Visualization of Depth in 2D Images of 2D and 3D objects (A Perspective Geometrical Model Approach)

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***Abstract** - While **3D visualization** technology is still in its infancy, hardware capabilities have progressed to the point where useful, practical work can be done. However, there exists significant barriers to using 3D visualization, primarily in usability and interfaces. 3D visualization is closely linked with the realization of depth or the distance between the objects along the 3 mutually perpendicular axes. Our position is that, to break through these barriers, research is needed on the following enabling technologies:*
a. User interfaces for 3D visualization / Depth
b. 3D / Depth visualization tools for engineers
c. Data navigation, data mining, and visualization of multidimensional databases, including visualization methods for categorical data.
d. Computer-Conferencing using 3-D / Depth Visualization. This proposal brings together researchers with a variety of backgrounds to focus on these problems, with our various interests integrated by the 3D CAVE environment that we propose to create. The CAVE is a 3D / Depth visual computing environment that recreates space and allows the researcher to interact and visualize complex shapes in an interactive 3D environment.

The aim of the present paper, is to investigate the various techniques available to convert a 2D image into a reasonably realistic 3D image showing the depth effect with the special reference to Perspective mathematical modeling approach. Over the past, many have developed techniques for 3D Depth visualization of 2D images. The above works were reviewed in detail.(1,6)

The commonly used methods, viz Stereoscopic visualization and cross eye visualization were briefly discussed(5). The perspective modeling method which provides the image of the object on the screen as it appears to the eye is developed. For convenience the images chosen are computer-generated images generated through suitable algorithms. Algorithms were also developed to give a color shading. Step by step procedure for visualizing the depth effect is illustrated through figures. Finally, various conclusions are drawn based on the present work.

Keywords: Visualization, Cross-Eye Vision, 3D vision, Perspective Modelling.

1 Introduction

1.1 Literature Review

A review of **many research papers (Specimen papers 1 to 6)** was done on the research findings of the above topic. Till date, the research has successfully simulated the animation on the monitor of the system to give a simulated 3D appearance of the graphics. (6) A lot more remains to be done for giving a **depth effect** for the graphics, in order that a real feel of the object/graphics is obtained. Numerous 3D rendering softwares (5) are now available to easily identify 3D pictures on the monitor. It helps better visualization of the images. Still not much work is done to realize the depth effect. Though, the monitor image, to some extent gives an idea about the object, still a realistic view can be obtained only by using some means to convert the images to have 3D / Depth effect. (4) Each time, when, one needs to VIEW something unreachable with a camera, or whether it is because it does not exist or is out of scale for human eyes, one can use a computer. However, how realistic can these images be, anyone looking at the computer screen knows that he is looking at an image, not directly at a real scene, or model. To start with a brief overview of Stereoscopic and Cross eye visualization is discussed below.

1.2 Stereoscopic Visualization

In this method, a stereo image is created by means of creating two images on a flat screen. One image corresponds to a photograph simulated to viewing with the left eye, the other one viewing with the right eye. This is easy to achieve by keeping the observer in the left eye position and applying an horizontal offset to the observer position and then render the right eye image. The offset is called the BASE in the stereoscopy vocabulary and is assumed to be the same as the interocular distance (About 6.5 cm). After obtaining the two images, a few colors of the pixels are drawn from the left image and superimposed on the right image to have an overlapping effect of the image in a particular manner. This superimposed image conveys absolutely no meaning when looked at. However by suitably filtering the colors, with an animation of left eye and right eye alternately opening and closing, we will obtain a wonderful 3D image on the computer monitor.

1.3 Cross – Eye Visualization

This method involves orienting our eyes so that they are looking at a nearby object while focusing further away. One can practice by holding up a finger between his eyes and the screen, and focus on the finger while paying attention to the stereo images. By moving one’s finger closer or further from the eyes while focusing on it, the images will converge or diverge. During this process three images are (obtained) felt as if they are on the screen. The middle one will be the stereo image. With a little practice, one should be able to cross the eyes and get the stereo image without using the finger for assistance.

2 PerspectiveApproach

2.1 Perspective Mathematical Approach for Visualizing 3D / Depth Effect

This method is based on capturing the image of an object on a screen called as picture plane. The object is assumed to be behind the picture plane and the observer is assumed to be in front of the picture plane. (Refer Figure 1 – b)

2.2 Notations

The various notations used are

1. hs – the height of the observer’s eye from the ground plane

2. vs – the distance of the observer infront of the picture plane

3. ho – height of the object above the ground plane.

4. vo – distance of the object behind the picture plane.

5. l – length of the object.

6. b – breadth of the object.

7. h – height of the object.

8. P P – the picture plane on which the perspective projection is obtained.

9. G L – Ground plane

3 Main elements of Perspective Projections

Referring to Figure 1 – a, the main elements of the Perspective Projections are

1. The Picture plane, which is seen as a line **PP** in the view in a direction perpendicular to the ground plane. It is located at a distance of “**y5**” from the x axis of the monitor.
2. The Ground plane, seen as a line **G L** in the view in a direction perpendicular to the picture plane.
3. The Object (say a point **O** represented as o in the view perpendicular to the ground plane and represented as **o** Œ in the view perpendicular to the picture plane).
4. The Observer’s eye, represented as s in the view perpendicular to the ground plane and represented as **s** Œ in the view perpendicular to the picture plane.

