IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 8, Issue 6 (Jan. - Feb. 2013), PP 89-92
www.iosrjournals.org

Development of a Cost Effective 3d Window for Stereoscopic 3d Visualization Using Distorted Stereo Pairs

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Abstract: *3D technology is broadly divided in to reconstructing 3D images (3DI) from given 2D images (2DI) and 3D visualization (3DV) using stereo pairs (SP). Literature Review revealed that many satisfactory techniques were developed for reconstructing 3DI from given 2DI and a reasonably good 3D reconstruction is possible. When a stereopair is viewed through a slot no attachments are needed as the basic law of stereoscopy is fulfilled, but focusing strains the eyes. The present work alienates the strain by positioning the stereopairs at an angle parallel to the plane of the stereopair. Different geometric parameters namely the distance between the plane of the eyes and the plane of stereo pair (L), distance between the stereopairs (s), width of the stereopairs (b), the inclination of the stereopairs with the plane of the stereopair (theta) were tried and for each trial the distance between the plane of stereo pair and the plane of 3DV window (L1) and the width of the window (d) are measured / computed. The ratio L1/L = R is also computed. The optimum values of the parameters L,s,b, theta resulting a minimum value of R are arrived at. 3DV using the above geometric parameters with and without tilting of stereo pairs revealed that the 3DV with tilting offered a considerable reduction in straining the eyes. Various results obtained through the experimental work are presented and discussed. The present work reveals that 3DV using distorted Stereopairs offers less strain to the eyes compared to undistorted stereopairs, enhancing the ease of 3DV.*
Keywords: *3D Visualization, Stereoscopy, Stereopairs*

I. Introduction

Reconstructing 3D images from given 2D images and 3D Visualization find extensive application in medicine, shop floor production, geographical analysis, satellite communication etc [1]. The 3D reconstructed images are 2D images shown pictorially. 3DV involves the third dimension (depth) which cannot be shown on a 2D image. Hence any 3DV is only a perception and not a 2D photography [2]. 3D image reconstruction involves using many algorithms and packages [3]. 3DV normally uses stereopairs which are viewed by wearing attachments to the eyes satisfying the law of stereoscopic 3DV [2]. Both cross eye and parallel eye 3DV are commonly used [4]. 3DV/3D reconstruction offers significant data about the objects and their properties. Hence the 3DV offers a new area of research providing techniques and tools for study of objects in space. The basic issue involves in 3DV is application of attachments to the eyes. Any research that leads to the elimination of attachments will go a long way in improving the 3DV technology [4].

II. Literature Review

Literature Review on 3D reconstruction revealed that image processing is an important aspect of 3D image reconstruction [1]. Algorithms and packages used for reconstruction are reviewed [3]. Image data management techniques for structural analysis for objects are reviewed [5]. Considerable work was carried out on depth computations using color queuing theory and non linear projection methods [6],[7],[8],[9]. The application of 3DV in robo operations revealed that there is a potential scope for using 3DV techniques in the kinematic design of Robos [10]. Techniques such as computer tomography, magnetic resonance, imaging for 3D reconstruction are reviewed in detail [11].

III. Methodology Of Present Work

The application of a 3DV window has resulted in the elimination of attachments to the eyes [4]. However, focusing the stereopairs on to the plane of the window resulted in straining the eyes. The methodology used in the present work consists of fixing the stereopair at an angle to the plane of the pairs, thereby reducing the distance between the planes of stereopairs and window. Figures 1 and 2 clearly illustrate, the basic principle of window operations satisfying the law of stereoscopic 3DV. Further, they show how the distance between the planes of stereopairs and window is reduced when the stereopairs are titled at an angle to the plane of the stereopairs.

Referring to Figures 1 and 2, let

e = distance between the two eyes of a normal human being
theta = angle by which the stereopair is tilted from the plane of the stereopair
s = distance between the stereopair
b = width of the stereopair
d = width of the window
L = distance between the planes of the eyes and the plane of the stereopair
L1 = distance between the planes of the window and stereopair
Let (x1, y1), (x4, y4) be the coordinates of left and right eyes;(x2,y2) and (x3,y3) be the coordinates of the starting and ending of the right eye image. Similarly let(x5, y5) (x6, y6) be the coordinates of the starting and ending of the left eye image. Let (x7, y7) be the coordinates of the start of the left side of the window and (x8, y8) be the coordinates of the end of the right side of the window.
From figures 1 and 2 we have
L = y4 – y5;
L1 = y7 – y2 = y8 – y5;
d = x8 – x7;
s = x5 – x2;
Let m1,m2 ,m3,and m4 be the slopes of lines joining (x1y1), (x2,y2); (x4y4), (x3y3); (x4,y4), (x5,y5) and (x1,y1), (x6,y6).
x7 = (y3 – y2 + m1 * x2 – m2 * x3) / (m1 – m2)
y7 = y2 + m1 * (x7 – x2)
x8 = (y6 – y5 + m4 * x6 – m3 * x5) / (m4 – m3)
y8 = y5 + m3 * (x5 – x8)

IV. Experimental Work

The tilting of the stereopairs, the planes of the stereopairs, window and eyes along with the geometric parameters theta, L, s, b and e are shown in Figure 2. Different combinations of values for L,s and b are tried out and in each trail the values of L1, ratio R=L1/L and d are computed. The parameters offering the least value for R are chosen as optimum values. For each trail the strain experienced is qualitatively noted down. The values are tabulated in Table-1.

