

Communicating Panoramic 360 Degree Immersed Experiences: A Simple Technique for Sketching in 3D

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Abstract. Immersive three-dimensional environments can give test users a valuable first-person experience of design ideas. Trained designers can quickly create mock-ups using three-dimensional modelling software, but this task is very hard and time-consuming for individuals without three-dimensional modelling experience. This paper presents a simple sketching strategy that allows simple two-dimensional panoramic sketches to be rendered in pseudo-three-dimensions using panoramic viewers. This allows designers without three-dimensional modelling experience to represent their design ideas that can be explored from single points in space. The paper explores the properties of the projections, and illustrates how to represent spatial shapes.

Keywords: Sketching, 3D, panorama

1 Introduction

Sketching is often associated with the design phase where the sketches represent ideas [1]. Sketching is usually performed before prototyping and user testing. The concept of a sketch is not limited to any particular representation or physical-visual genre, but in practice, it is usually associated with two-dimensional hand-drawn representations of graphical user interfaces [2]. Hand-drawn sketches look very unlike finished products and therefore do not give involved users and customers false expectations that a product is finished. From the developers' perspective, the sketch should be quick to render allowing "bad" ideas to be discarded quickly.

The value of sketching in two- or three-dimensions for conceptual design has been explored and documented [3]. Sketches of three-dimensional experiences can be used for the design of products that are to be used in the wild, such as mobile apps, wearable computing technologies, or ubiquitous and pervasive technologies embedded in the physical environment such as buildings and structures. There are several ways to make sketches to communicate such ideas. Simple three-dimensional static snapshot of the environment are quick to draw and indeed look like drawings. To make non-static sketches of an environment, that can facilitate immersed experiences, designers often rely on three dimensional design software where the environment is modelled mathe-

matically. Such models allow users to view the environment from any angle, for instance using virtual reality technology. Another approach is to place sketched in a real physical environment and thus achieve a very realistic experience while at the same time communicating that the product is not finished.

This paper presents a novel approach to sketching three-dimensional immersed experiences while maintaining the impulsiveness and organic feeling of the pen-stroke [2]. Sketches are made by making panoramic, even hand-drawn, sketches in the equirectangular projected plane which is quite different from classic panoramic drawings and paintings. These sketches are later viewed using panoramic viewing software [4]. The idea of panoramic viewing has successfully been applied in Google street view [5] and other domain such as the communication of heritage and history [6]. This paper illustrates practical techniques for how to represent various spatial shapes directly in the equirectangular plane to achieve the desired effects. In particular, the representation of common spatial shapes and distance is discussed in detail. The sketches are displayed using the FSPViewer [7].

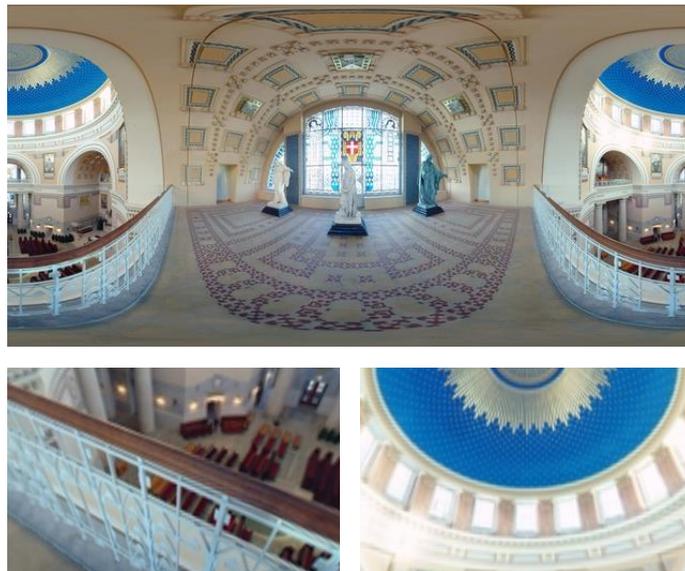


Fig. 1. An equirectangular panorama (top), from PanoTools wiki, GNU Free Documentation License 1.2. And two panoramic renderings using FSPviewer (bottom).

The ability to make quick and cheap three-dimensional sketches that gives the viewer an immersed experience of the end result opens up for new ways of working. For instance, in universal design there are techniques for involving users when designing in the physical domain and different techniques for working in the virtual domain. Architects and construction engineers typically work in the physical domain and computer scientists in the virtual domain. There bridging of the virtual and physical domain is less explored. The proposed sketching technique may be used to involve users earlier

and more closely in the design process and perhaps the technique may even facilitate participatory design [8].

