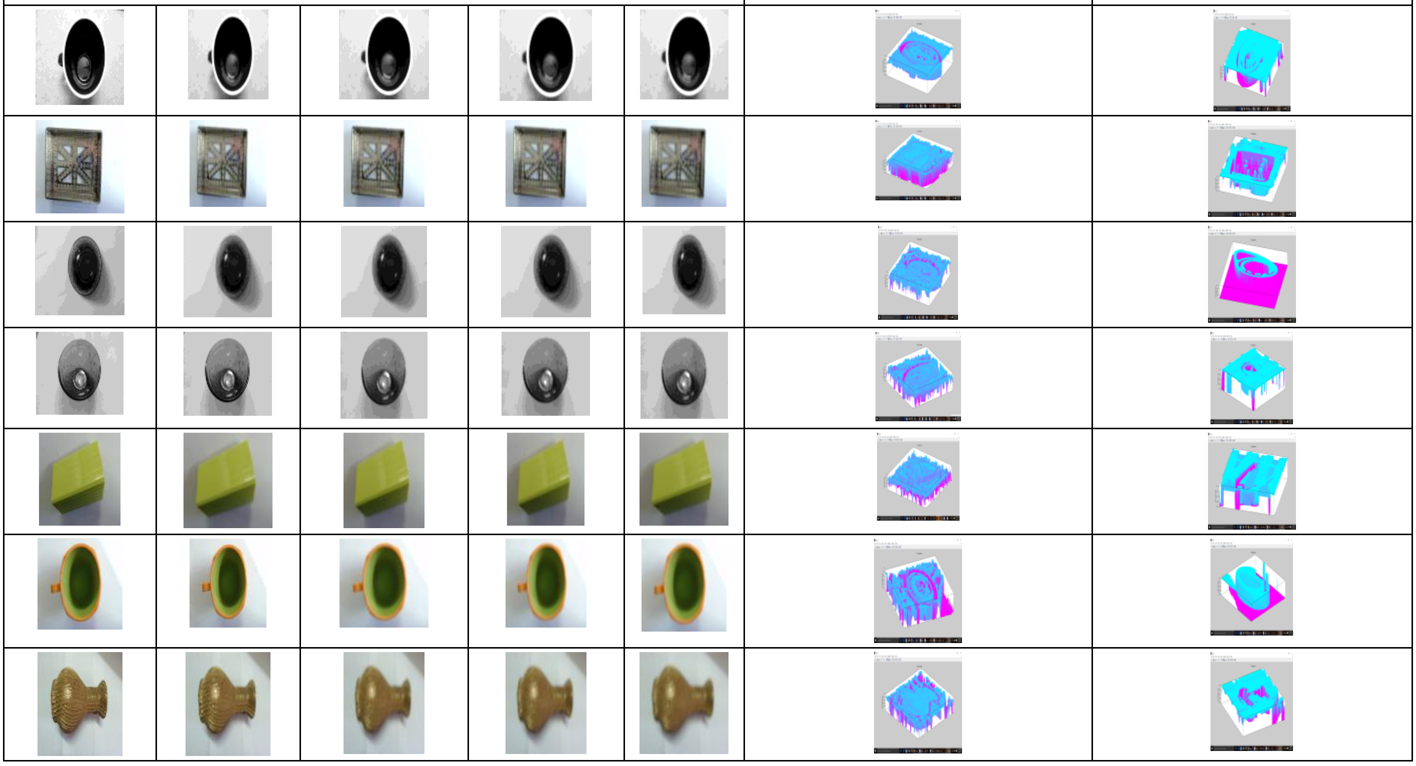

Table 1: Statistical performance evaluation of real time images using GLV with Bezier Bernstein polynomial

S.NO.	RMSE	MSE	PSNR	NK	AD	SC	MD	AE
Image 1	0.1591	0.0253	64.0994	0.4794	0.0106	1.8078	0.4500	0.6935
Image2	0.2388	0.0570	60.5689	0.3097	0.1005	3.7362	0.4510	0.7730
Image3	0.3305	0.1092	57.7483	0.2983	0.2976	1.9978	0.4400	0.6914
Image4	0.1387	0.0192	65.2872	0.5746	0.0106	1.2249	0.4410	0.6674
Image5	0.1287	0.0166	65.9405	0.6122	0.0029	1.3224	0.4455	0.5814
Image6	0.3220	0.1037	57.9740	0.2937	0.0267	2.2461	0.4500	0.7096
Image7	0.1689	0.0285	63.5762	0.4467	0.0255	1.9862	0.4432	0.6894

Table 2: Statistical performance evaluation of real time images using GLV with B-Spline polynomial

S.NO.	RMSE	MSE	PSNR	NK	AD	SC	MD	AE
Image 1	0.1467	0.0215	65.80	0.5233	0.358	1.8521	0.4492	0.5612
Image2	0.1543	0.0238	64.3614	0.4978	0.0653	2.6515	0.4152	0.5190
Image3	0.1328	0.176	65.6671	0.5678	0.0414	1.8521	0.4427	0.5054
Image4	0.1420	0.0202	65.0870	0.5313	0.0646	2.3027	0.4498	0.4902
Image5	0.1208	0.0192	63.4815	0.4633	0.1152	3.2511	0.4487	0.5299
Image6	0.2154	0.0464	61.4665	0.3863	0.1324	4.2653	0.4499	0.6107
Image7	0.1494	0.0223	64.6410	0.5107	0.0518	2.4124	0.4403	0.5198

CONCLUSION

In this paper a new depth approximation is developed by using B-Spline polynomial on GLV focus measure operator. In GLV with Bezier-Bernstein polynomial methods the curves are global because of this by changing a simple control point it will have the influence on total shape of the curve. This can be avoided by B-Spline polynomial and we can obtain smooth depth map outputs. Experimental results show that the perspicuity and productiveness of the proposed depth evaluation method is more useful in 3D world.

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