Workshop—Drawing Equirectangular Perspectives for VR Panoramas with Eq A Sketch 360

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***Abstract*—In this workshop we will explore the construction of immersive environments in equirectangular perspective using the Eq A Sketch 360 software. Eq A Sketch 360 is a serious toy for spherical perspective drawing. It has two innovative features: a sliding geodesic grid and an equirectangular snap-to ruler. These tools turn equirectangular drawing into a proper perspective, where all lines and vanishing points may be drawn by hand, to create immersive environments from either observation or imagination. This contrasts with previous methods of equirectangular drawing, that either avoided perspective altogether by drawing directly in VR view, or were limited to fixed grid methods with ad-hoc estimation of measurements. Eq A Sketch both forces and helps the user to learn spherical perspective. We will show how to draw by hand with perfect control of proportions and bearings, to make standalone designs or constructions that can be mixed with 360-degree photography.**

***Index Terms*—spherical perspective, VR panorama, immersive drawing, hybrid models, equirectangular perspective**

I. Introduction

Spherical perspectives are an emerging artform with multiple applications to the visual arts. They can be used in product design, in the documentation of cultural heritage, in full dome presentations, and in architectural design and visualization [1], [2]. Spherical *perspectives* are not the same as simply spherical *projections*, such as equirectangular or azimuthal equidistant projections. Projections may be easily achieved by brute force calculation, pixel by pixel on a computer, but are unwieldy to the human draughtsman. A projection becomes a *perspective* only if, as in classical perspective, we have a method for systematically drawing all lines and vanishing points through simple operations with basic tools such as ruler and compass. Then the image may be drawn by a human artist in a manageable number of operations rather than the millions of pixelwise operations required to generate a panorama from a 3D model. Spherical perspectives allow the creation of *hybrid models* [3] that can be visualized immersively in VR while worked upon in a mixed media workflow involving both physical and digital media [4], [5].

Currently, three spherical projections are well understood as perspectives [6]: equirectangular, azimuthal equidistant, and cubical. In this workshop we will focus on equirectangular. This perspective is especially interesting since it easily connects with the standard format of 360-degree photography, simplifying integration with the usual workflows of design, architecture, and cultural heritage documentation [7].

II. Target Audience and Requirements

The target audience includes all who work in art, cultural heritage, architecture, 360-degree photography or video, or full-dome presentation design. In education, drawn panoramas can be overlayed on photo panoramas to highlight or add content to an area of interest, e.g. by adding a drawn speculative reconstruction of an ancient building to a photo of a dig site, or doing small changes to an existing location, or overlaying drawings of hidden structures (e.g., columns, beams, plumbing) on an architectural photo, adding features to a night sky in astronomy, etc. Wherever illustration plays a part with regard to photography, immersive drawing plays the same role with regard to immersive visuals. Drawing selects, highlights, and articulates visual concepts. Immersive drawing is no different.

As for Requirements, a basic knowledge of perspective and ability for drawing is a plus, but not required, as Eq A Sketch will help with the rendering. A Windows or Mac computer is needed. As an alternative, you can use Microsoft's Sketch 360 on Android. As a last resort, you can use tracing paper on a printed grid, as seen in the author's video tutorials in [8]. These tutorials will also serve as supplementary materials for the talk.

III. Novelty and Timeliness

Spherical perspective, which can be said to begin with the 1960s work of Barre and Flocon in the 180-degre fisheye case [9] is currently having a renaissance, due to its connection with VR, but workflows have been until recently hampered by a division into either direct VR drawing (which misses the overall view of a full perspective, being fragmented into multiple linear projections) and ad-hoc fixed grid methods that miss the formal, systematic perspective constructions that Barre and Flocon brought to the subject. Although these methods can lead to exquisite results in the hands of the virtuoso [10], they lack the systematic procedures of classical perspective, which can be taught to anyone. The method presented here is the first formal perspective method that achieved true perspective constructions with systematic measurements and rendering procedures, while still keeping to a truly sketching experience. It is based on recent theoretical works that generalized Barre and Flocon's methods first to the 360-degree case of the fisheye (azimuthal equidistant) perspective [11], then to the equirectangular case [12]. The software we will use is also the first drawing program to provide

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an equirectangular slider and snap tool [13] that integrates with the hand drawing methods presented in [12] and [14], where it was first pointed out how and why a sliding equirectangular grid of geodesics allows a user to plot any line. These tools now begin to be adopted by other software: in a recent collaboration with Microsoft, the equirectangular tools of Eq A Sketch 360 have been adapted to Microsoft's Sketch 360 software as the *Eq A Snap* tool. Eq A Sketch 360 remains a minimalistic, experimental testbed for innovative methods in perspective while Sketch 360 is a polished app aimed at multimedia and journaling. This workshop is a timely opportunity to start learning the possibilities of these perspectives, even as the methods and software are in development and the boundaries and applications of the subject are being found.