2 Sketching method

The sketching method outlined herein relies on standard panoramic rendering software that will render equirectangular panoramic images at various viewing angles in real time. For example, Fig. 1 shows a heritage building with a spherical dome. This is a relatively complex environment. One characteristic that can be observed from the equirectangular panorama is that horizontal lines are relatively straight towards the vertical centre of the image and such lines become more curved as one gets further away from the horizontal midline. This is especially visible by observing the floor mosaic and the railings. However, the vertical lines are relatively straight throughout, for example, the vertical sides of the window and the squares on the wall. Another important characteristic is that the left side of the panoramic image ends where the right part begins, or vice versa. This allows the panorama to be viewed seamlessly from any angle.

Such panoramic images are typically captured using special camera equipment or special image stitching software that transform a set of regular images into equirectangular panoramas. The rest of this paper explores how to sketch in the equirectangular domain. The objective is not to achieve complete mathematically correct projections, but panoramas that give a sufficient experience of the spatial environment.

The images in this paper are rendered using the FSPviewer, but most other panoramic renderers can be used. Note that these are still images. The interactive viewing experience of moving the view around with the cursor cannot be captured on paper in a fair manner. The interactive property of the panoramic viewers is the key advantage of the outlined method.

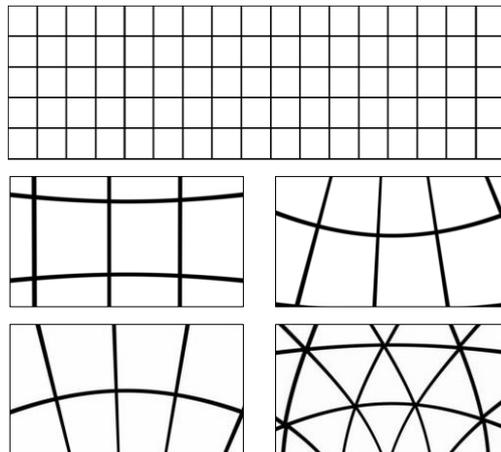


Fig. 2. Regular grid used as an equirectangular panorama and renderings of this panorama looking straight, up and down (sphere). Bottom left: Rendering of a regular grid of triangles (dome).

3 Sketching with equidistance.

An inspection of panoramic images published on various web-sites reveal that their aspect ratios vary from approximately 6:1 to 4:1, that is, the images are from four to six time as wide as they are tall. Equirectangular projections are also known as direct polar and spherical projection. Therefore, to represent all possible angles 360 degrees in the horizontal direction and 180 degrees in the vertical direction gives an aspect ratio of 360:180 or 2:1. This is analogous to latitude and longitude [9, 10, 11]. Equirectangular world maps therefore often have an aspect ratio of 2:1.

Fig. 2 illustrates how a regular grid used as an equirectangular panorama is rendered. The viewing experience gives a perception of a sphere. This is because all the cross points are regularly spaced and becomes rendered as having the same distance to the viewer (equidistance).

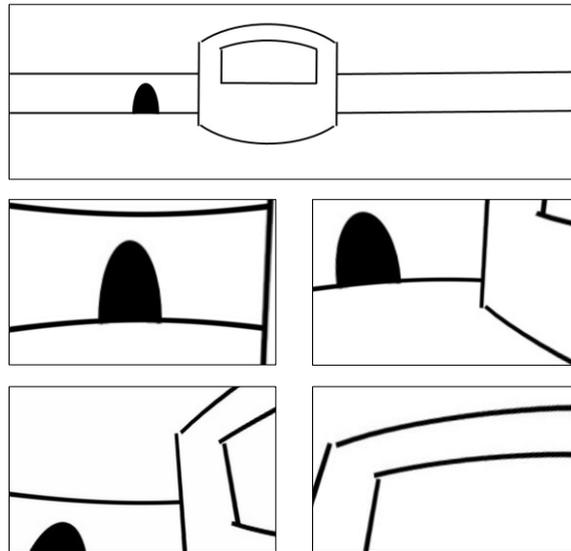


Fig. 3. A panoramic sketch of a circular hall with an entrance and a vending machine and four renderings of the panorama.

Fig. 3 illustrates how the regular distance can be used to create the perception of a circular hall. Two horizontal lines are used to represent the walls of the hall. When rendered these lines become curved as one would see an actual circular hall. The vending machine in the middle has a straight horizontal line at the bottom of the screen and a curved line on the top of the screen. The straight line is located at the vertical centre of the view while the other horizontal lines are further away from the vertical centre. The horizontal lines at the top and bottom of the machine are even more curved. The renderings of the panorama shows that the curved lines on the vending machine are perhaps too curved.

