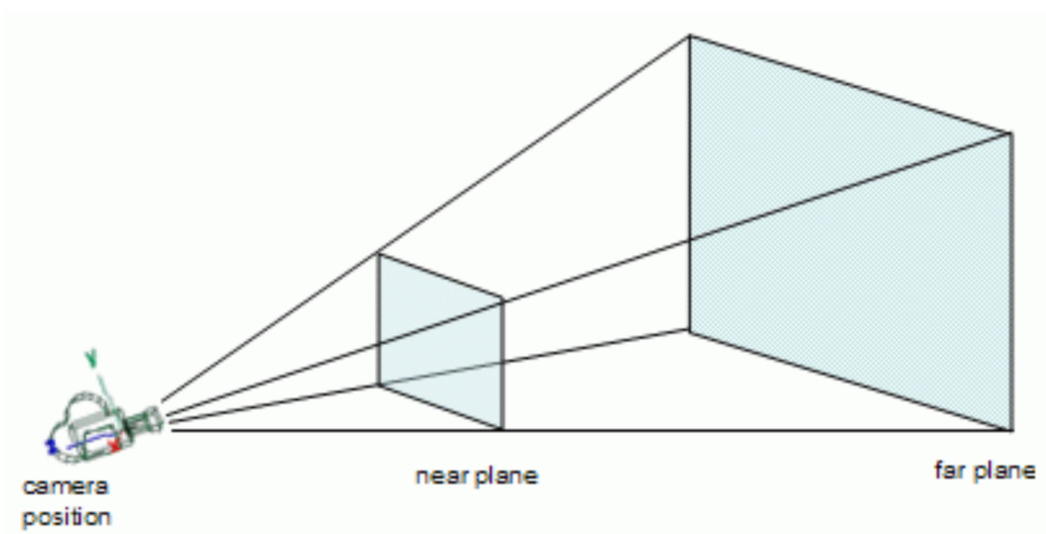
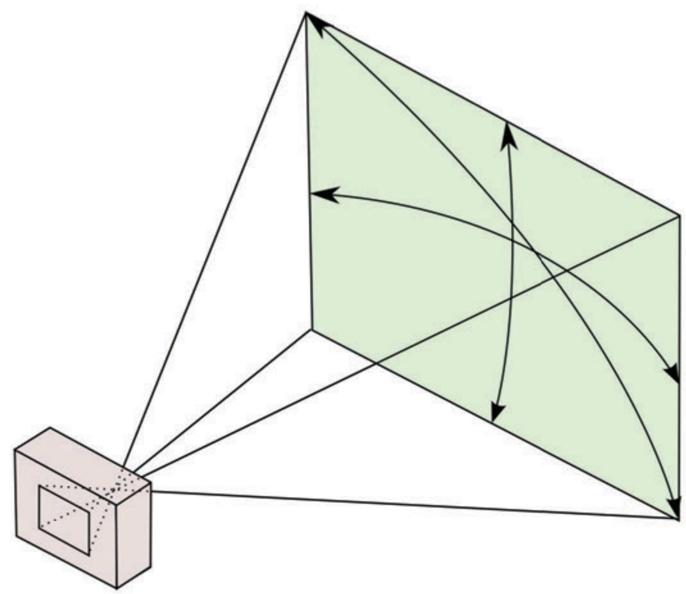
Field of View | Anamorph

