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A STUDY ON EDGE BASED WIREFRAME MODELING IN PHOTOREALISTIC 3D IMAGE

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ABSTRACT

The study is to keep the framework necessities as low as conceivable with the goal that the calculation can be utilized as a part of numerous application regions. We proposed method emphatically relies upon the input from the user about the scene and the representation of the objects using intensity depth cueing. When the inputs like surface orientation or intensity to depict the depth are wrongly assigned by the user, then the resultant wireframe model might not have photo realistic yield. A method is proposed based on the presence of symmetric patterns in the scene that the perspective surface can be rectified to the scale. A method for rendering a video sequence by selecting ideal number of frames has been addressed.

KEYWORDS: application, sequence, depth, photo realistic, wireframe, model.

I. INTRODUCTION

Extracting depth information is the fundamental step in building the 3D wireframe models from single view perspective images. In the recent methods it has been proved that the depth can be extracted with or without camera parameters. In the absence of camera parameters the depth can be measured using the inputs (like surface typical, vanishing point, etc) supplied by the user interactively. However, the proposed method emphatically relies upon the input from the user about the scene and the representation of the objects using intensity depth cueing. When the inputs like surface orientation or intensity to depict the depth are wrongly assigned by the user, then the resultant wireframe model might not have photo realistic yield. To evade such erroneous inputs, the user interaction must be eliminated and the process of wireframe extraction must be automated. Computerization of depth extraction can be possible if the image contributes some visual clues. The visual clues could be in terms of points, edge detection, size consistency, skyline lines, stereopsis and optical flows. Stereo correspondence and optical flows can be the choice for multiple images. Since the objective of the current research is focused on single perspective images, the clues can be just points, edges and size inconsistency. In a perspective image, the objects of comparative size on the planet space appear to be different in size in the image space due to the perspective mutilation.

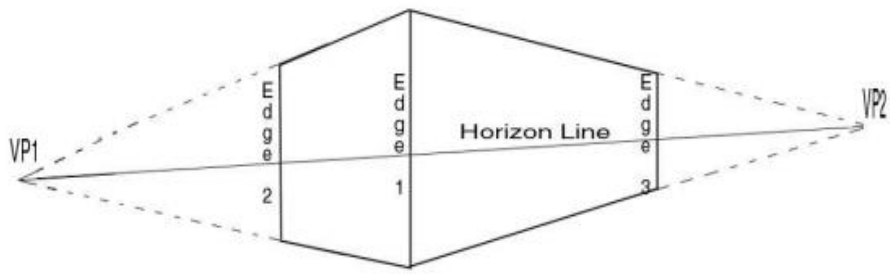

Figure 1: Visual clues in terms of edges in perspective image

In the single view perspective images, parallel lines converge at vanishing point. The line which is passing through more than one vanishing points and parallel to the ground plane is known as the skyline line. The lines perpendicular to the skyline line may contribute a vanishing point which might be very a long way from the image limit (Figure 1). In Figure 1, the edges 1, 2 and 3 are of equal length on the planet space. However, they appear to be in different lengths due to perspective bending.

It can likewise be observed that the length of these vertical (edges 1, 2 and 3) decrease towards the vanishing point. With this observation, it is discovered that there is a scope for estimating the 3D coordinates from single view perspective images by measuring the vertical edges and its lengths. The vertical edges and its lengths lead to a new avenue for extracting the depth information on a relative scale. In the event that the lengths of the vertical edges are estimated, there is a chance of estimating the relative depth from perspective images without user interaction. The core of the investigation could be on extracting the vertical edges, measuring its lengths and assigning a relative intensity to depict the depth. The length of the vertical edges may not be used as the scale of depth because the length may fluctuate depending on the resolution of the image. Be that as it may, the intensity can be assigned as a relative scale because the range of values is fixed and can be assigned based on the length of the line segments.

II. VERTICAL EDGE EXTRACTION

From the extracted set of edges, the fundamental intention is to filter just the vertical edge segments. The standard method of detecting vertical lines is using the cover as given in Figure 2

-1	2	-1
-1	2	-1
-1	2	-1

Figure 2: Vertical line detection masks

The downside of the filter is that it cannot be generalized. Based on the size of the veil, the length of the vertical lines may fluctuate. It may filter trifling edges which may not contribute the real vertical edges. Hence a more convenient filter must be designed to extract the vertical edges. The essential property of vertical edges is the angle of inclination with respect to X-axis and the number of pixels which forms the line segments. By keeping these two parameters as the key component, a filter to extract vertical edge segments can be designed. The parameters comprise of two components: length (l) and the angle (θ). As the vertical lines are to be considered, the angle of inclination with respect to X axis could be regularly 90•. Since many discontinuities may happen along the vertical edge segments, the length parameter can be fixed at a value which could either extract a part or whole line.