IV. A Serious Toy for Immersive Perspective Sketching

Eq A Sketch 360 is a very simple perspective drawing program. It has no frills, but has a unique set of tools specific to equirectangular perspective: a sliding equirectangular grid and an equirectangular snap-to ruler that allows the user to draw the line projection between any two points. Eq A Sketch 360 will not draw perspectives for the user: it is meant to both *force* and *help* the user to actually learn the rules of the perspective if anything at all is to be achieved. It helps the user by separating the manual aspects of equirectangular drawing (the rendering of lines by the sliding grid method [12]) from the theoretical aspects of the constructions themselves. This separation helps the student to more quickly reach mastery of both aspects.

The software has minimal commands: Press N or M to place two probe points under the mouse. Press the arrow keys to move the sliding grid. Other keys control special reference vanishing points or find the antipodes of given points. An auxiliary display shows angular coordinates and apex points. From these simple operations all can be done. The focus is on perspective constructions, not on program presets. The name Eq A Sketch is a reference to the old toy Etch A Sketch, that invited the user to draw complex images using only horizontal and vertical motions. Similarly, the sliding grid method allows any rectangular line to be drawn by using a grid of horizontals and verticals [12], which generate all equirectangular lines (in fact *geodesics*) through the projection's group of symmetries.

Although it is meant as a learning tool, the software can be useful in a workflow pipeline, where more polished tools can handle the final rendering once the perspective has been constructed. Work is saved as tiff/png/jpeg and visualized immersively with an external program.

Participants should install the software (available in the author's page [8]) as well as any free viewer for the final VR panoramas (the free *FSPViewer* works well). The software is available for both Mac and Windows platforms.

V. Plan of the Workshop

The workshop will have two parts. A brief theoretical introduction followed by exercises.

A. Theory

The theory will follow the spherical perspective survey in [6], quickly introducing the general relation between anamorphosis and spherical perspectives, and drawing methods focusing on transformation groups. Spherical perspectives are seen as two-step entailments of anamorphosis followed by cartographic mapping, and it is shown how the flattening transformation groups result in mechanical drawing methods – in this case the sliding grid method. We will show how all lines have two vanishing points, and how to find and render them; how geodesics (the images of planes) and not lines are the elegant construction blocks of this perspective and how geodesics are characterized by their apex; how this apex is calculated by Eq A Sketch and can be found even by hand through the sliding grid process; how it allows any diagonal line to be replaced by an equivalent set of mutually antipodal horizontal lines.

B. Program Operation

The operation of Eq A Sketch will be introduced. Features will be gradually introduced in the context of specific exercises:

C. Perspective Exercises

1) Horizontals and Verticals: we will use horizontals and verticals to draw a simple box with the user inside it such as a room or as the corridor-like passage in Fig. 1. We will discuss what is the minimal number of points required to define the room in this perspective.

2) Diagonals and Vanishing points. We will see how we can draw general lines, both with the sliding grid method and with the snap-to ruler. We will then take a vanishing point at random and draw a pencil of parallel lines vanishing to it (Fig. 2).

3) Perspective arithmetic: We will use diagonals to both measure and build. Crossing diagonals to find centers of figures, crossing though midpoints to multiply segments, then multiplying upwards to make towers of repeating elements.

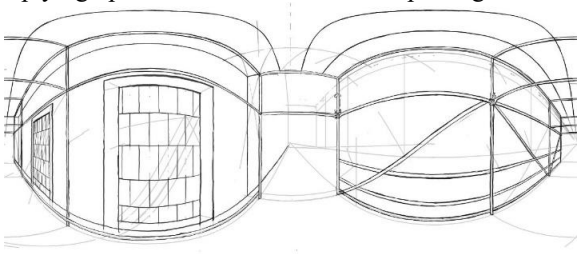

Fig. 1. Building a box like environment inside which the viewpoint lies.