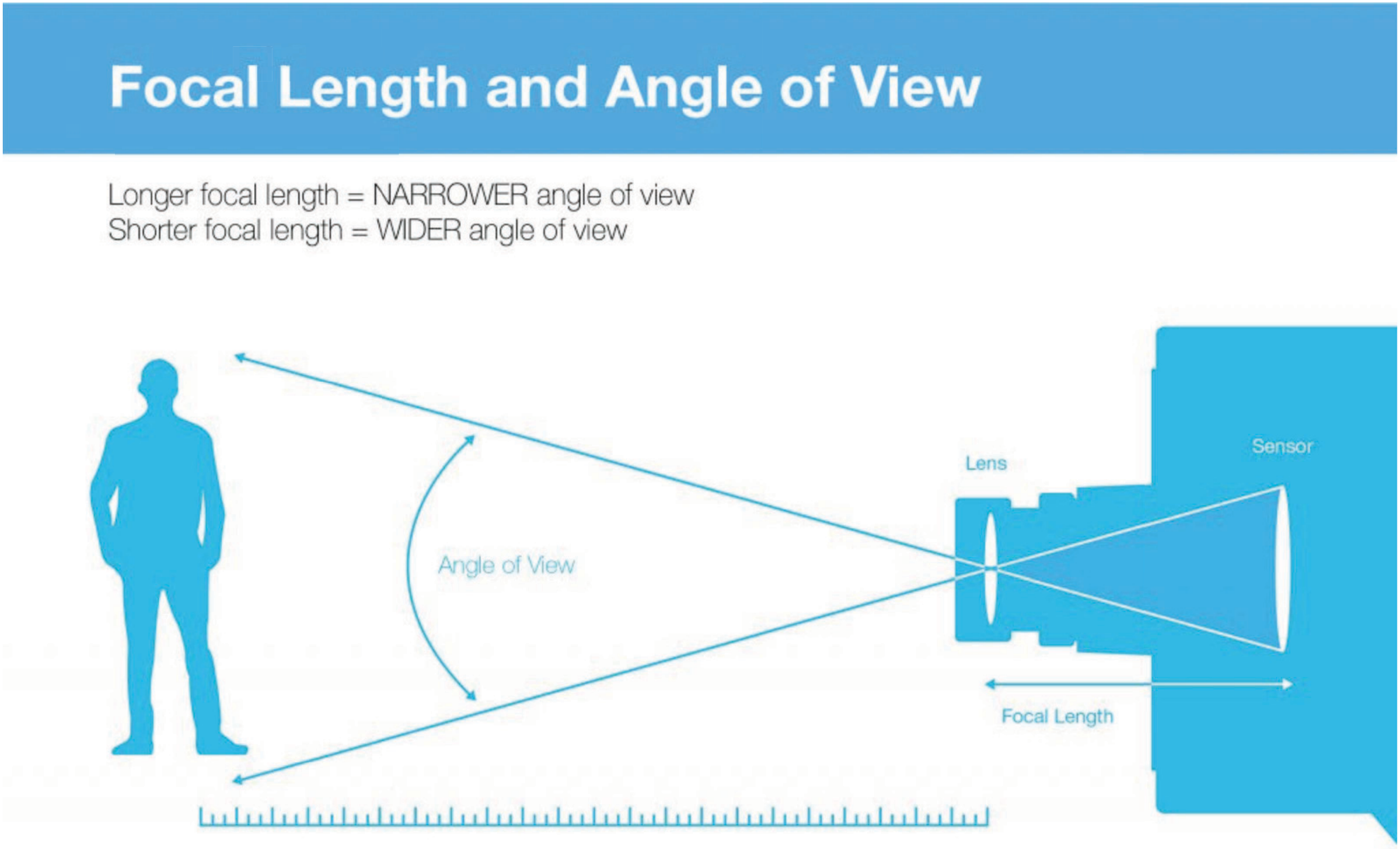
Terminology

- **Field-of-View**: What is seen at a given moment
- **Angle of view**: Angular extent of a scene imaged by a camera
- **Vantage point**: The location where the photo is taken from
- **Frustum**: 3D region viewed on the screen