It is observed that in the event that the length parameter chosen for filtering is more, then many little edge segments might be missed out. Essentially on the off chance that the length parameter for filtering is little, then some of the unimportant edges might be selected. As the outcome of the filtering parameters, a line in the image may appear as disconnected line in the resultant image. Additionally the discontinuity happens due to the orientation of the vertical edges in the images. It tends to be observed from the Figure 3that some of the vertical edges are not perpendicular (90^o) to the X axis. It tends to be verified by manually drawing a line perpendicular to skyline line as in Figure 3. Applying the filtering to these vertical lines will result in disconnected line segments.

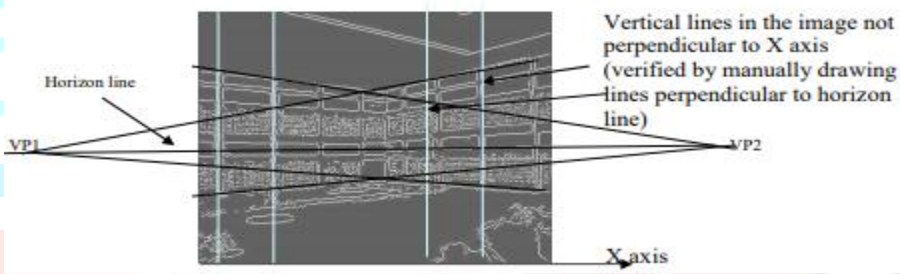

Figure 3: Vertical edge segments not perpendicular to X-axis

To resolve the problem of discontinuity there are some approaches proposed in the literature wherein a large portion of they are based on either gradient filtering or Hough transform. Following them, the Hough transform based turn could be used as one of the answers for first fit the straight lines and then rotate the image for an angle equal to the angle of inclination between any of the straight lines with X-axis (or skyline line). The consequence of this approach is that the whole image is rotated based on any one of the vertical edge's orientation. Other vertical edges may not be rectified to 90^o. For example applying Hough transform based turn to the image in 5.5 will result in an image as in Figure 4. Again it tends to be observed by drawing vertical lines perpendicular to skyline line manually over the edges. In Figure 4 edges on the correct side are 90^o to the X-axis where as the edges on the left side isn't vertical after turn. The reason behind this is that the vertical edges are not parallel in the image space. They appear to converge at a vanishing point farther from image limit.

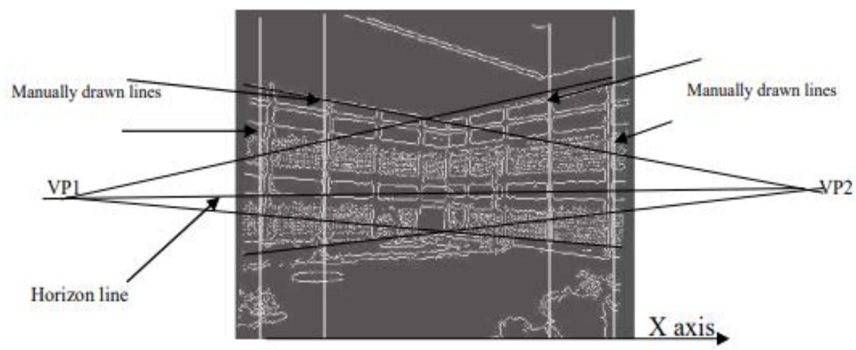

Figure 4: after rotation Vertical lines on left are not parallel and vertical lines on right are parallel with manually drawn lines

Other method could be a heuristic approach based on the orientation of each line segment. In this case a threshold along the X axis called Xdiff can be considered for connecting the line segments. As we probably aware, each line segment can be represented with a couple of coordinates as (Xstart, Ystart) and (Xend, Yend). Since the disconnected line may contain more than one line segments, there might be more than one set of coordinates on the line segment. In the event that the Xstart and Xend of any line segment fall within certain threshold Xdiff, then it tends to be considered to be a piece of length line segment. However long the line segments are within the threshold, their Y coordinates can be traced to find the end. With all the line segments within the threshold, the Y-start of the principal line segment and the Y-end of the last line segments can be considered as the Y coordinate of two end points of a single line segment.