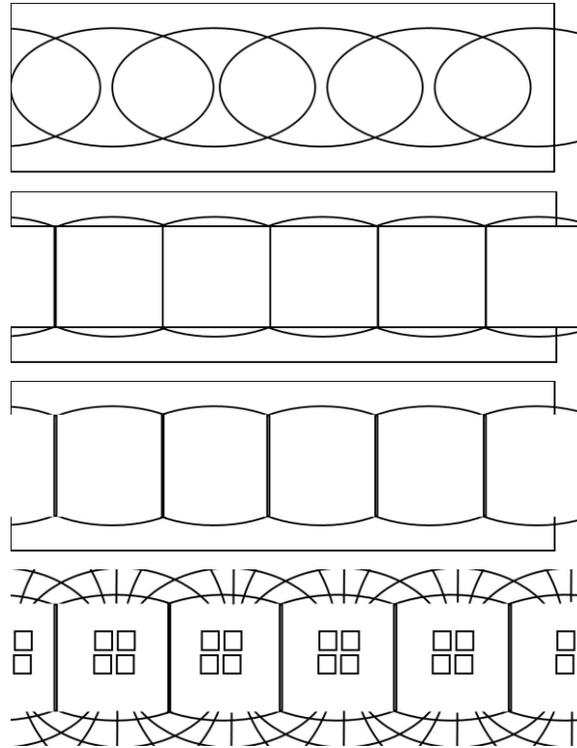


Fig. 4. Constructing a room in equirectangular space: a) drawing overlapping ellipses, b) adding straight vertical lines, c) removing construction lines and d) Adding windows and floor tiles.

4 Sketching flat faces

The sketching of flat planes is explored further in Figs. 4 and 5, which illustrates how to construct a pentagonal room. First, six overlapping ellipses are drawn to establish the horizontal lines of the walls of the room. The sixth ellipse is used to ensure that the left and right sides of the image overlaps smoothly allowing the image to be viewed completely around 360 degrees. Next, the straight vertical lines are drawn. Then, the construction lines are removed and finally windows and floor and ceiling tiles are added. The windows are drawn using regular squares since these are close to the horizontal midline of the panorama, while the lines indicating the floor tiles are further extensions of the ellipses. Hence, these lines become even more curved.

Fig. 5 shows several renderings of the result. As can be seen the lines that were curved has become straight, while the top of the window, which was straight, has become slightly curved.

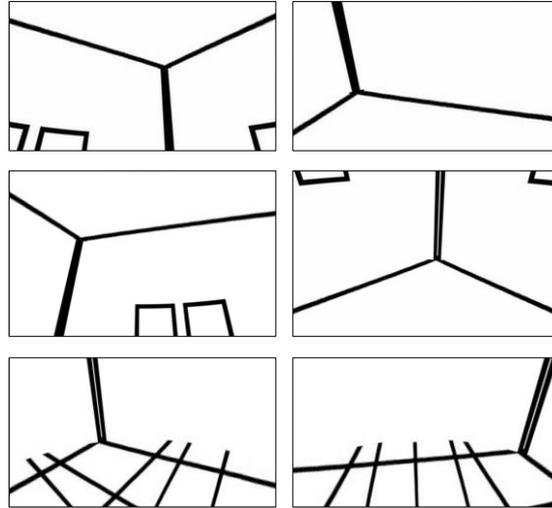


Fig. 5. Renderings of the panorama in Fig. 4 d).

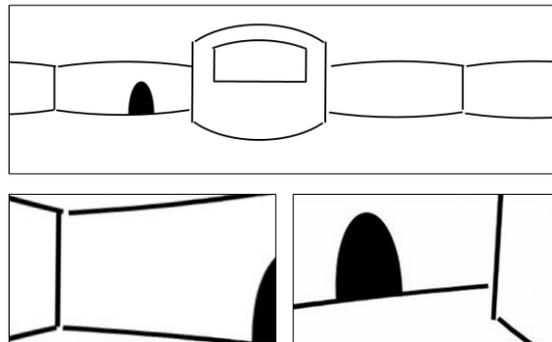


Fig. 6. Making the circular hall in Fig. 3 square.

Fig. 6 shows how the technique of making curved horizontal lines is applied to the circular hall in Fig. 3 by making the room square. The four walls are thus highlighted by adding the four vertical corner lines. Next, the top and bottom horizontal lines for each of the four walls are traced along the edge of an ellipse. Fig. 7 shows this technique applied to an example where also colours are used. Note that the bottom three renderings are achieved with a 138 degrees field of view and the others are rendered with a 70 degrees field of view.