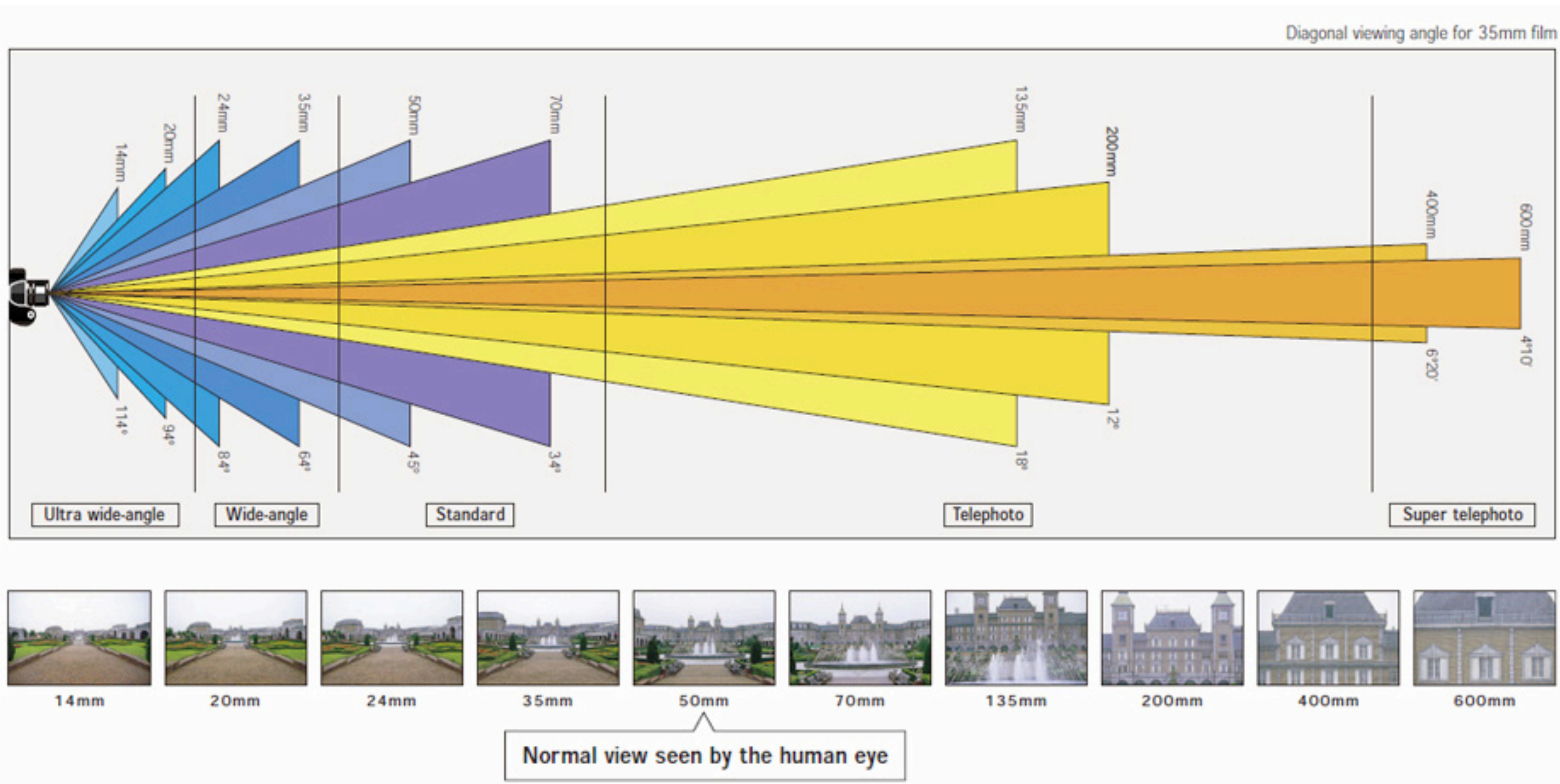




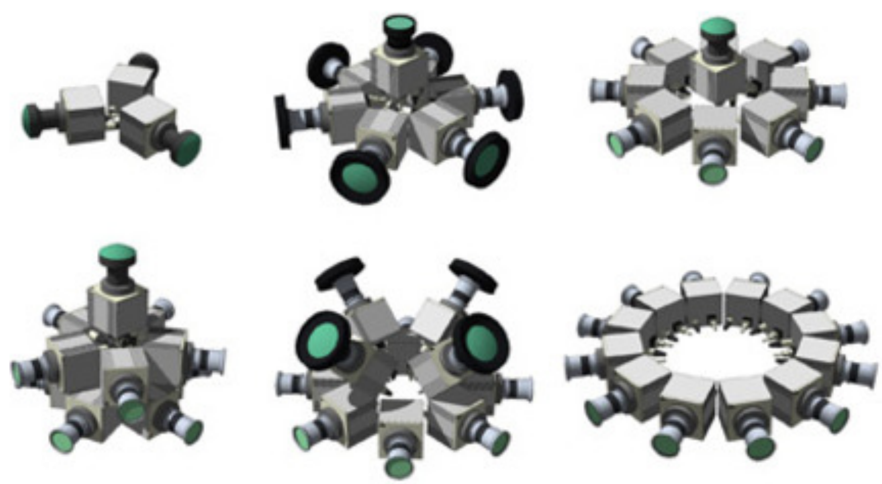
Basic optical-mechanial camera format



Focal lens – the distance between the lens and the image sensor



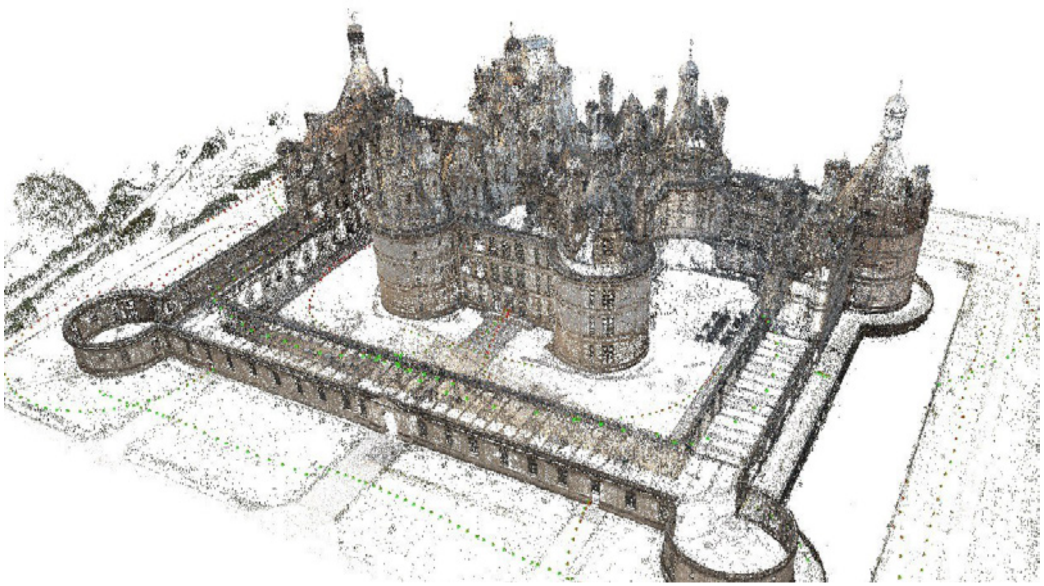
Full Sphere camera– iCinema, UNSW https://vimeo.com/2831635

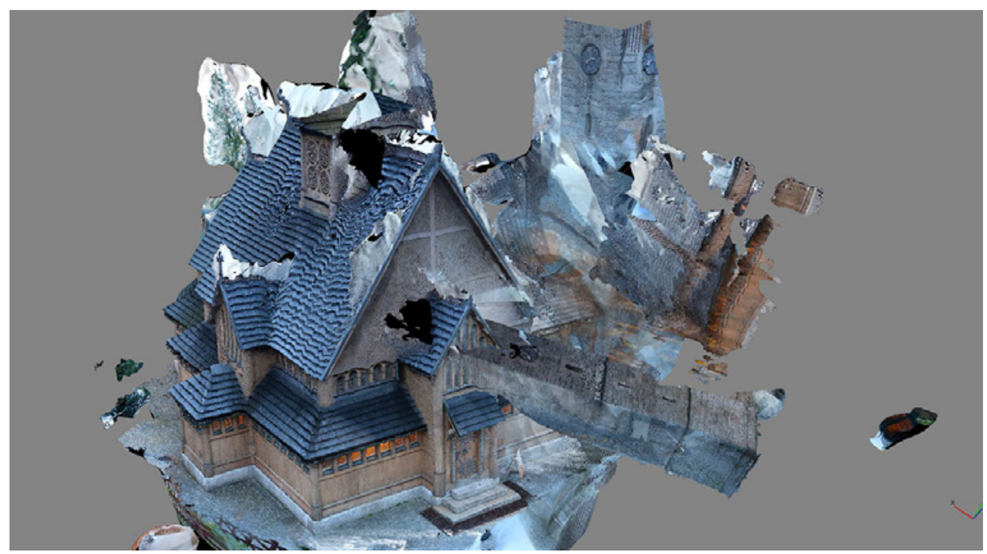


Matterport 360 spherical camera - https://matterport.com/gallery/

Photogrammetry – Making measurements from photographs

The input to photogrammetry is photographs, and the output is typically a map, a drawing, a measurement, or a 3D model of an object or scene. The *3-D co-ordinates* define the locations of object points in the 3-D space