III. THE PERSPECTIVE DISTORTION

The primary phase in the image based modeling and rendering is building the 3D wireframe models. The second phase is rendering where the images are mapped onto the wireframes as textures to generate novel views. As the images considered for 3D modeling in this work are single view images, the objects in the scene may appear perspective distorted. Perspective distortion happens due to the perspective projection of 3D scene on a 2D surface. Due to this distortion, nearby objects appear larger than faraway objects of the same size and the lines that are parallel on the planet space appear to converge. Consider the perspective distorted surface of a book in Figure 5, where the height of the book at X and Y (marked with bolt) on the planet space are same. In the image space, it appears to be at different heights due to the perspective distortion. Additionally the level edges An and B connecting these vertical edges are parallel on the planet space however appear to meet at a point called vanishing point due to perspective distortion.

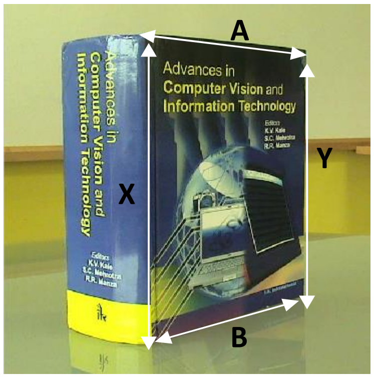

Figure 5: Perspective distortion of a surface

The perspective distortion affects the 3D modeling in two different ways. First while generating wireframes, the x, y coordinates are directly taken from image space and hence the parallel lines on the planet space appear to converge in the 3D space. This in turn affects the photo realism of the 3D model. Secondly, the texture mapping which uses image as texture ought to be rectangle in shape for mapping on to a wireframe. Since the perspective distorted surface isn't rectangular (it is quadrilateral) it isn't possible to apply them during texture mapping.

However, it might be possible to acquire the images without perspective distortion if the camera is positioned properly by covering the entire scene without distortion. In Figure 6 the same book is captured by keeping the camera parallel to the front surface and there by the edges appear to be parallel and the height remains the same. In such cases a solid prerequisite is imposed on the image acquiring process. Acquiring such images may not be possible in reality when the object or scene to be captured is wider than the width of the lens of camera. Hence it may not generally be possible to acquire the images without perspective distortion. The possible arrangement is to rectify the perspective distortion as though the image appears to be taken from a camera keeping it parallel to the surface.

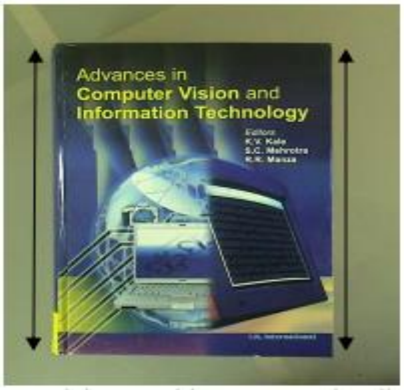

Figure 6: Book image without perspective distortion

So a detailed investigation on the possibilities of rectifying the perspective distortion from single perspective image without knowing the camera parameters is carried out in this chapter. There is a chance of bringing the photo realism if the perspective distortion is removed and likewise it is possible to correct the coordinates of the wireframe if the aspect proportion of the surface is known.

IV. ANALYSIS OF DEFORMATION OF CIRCLE TO AN ELLIPSE DUE TO PERSPECTIVE DISTORTION

A detailed report on how the symmetric objects get deformed due to perspective distortion has been carried out in this section. As a case study, circles of different radii and its perspective distortion at different viewing angles (θ) are considered for the analysis. The objective of this examination is to analyze how the distance between center of the circle and perimeter along the X-axis varies based on perspective distortion. The investigation shows that the circles deform into ellipses due to perspective distortion. When the circles are parallel to the camera, the distance (in pixels) from the center of the circles to one side and left perimeters over the even axis (X-axis) give the same values. It implies that there is no distortion happens in this case and hence the circle appears as circle (Figure 7 Top). When the viewing angle θ increases, the distance from the center to one side and left perimeter varies unequally. In the case study given in Figure 7, the distortion is more on the correct side of the circle which is towards the vanishing point. The correct half is getting deformed as the vanishing point is converged on the correct side of the circle. For example, when the viewing angle θ varies from 15 degrees to 75 degrees the deformation steeply increases and hence the distance from center of the circle to the left and right perimeters additionally decreases (Figure 7 Bottom). Hence it is observed that the distortion is more on the minor axis of ellipse as the object is oriented with respect to Y axis on the planet space. Additionally it is understood that the distortion is more towards the vanishing point.