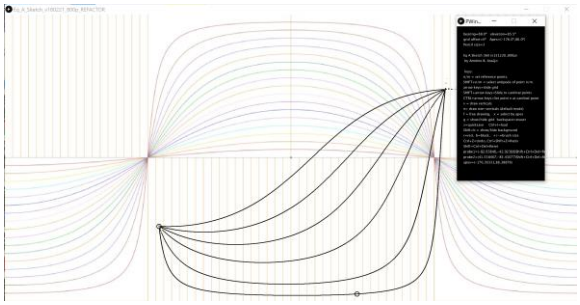

Fig. 2. The Eq A Sketch 360 GUI. The user has draw a set of lines between two vanishing points using the Eq A Snap tool. Because they have common vanishing points, the lines are assured to look parallel when seen in VR.

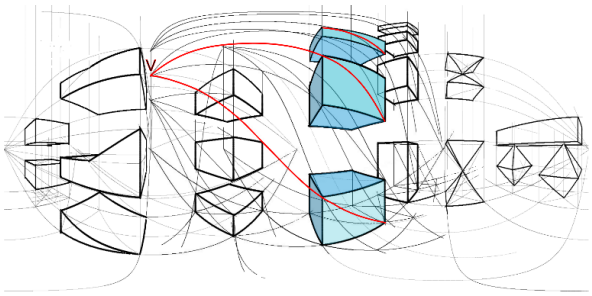

Fig. 3. Parallel transport. The blue stack is made of identical boxes. Sizes are set by the red diagonals vanishing to a control point V which sets their angle.

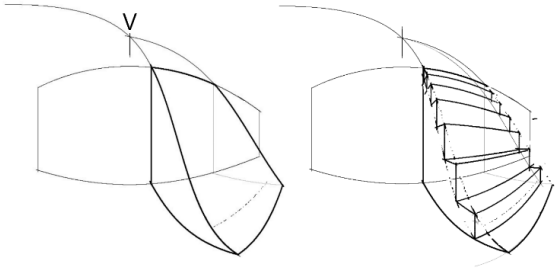

Fig. 4. A ramp going to vanishing point V and a stairway built upon it.

4) Parallel transport. This generalizes perspective arithmetic. For instance, in Fig. 3 we control the proportions of the boxes in the blue stack by sending diagonals from their vertices to a common vanishing point V. This ensures that the boxes in the stack have the same proportions and look correct in VR, in spite of the heavy deformation in the flat view (notice the extreme deformation of the topmost box in the blue stack). This also allows us to define controlled sloping surfaces as we see in the second stack from the left.

5) Slopes and stairs. We show how to use a vanishing point V to draw a ramp sloping at a prescribed angle by sending two parallel lines to V over a right-angled scaffolding (Fig. 4, left). Then we show how make a flight of stairs over the ramp by bouncing a line between parallel planes (Fig. 4, right).

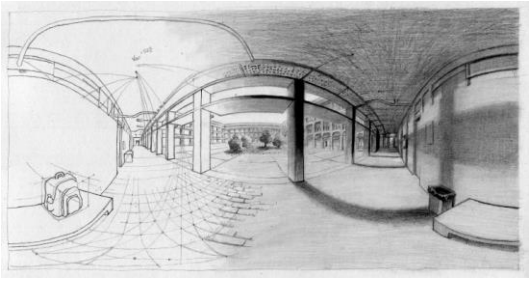

Fig. 5. Perspective multiplication. Drawing by the author. Graphite on tracing paper. 15cmx29cm.

6) The ping-pong snake method. We apply the zig-zag method of [6] to make a uniform tiling of the plane (e.g. a checkered floor) by bouncing a line between two diagonals vanishing to a common point at 45 degrees to the tile axis. See the example in Fig. 5, made by hand with graphite on paper, using a printed grid sliding under tracing paper.

VI. Objectives

In two hours, we can barely scratch the surface of spherical perspective, but the participant should leave with an understanding of the basics. This is enough to make quite complex drawings that can be turned into VR panoramas. It is also a sound foundation for further readings on the subject.

VII. About the Presenter

António B. Araújo has a Ph.D. in Mathematics and researches mainly on immersive perspectives. His illustration work informs his theoretical research. He lectures at Aberta Univ. (Portugal) and coordinates the pole of the Research Center for Arts and Communication (CIAC) at UAb.

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