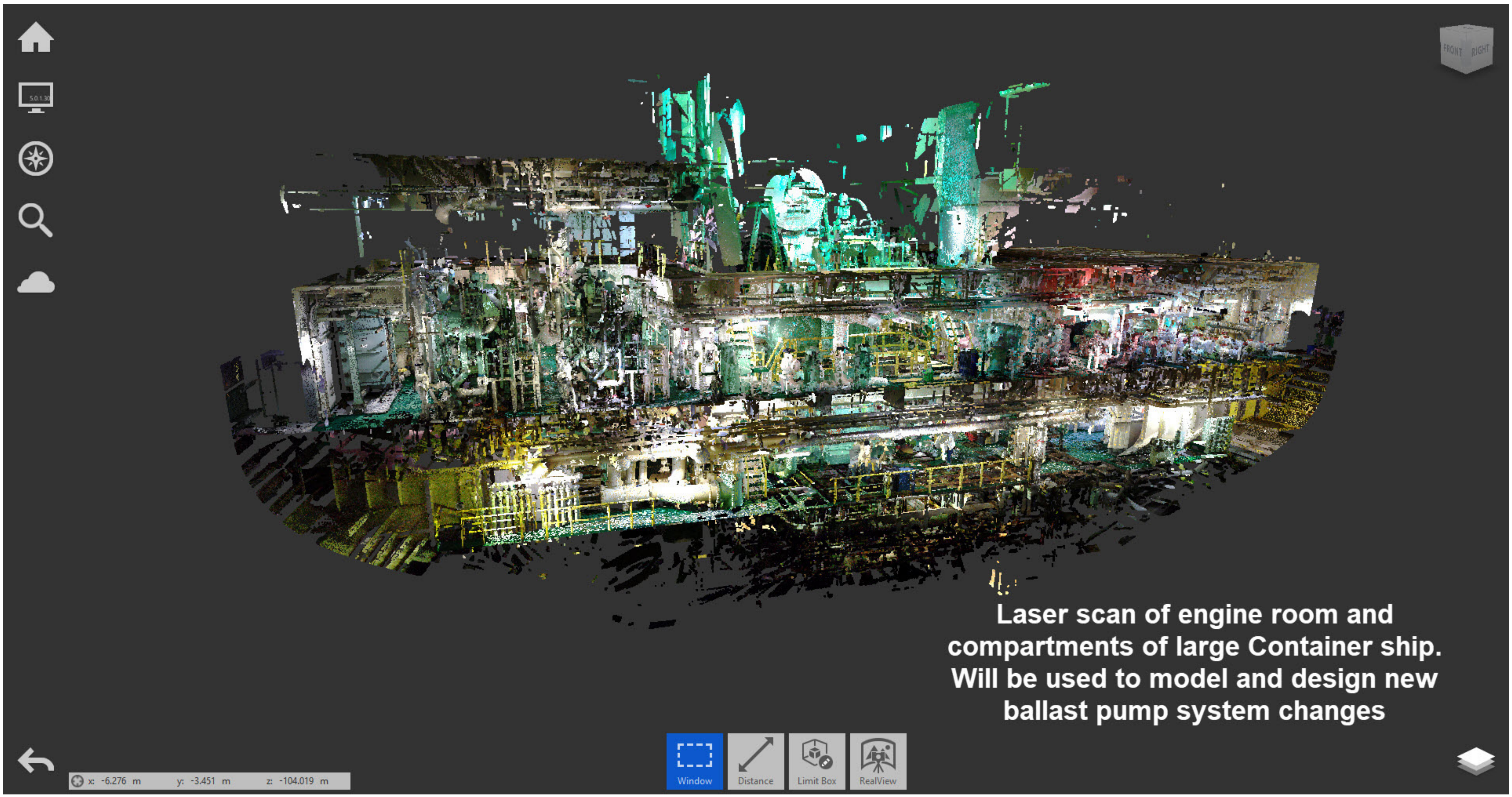


Photogrammetry – Volker Kuchelmeister - https://vimeo.com/225514735

With one trend in CGI to generate ever more realistic depictions, this project takes a deliberate step back and makes use of a primitive reconstructed reality, the point-cloud representation

3D Laser Scan

3D Laser Scanning is a non-contact, non-destructive technology that digitally captures the shape of physical objects using a line of laser light. 3D laser scanners create “point clouds” of data from the surface of an object. In other words, 3D laser scanning is a way to capture a physical object’s exact size and shape into the computer world as a digital 3-dimensional representation.



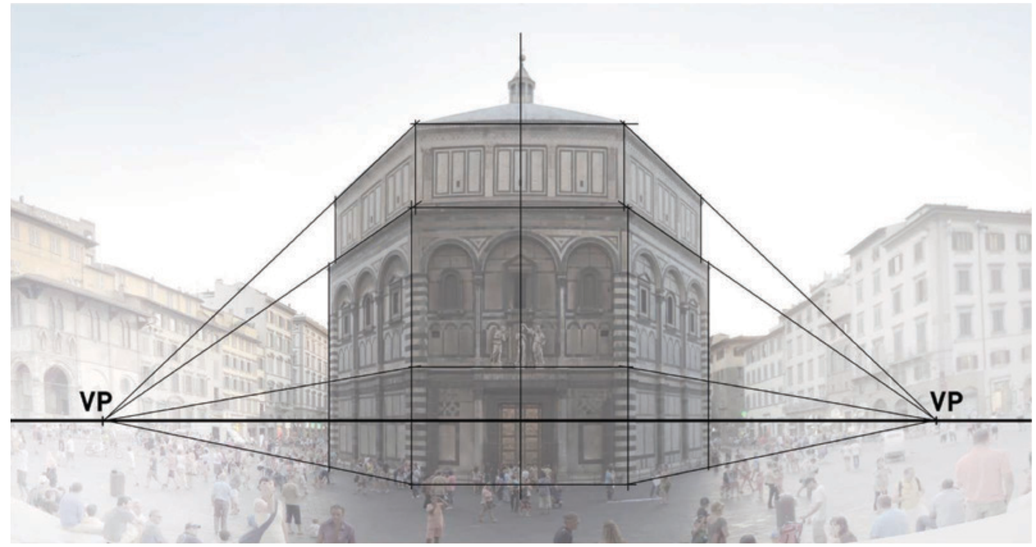
Laser scan of engine room and compartments of large Container ship. Will be used to model and design new ballast pump system changes

St. Catherine of Siena dictating her dialogues, Giovanni de Paolo (1447-1449)