Figure 7: Top: Parallel image with five circles. Bottom (from left to right) Circles rotated and captured at 15,30,45,60 and 70 Degrees respectively

It tends to be observed from the table 1 and the diagram (Figure 8) that, the distance from the center to both the sides are not equal. From Figure 8, it tends to be observed that in each circle, the distance from center of the circle to the two perimeters decreases as the angle θ increases. The decrease in the distance implies that the distortion is more. Hence it very well may be inferred that the distortion is more when the angle of inclination of the surface θ is more.

Table 1 Distance of the left and right perimeter from the center of the circle at various orientations (distance in pixels)

Degrees of Orientation	Circle 1 (innermost)		Circle 2		Circle 3		Circle 4		Circle 5 (Outermost)	
	Left Half	Right Half	Left Half	Right Half	Left Half	Right Half	Left Half	Right Half	Left Half	Right Half
0	63	63	74	74	90	90	107	107	116	6
15	61	58	69	68	88	82	104	96	115	106
30	56	54	63	61	82	73	98	85	108	95
45	44	42	52	46	66	57	78	66	88	72
60	33	31	40	35	52	42	61	49	69	54
75	18	14	19	17	24	19	29	24	33	24

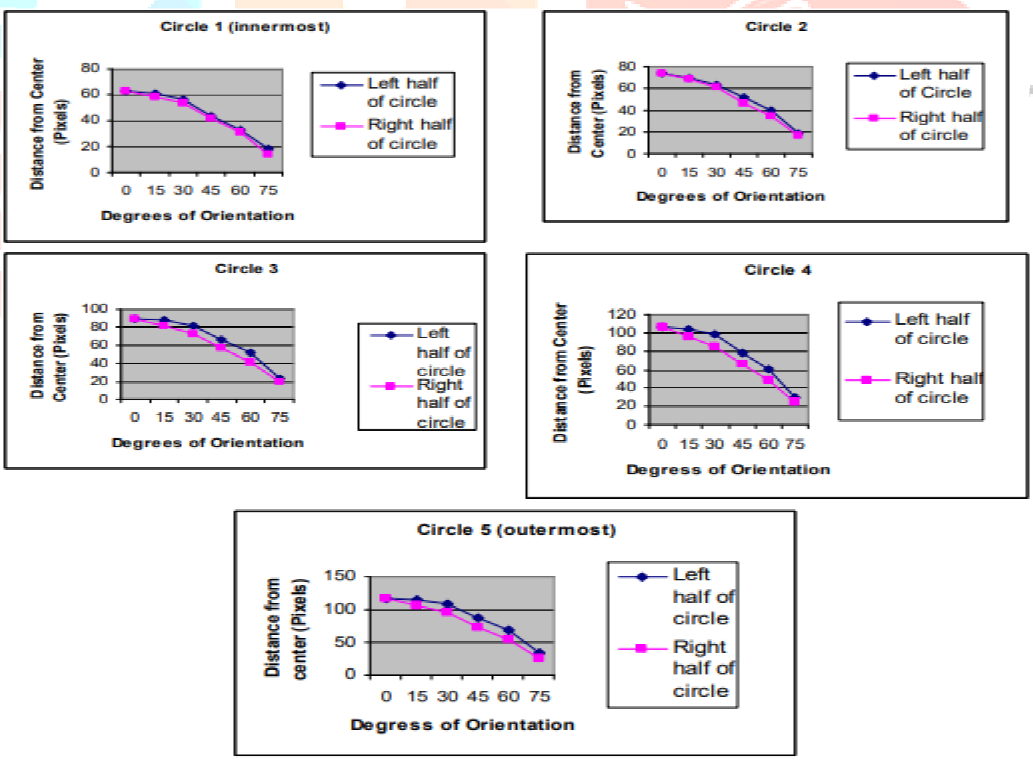

Figure 8: Graph showing the distance from center of the circle to the left and right perimeter at various angles for circles of five different radii