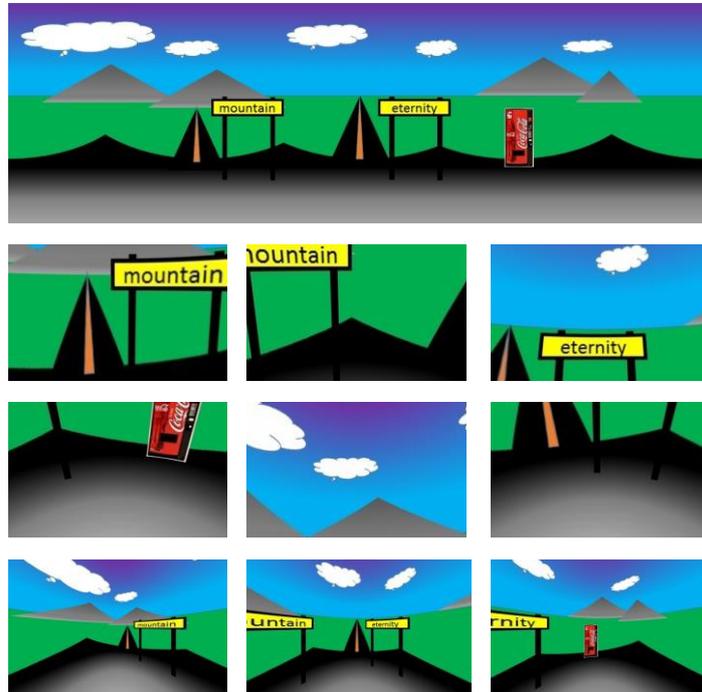


Fig. 7. A colour sketch with two signs and a coke vending machine.

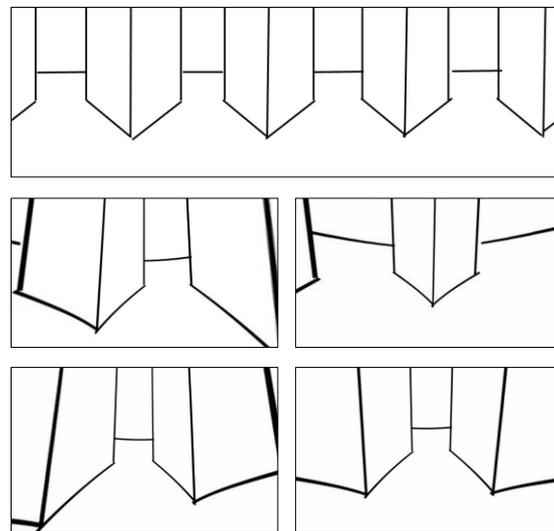


Fig. 8. Sketching diagonal lines and faces

5 Diagonal lines and faces

Fig. 8 illustrates how to sketch diagonal faces using diagonal lines. As shown by the panorama, the diagonal lines of the faces are straight. The resulting renderings show that the straight-line approximations give sufficient perception of straight lines although the rendered lines are actually curved. Fig. 9 shows this technique applied in colour.

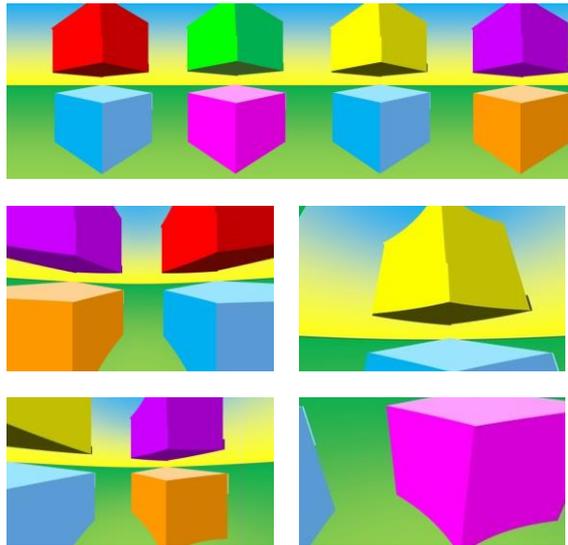


Fig. 9. Sketching diagonal lines and faces in colour.

6 Conclusions

A method for making interactive three-dimensional immersive sketches using off-the-shelves panorama viewing software was presented. The sketches are simple to make and can even be drawn by hand. Techniques for representing various spatial shapes have been presented using several examples. The technique can for instance be used to represent ideas about how virtual computer technology can be placed in the physical built environment. The technique can also be used to sketch and represent ideas and concepts for three-dimensional games. It may be valuable to study equirectangular panoramic images to develop ones' sketching technique.

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