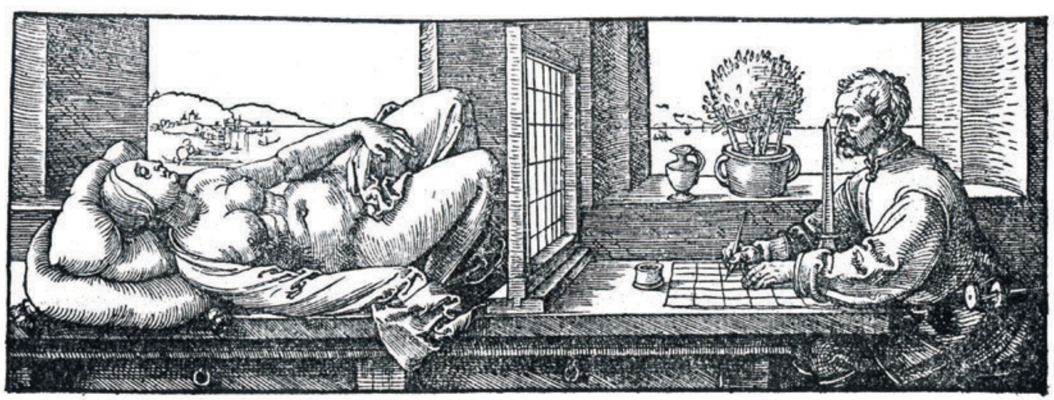
In a series of at least ten paintings Giovanni di Paolo presented the mystical episodes in the life of Catherine (1347–80), a Sienese tertiary of the Dominican order. Contemporary accounts of her life tell that on occasion Catherine would be overcome by rapture, whereupon she was able to explain points of holy doctrine.

Various Perspectives

Oblique*: Entrance and yard of a yamen*. Detail of scroll about Suzhou by Xu Yang, ordered by the Qianlong Emperor. 18th century



Brunelleschi 2 point perspective, 1415-1420 (video)



Albrecht Dürer, grid window (1525?) Right panels: Giotto (1310), Cimabue (1280-1285)

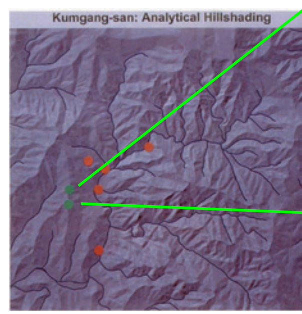
Intae Hwang thesis to transfer Jeon Seon's traditional paintings into virtual environments

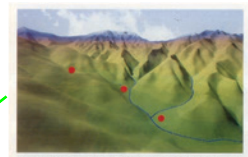
St. Ottilien's Six "True View Landscapes" by Chông Sôn (1676-1759) *3

Kay E. Black and Eckart Dege

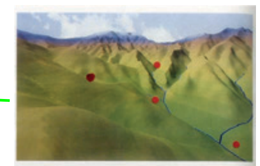
Jeong Seon, *The Complete View of the Diamond Mountains*, deep color on silk, 33.3 x 54.8cm.

Fig. 15. **1954 USAMS map detail** used for digitised elevation model. Courtesy Eckart Dege.

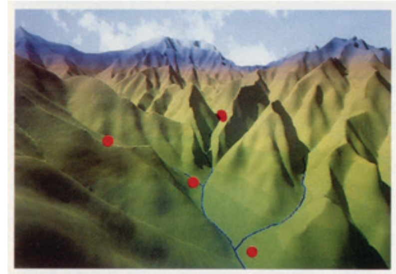




Printout 3. Neither Changan-sa nor Podŏk-am is visible from vantage point 930. Courtesy Eckart Dege.



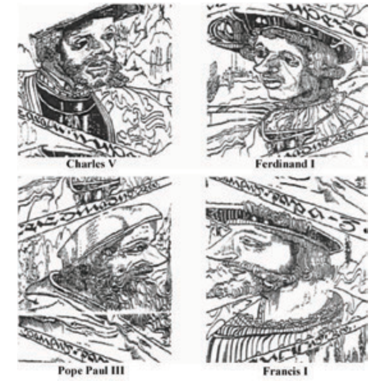
Printout 4. All the landmarks are visible from Peak 3 except Changan-sa which is hidden deep in the valley. Courtesy Eckart Dege.



Printout 5. A virtual landscape as seen from vantage point Peak 3, with vertical exaggeration. Courtesy Eckart Dege.

[Kay E. Black, Eckart Dege, 1999]

Vexierbild – Erhard Schön, 1530



Nexus Netw J (2015) 17:253–285
DOI 10.1007/s00004-014-0225-5

NEXUS NETWORK JOURNAL
Architecture and Mathematics

RESEARCH

Anamorphic Projection: Analogical/Digital Algorithms

Francesco Di Paola   Pietro Pedone
Laura Inzerillo   Cettina Santagati

Published online: 27 November 2014

Abstract The study presents the first results of a wider research project dealing with the theme of "anamorphosis", a specific technique of geometric projection of a shape on a surface. Here we investigate how new digital techniques make it possible to simplify the anamorphic applications even in cases of projections on complex surfaces. After a short excursus of the most famous historical and contemporary applications, we propose several possible approaches for managing the geometry of anamorphic curves both in the field of descriptive geometry (by using interactive tools such as Cabrì and GeoGebra) and during the complex surfaces realization process, from concept design to manufacture, through CNC systems (by adopting generative procedural algorithms elaborated in Grasshopper).