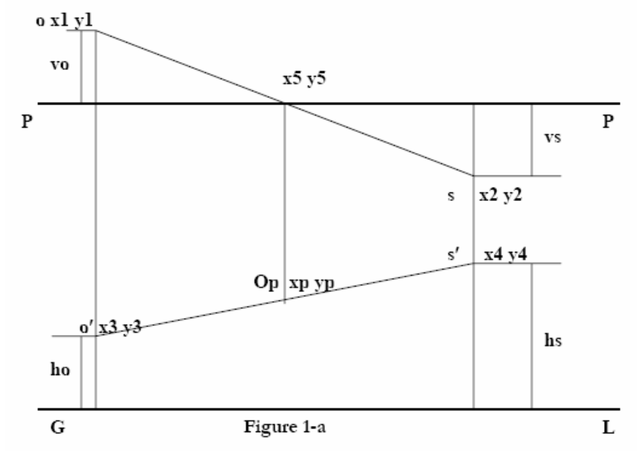

Figure 1-a

By definition, **Op** represents the perspective projection of the object (say point **O**).

Let the coordinates of point **Op**(perspective projection) be **xp, yp** with respect to the origin on the monitor. Let **x1y1, x2y2, x3y3, x4y4, x5y5** be the coordinates of points **o, s, o** Œ**, s** Œ and the point of intersection of lines **s o** and **PP**. It may be noted that **y5** is the height of the line **PP** from the origin on the monitor (a known quantity). Now **xp, yp** representing the coordinates of perspective projection (**Op**) of the point **O** can be derived and written as **:**

$$xp = x2 - ((y2 - y5)(x2 - x1) / (y2 - y1)) \rightarrow 1$$

$$yp = y3 - ((xp - x3)(y3 - y4) / (x4 - x3)) \rightarrow 2$$

Using equations **1** and **2** the perspective projections of different points on the surfaces of the given objects can be obtained. The constructional details for a set of solids are shown in figure 3.

As the observer looks at the object, the visual rays from the eye of the observer will have to penetrate through the picture plane. This is so because the picture plane is between the observer and the object. By suitable orthographic projection of the perspective elements (the plan of the observer, plan of the object, plan of the picture plane and elevation of the observer, elevation of the object, and elevation of the ground plane) the penetration point of the visual ray on the picture plane can be obtained. (Refer Figure 1 - b). By definition, this penetration point is the perspective projections of the given point namely the object on the picture plane.

3.1 Final Perspective Projection

If the object is assumed to be a summation of various points on it, then the corresponding penetration points can be obtained on the picture plane. Smooth lines or curves joining these penetration points on the picture plane will give us the perspective image of the object on the picture plane. This image, to a great extent approximates object. By further manipulating the color pixels on the surface of the image, a fairly good 3D effect (depth effect) can be obtained on the monitor. Consider the Figure 1 – b, the orthographic projections of the perspective elements namely the ground plane, picture plane, the observer's eye and the object are shown.

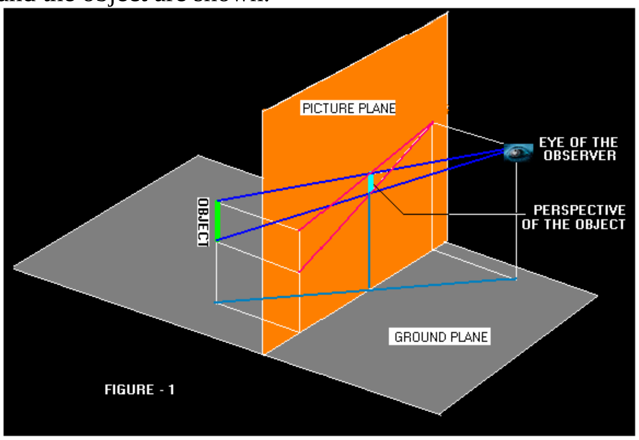

Figure –1 - b

As the observer looks at the object, which is behind the picture plane (observer infront of the picture plane), the visual rays penetrate through the picture plane. The construction which is self explained in the figure will give us the image of the object on the picture plane. This image, by definition is called as the perspective projection of the given object on the picture plane. This theory forms the basis for obtaining the perspective images of various objects. This method is called as perspective projection by visual ray method. There is yet another method called as vanishing point method.