V. Results And Discussions

Figure 1 illustrates the schematic arrangement of the components involved in 3DV with the application of 3DV window along with parameters L,s,b,e without tilting of stereopairs. Figure 2 illustrates the tilting of the stereopairs at an angle theta.
Table 1 reveals that, for given values of theta, e, s and b: L1 increases considerably as L is increased, resulting in increase in the strain on the eyes.
Table 1 also reveals that, for given values of e, theta, L1 and b there is a slight decrease in the value of L1 as s is increased, resulting in a slight decrease in the strain on the eyes.
Table 1 further reveals that, for given values of e, theta, L and s there is a considerable increase in the value of L1 as the value of b is increased, resulting in considerable increase in the strain on the eyes.
In all combinations the ratio L1/L is maximum when theta = 0.
The R value for the combination e=60mm, theta=45°,L = 240 mm, s=100 mm, b=80 mm offered the least value for R namely R=0.35 (sl. no 4 in Table 1) and offered a qualitative minimum strain on the eyes. These values are chosen as the optimum values of the parameters for the experimental set up.
By further increasing theta, the value of R can further be reduced rendering still lesser strain on the eyes. However, it has been observed during the experimentation that as theta is increased beyond 45 degrees the clarity of the 3DV is reduced. Hence, the limiting value of theta is chosen as 45 degrees. The above 3DV is based on cross eye 3DV. The equations are derived based on trigonometry.

VI. Conclusion

Visualization through stereopairs offers 3DV in its real terms and 3D images reconstructed from 2D images is again a 3D representation on a 2D plane and hence is not 3DV par se.
As such, a 3DV using distorted stereo pairs (as a result of tilting the pairs), has been shown to be offering lesser strain to eyes, compared with 3DV using undistorted stereopairs.

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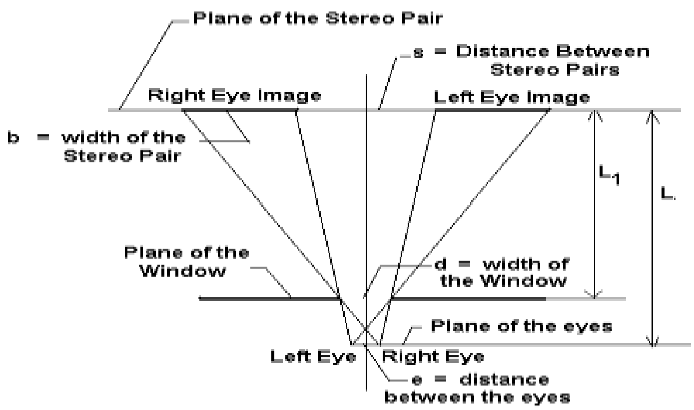

Figure 1: Schematic Representation of 3DV using a 3D window with undistorted Stereopair (theta = 0) using cross eye 3DV

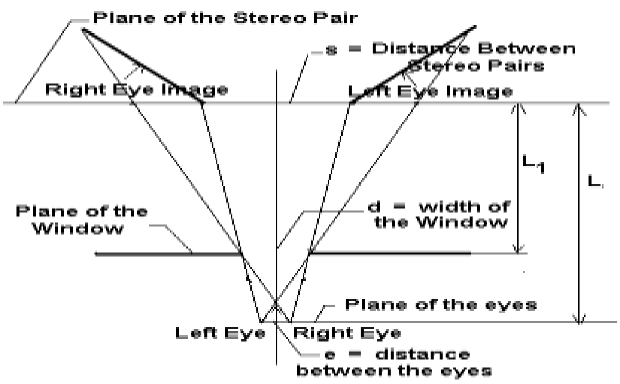

Figure 2: Schematic Representation of 3DV using a 3D window with distorted Stereopair (theta > 0) using cross eye 3DV

Sl.No	**e (mm)**	**theta (deg)**	**L (mm)**	**s (mm)**	**b (mm)**	**d (mm) computed**	**L1 (mm) computed**	**R=L1/L**
1	60	0	240	100	80	80	144	0.6
2	60	15	240	100	80	84	128	0.53
3	60	30	240	100	80	88	116	0.48
4	60	45	240	100	80	92	84	0.35
5	60	45	360	100	80	88	148	0.41
6	60	45	480	100	80	84	220	0.46
7	60	45	600	100	80	80	284	0.47
8	60	45	600	160	80	120	280	0.46
9	60	45	600	220	80	144	276	0.46
10	60	45	600	280	80	184	272	0.45
11	60	45	600	280	120	160	320	0.53
12	60	45	600	280	160	152	352	0.58
13	60	45	600	280	200	140	358	0.59

Table 1