Keywords Anamorphosis Anamorphic technique Descriptive geometry Architectural geometry Generative algorithms Free form surfaces

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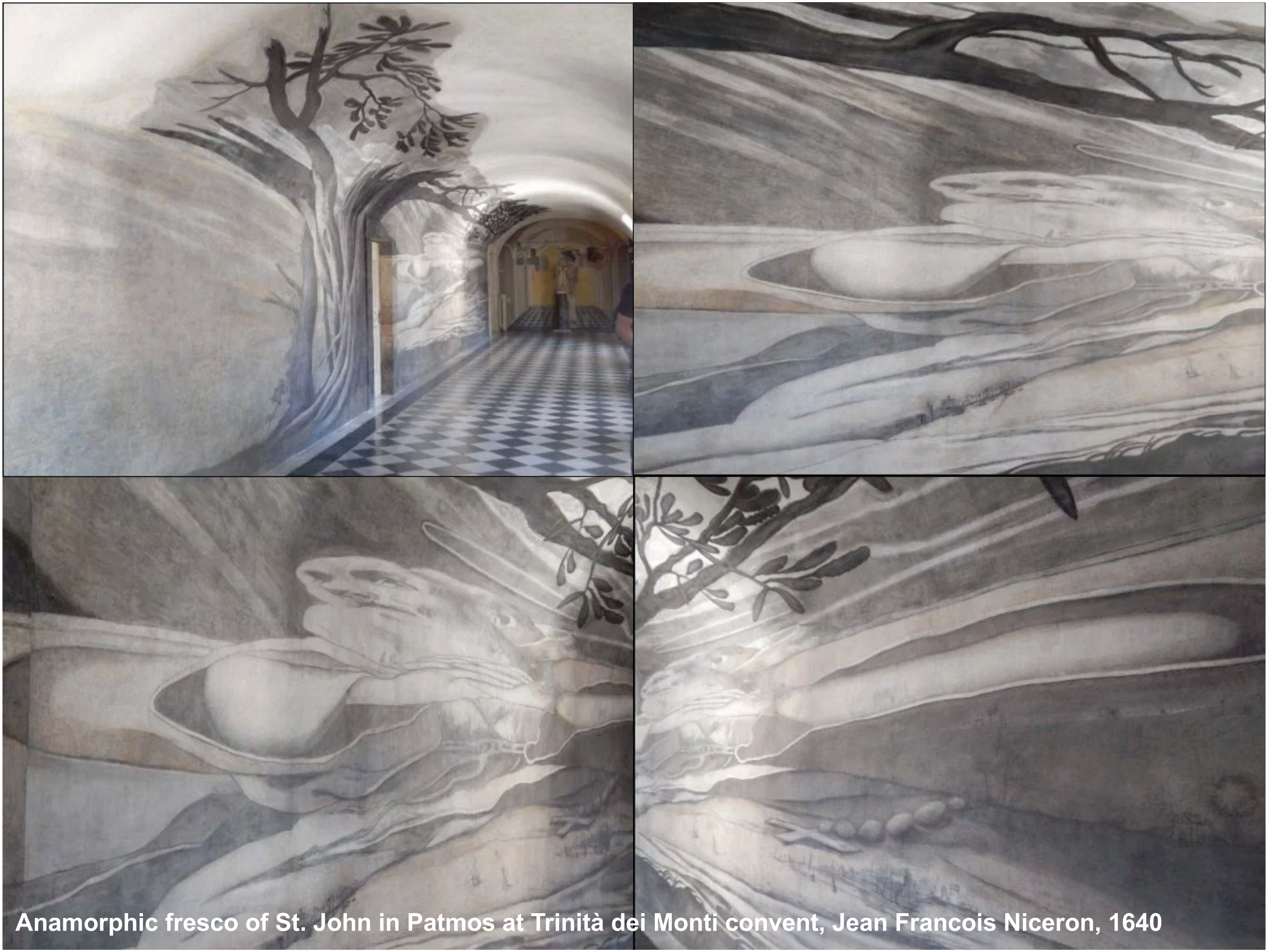
Fig. 4 *Center, right The Ambassadors* by Hans Holbein the Younger, National Gallery, London, 1533. The anamorphic skull on the floor becomes recognizable only observing the painting from the left side according to an oblique point of view. http://www.it.wikipedia.org/wiki/Gli_ambasciatori (Holbein_il_Giovane) Author: Lisby, licenza Creative Commons Attribution 2.0 Generic. https://creativecommons.org/licenses/by/2.0/legalcode, no change to the figure, https://flic.kr/p/6VsvNa

Fig. 5 Jean François Nicéron, anamorphic fresco of the Gallery of the Monastery of Trinità dei Monti in Rome, 1640. On the *left*, the *figure* shows the central part of the fresco as it appears walking through the corridor. On the *right*, there is the image of Saint John the Evangelist as appears from the privileged point of view (De Rosa and Cristian 2012, p. 597)

The painters used the concepts of anamorphosis in the creation of their works, with extreme skill and mastery, creating wonderful examples on the curved surfaces of apses and niches, over large areas of aristocratic salons or on the articulated vaults of churches.

We can cite, among the examples of anamorphosis on large scale, the apse of the church of Santa Maria in San Satiro in Milan created by Donato Bramante (1483), the corridors of Palazzo Spada in Rome by Francesco Borromini (1540), and the trompe-l'oeil scenography of Palladio's Teatro Olimpico in Vicenza designed by Vincenzo Scamozzi (1584).

The architect and painter Andrea Pozzo was one of the greatest exponents of illusory architecture as well as a theorist of perspective. The frescos on the ceiling of



Anamorphic fresco of St. John in Patmos at Trinità dei Monti convent, Jean Francois Niceron, 1640