4 Methodology of Modelling

This paper concentrates on the perspective visualization based on visual ray method, since complicated non-parallel boundary objects can be easily negotiated with this method. To further illustrate the procedure involved, two prisamatic objects kept at different locations and heights on a slab are considered and the perspective modeling of the assembly of the objects is shown below. (Figure – 2)

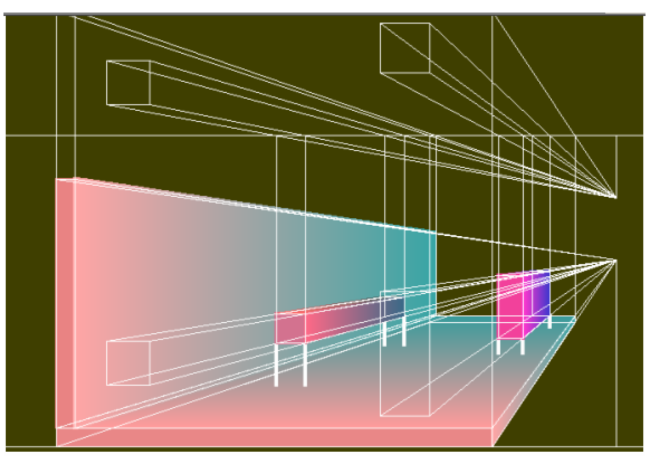

Figure – 2

4.1 Analysis

Now, let us analyze the 3D / Depth effect as seen in the perspective modeling. Figure–3 shows the constructional details without colouring effect (Wire – frame model).

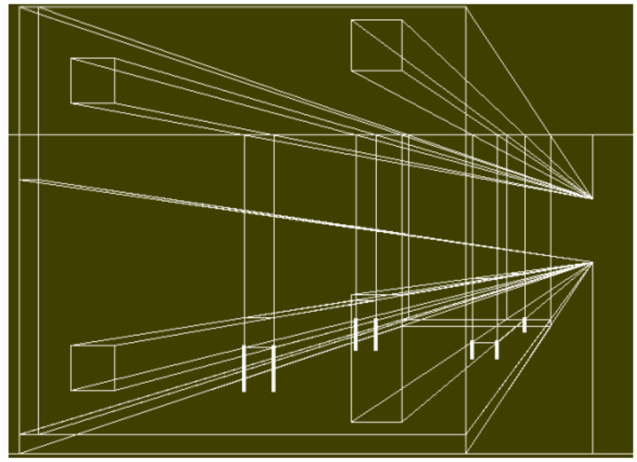

Figure - 3

After identifying the objects, (Slab, Wall, Prism1 and Prism 2) in their perspective, an attempt is made to give a varying color effect to show the depth effect in the third dimension. After giving this effect, and deleting the constructional lines we have Figure – 4 as shown below:

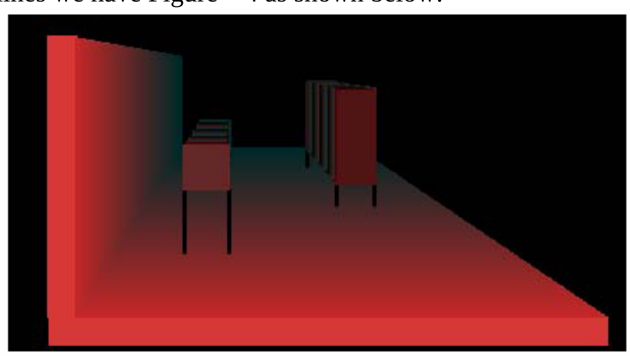

Figure – 4

The Color shading gradation for different surfaces is based on a common observation that in a monochromatic color the surfaces of the object near to the observer are brighter and as the surface recedes from the observer, the intensity of color gradually decreases and for the surfaces far off from the observer the color of the surface matches or coincides with the background / screen color. Hence, in the algorithm the color loop is closed with a suitable algorithm based on the logic given below.

4.2 Generic Algorithms

The color gradation is fixed by making use of the following equation

RGB]vo ho = RGB](100, 20, 20) at vo)i To RGB](80, 10, 10) at vo)f 3

Where RGB]vo ho is the color resolution at a given point **vo ho** (**vo** corresponds to distance behind **PP** and **ho** refers to height above Ground plane) on the surface of the object.
vo)i is the value of **vo** nearer to the picture plane.
RGB](100, 20, 20) is the corresponding color resolution value **vo)f** is the value of **vo** for the farthest point on the surface from the picture plane.
RGB](80, 10, 10) is the corresponding color resolution value.
As **vo** varies from **vo)i to vo)f** the color resolution varies accordingly and as **vo) f** takes the farthest value, the corresponding color resolution matches or coincides with the screen of the monitor or the background color.
This is applicable for surfaces bounded by four points say1, 2, 3 and 4.

5 Conclusion

a. An attempt is made in this paper to show the 3D effect of objects on the 2 dimensional computer monitor through the perspective modeling techniques.
b. Various Figures with and without construction are considered and are shown.
c. The authors have reviewed many papers on the related topics. It is their observation that though, many techniques such as stereoscopy, using polaroid lenses and colored glasses, LCD shutters, holography etc., a real image showing the depth effect could not be reported. In fact the so called 3D image is something that we feel in our mind through our brain. All the above reported techniques are only a partial substitution for the real imagination of the human brain.
d. If one really succeeds to show a real 3D image (as visualized by the human brain), without the application of colored glasses or using cameras with poloroid lenses or LCD shutters etc., it will be a break through in 3D technology. Perhaps a day is not very far off, for developing suitable softwares to achieve the above effect. This will eliminate the use of the above said cumbersome attachments.

6 References

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