V. USING SYMMETRIC CLUES - PROPOSED METHOD FOR RECTIFYING THE ASPECT RATIO OF IMAGES

The results of plane homography applied on the perspective images are the images retained where the parallel lines are rectified. Finding the final limit on which the image to be mapped involves homography estimation. In the event that a reference plane and its coordinates the mapping could result in recovering the aspect proportion of the surface. In our case, there is no known reference from the site of the scene and hence a geometrical manipulation can be applied to rectify the surface to its genuine aspect proportion. The presence of symmetric patterns in the images like circle, square, hexagon, etc can be exploited as clues while recovering the aspect proportion of the surface. Using the clues there is a chance of finding the aspect proportion. Consider the Figure 9a) where the round object remains as ellipse after applying the perspective transformation. The ellipse can be rectified to a circle by scaling either along the minor or significant axis of the ellipse. In both the cases, the factor could be to equalize both the axes with the goal that the length of the axes becomes the range of the circle. In the event that the ellipse is enclosed by an ideally fit rectangle, the major and minor axes can be identified as in Figure 3.23b. On the off chance that the proportion between the major and minor axis is known, then the scaling factor can be accordingly determined.

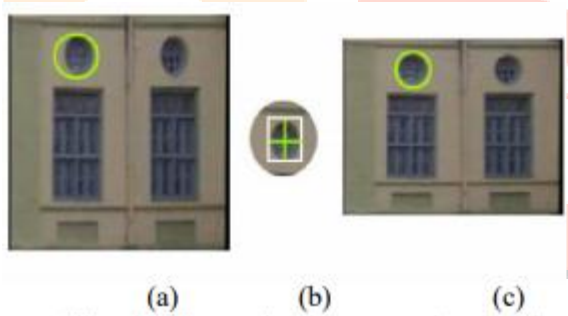

Figure 9: a. Circle appears as Ellipse b. Ellipse enclosed in a rectangle c. Circular Object Rectified

The correction can be carried out either by increasing the minor axis (Figure 9b) with the end goal that it is equal to the significant axis or by decreasing the significant axis to such an extent that it is equal to the minor axis. In both the manners in which the ellipse will become a circle. The strategy adopted for correcting the circle is applicable to the entire image. The measure of increase or decrease in the shape gives a valuable input for the image which contains the round object to resize to its relatively true size (Figure 9). The proportion between major and minor axis is used to either increase or decrease the shape of the whole image. It is calculated as below. When Major axis is greater than minor axis

$$R=H/W \quad (1)$$

When Minor axis is greater than major axis

$$R=W/H \quad (2)$$

Where R-Ratio between height and width, H-Height of rectangle encloses circle, W-Width of rectangle encloses circle. The new Height (H') and width (W') of the limit enclosed by rectangle can be computed in two different ways as

- ✓ **Case 1: To increase the minor axis (width)**

$$W'=W * R \quad (3)$$

$$H'=H$$

Where W'-New width, H'-New Height, W-Width of rectangle encloses circle, R- Ratio calculated from either Eq 1 or 2.

- ✓ **Case 2: To decrease the major axis (height)**

$$H'=H * R \quad (4)$$

$$W'=W$$

Where H'- New height, W'- New width, H-Height of rectangle encloses circle, R-Ratio calculated from either Eq1 or 2. Presently the height (H') and width (W') of the object become same and hence the ellipse became a circle. The measure of increase in height and width is passed on to the next step to find the true size of the image. Here the image which was rectified by perspective warping is resized to the new height (H') and width (W').

VI. CONCLUSION

An approach based on vertical edge segments is proposed to find the approximate 3D coordinates from single perspective images. The vertical edge extraction is the significant challenge involved in the preprocessing. In a large portion of the cases the edges may not be continuous. Hence the preprocessing methods like sharpening, edge detection and vertical edge filtering assume significant role. The intensity based depth cueing is applied to the edge segments based on the length of each segment. The intensity is assigned with the end goal that it is directly corresponding to the length of the vertical edges. Significant restriction of the method is the extraction of vertical edges and the assignment of intensities to the edges irrespective of the planes and its orientations. The advantage of this proposition is that the user interaction isn't required during the wireframe modeling. Perspective distortion is removed by applying plane homography.

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