Anamorph Transformation

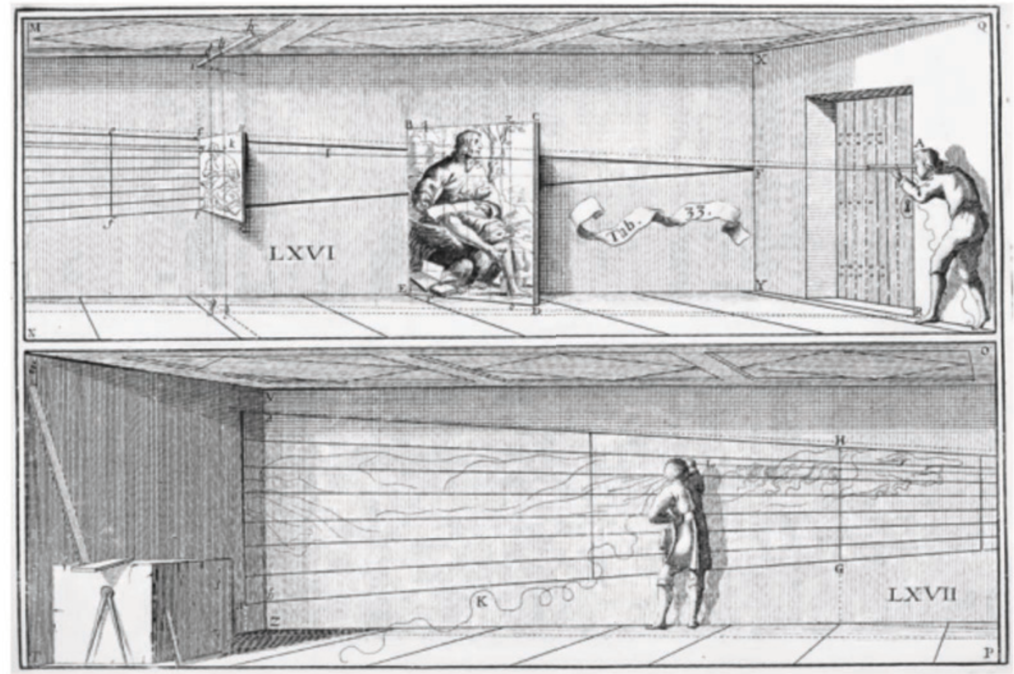


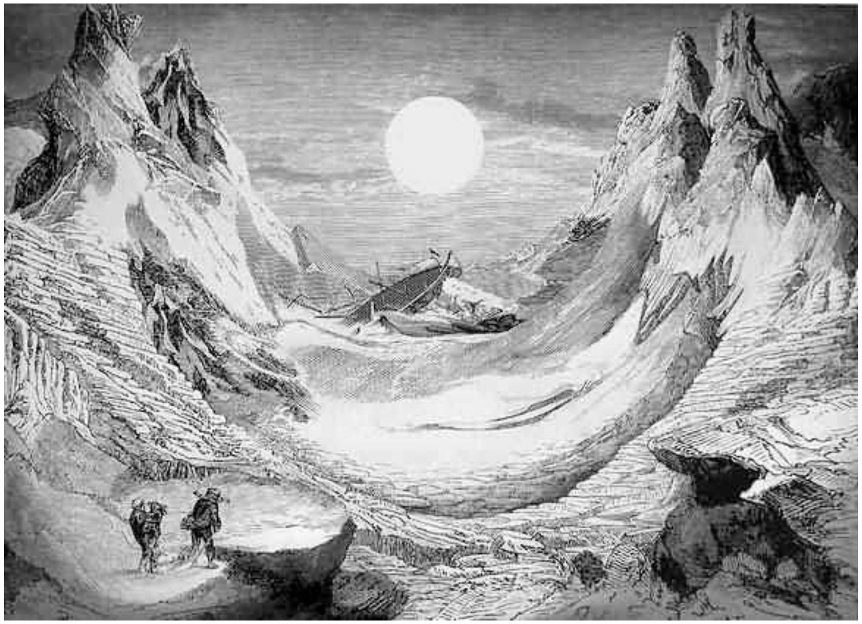
FIG. 5 – Anamorphic structure by J.F. Niceron, Thaumaturgus Opticus (Tab. 33, Fig. LXVI and LXVII), Paris, 1646.

Fig. 3. Hans Holbein, 1533, The Ambassadors, oil on panel with an anamorphic image of a skull in the bottom of the image

Fig. 4. The Skull – visualisation of the **flat surface** anamorph from *The Ambassadors*

Catoptric anamorphic images – Istvan Orosz, William Kentridge

(*Catoptric – phenomena of reflected light as in mirrors*)



Spatial Transfiguration: Anamorphic *Mixed-Reality* in the Virtual Reality Panorama

Abstract

Spatial illusion and immersion was achieved in Renaissance painting through the manipulation of linear perspective's pictorial conventions and painterly technique. The perceptual success of a painted trompe l'œil, its ability to fool the observer into believing they were viewing a real three-dimensional scene, was constrained by the limited immersive capacity of the two-dimensional painted canvas. During the baroque period however, artists began to experiment with the amalgamation of the 'real' space occupied by the observer together with the pictorial space enveloped by the painting's picture plane: real and pictorial space combined into one pictorial composition resulting in a hybridised 'mixed-reality'.[1] Today, the way architects, and designers generally, use the QuickTime Virtual Reality panorama to represent spaces of increasing visual density have much to learn from the way in which Renaissance and baroque artists manipulated the three-dimensional characteristics of the picture plane in order to offer more convincing spatial illusions. This paper outlines the conceptual development of the QuickTime VR panorama by Ken Turkowski and the Apple Advanced Technology Group during the late 1980s. Further, it charts the technical methods of the Virtual Reality panorama's creation in order to reflect upon the VR panorama's geometric construction and range and effectiveness of spatial illusion. Finally, through a brief analysis of Hans Holbein's Ambassadors [1533] and Andrea Pozzo's nave painting in Sant 'Ignazio [1691-94] this paper proposes an alternative conceptual model for the pictorial construction of the VR panorama that is innovatively based upon an anamorphic 'mixed-reality'.

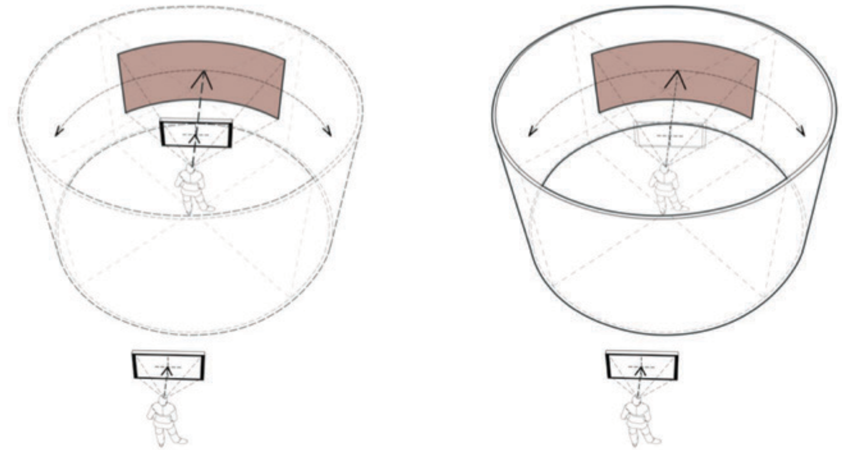


Fig.01 [above]
Cylindrical VR panorama interactivity diagram illustrating the panning of the drum around the observer, and their tele-present location at the drum's centre.

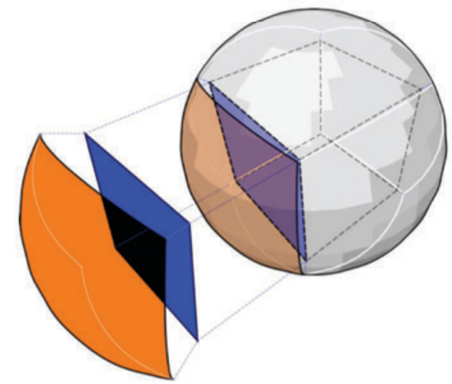


Fig.02 [right]
Diagram representing the translation of sptial information through anamorphosis, from the cube-based typological state to the sphere-based VR panorama.

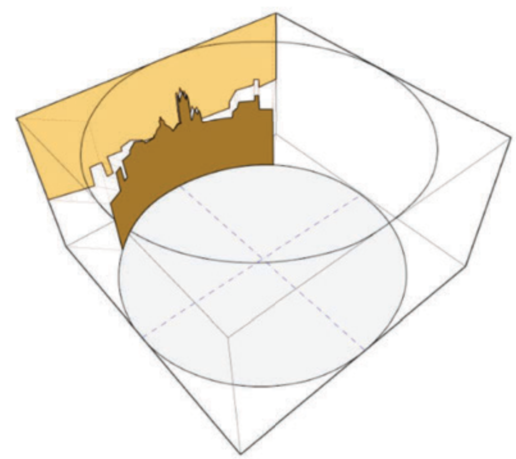
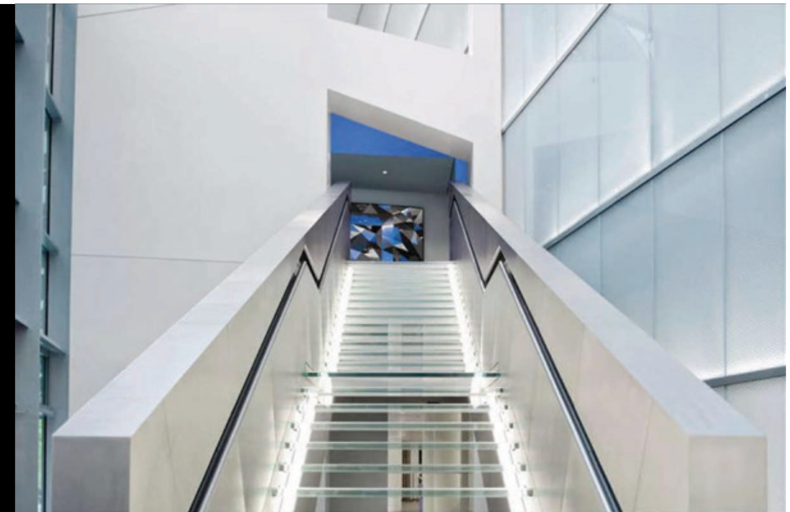
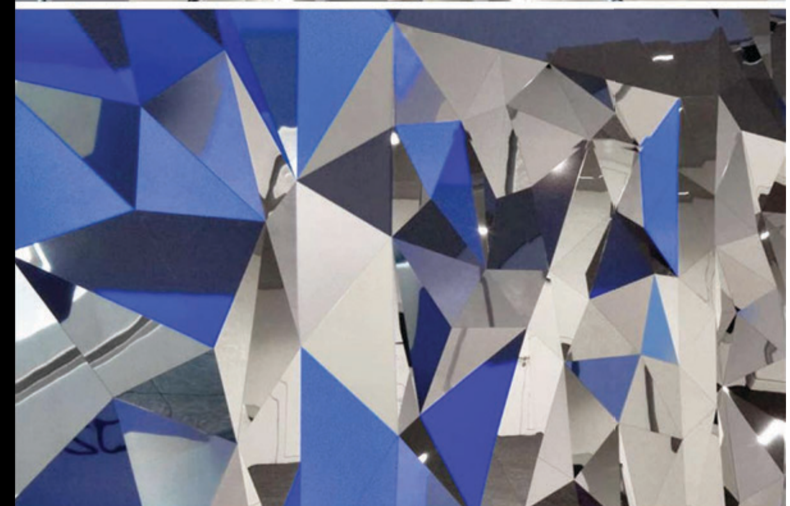
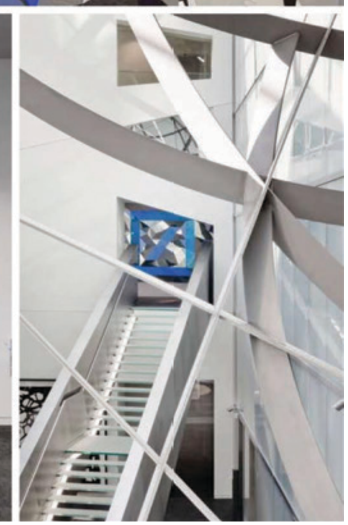


Fig.03 [right]
Diagram representing the anamorphic translation from the cyclinder-based typology to the cube-based typology. This diagram also represent the change in displacement from the central viewing position in the drum & cube's centre, to the outer surface fo the panorama's geometry.

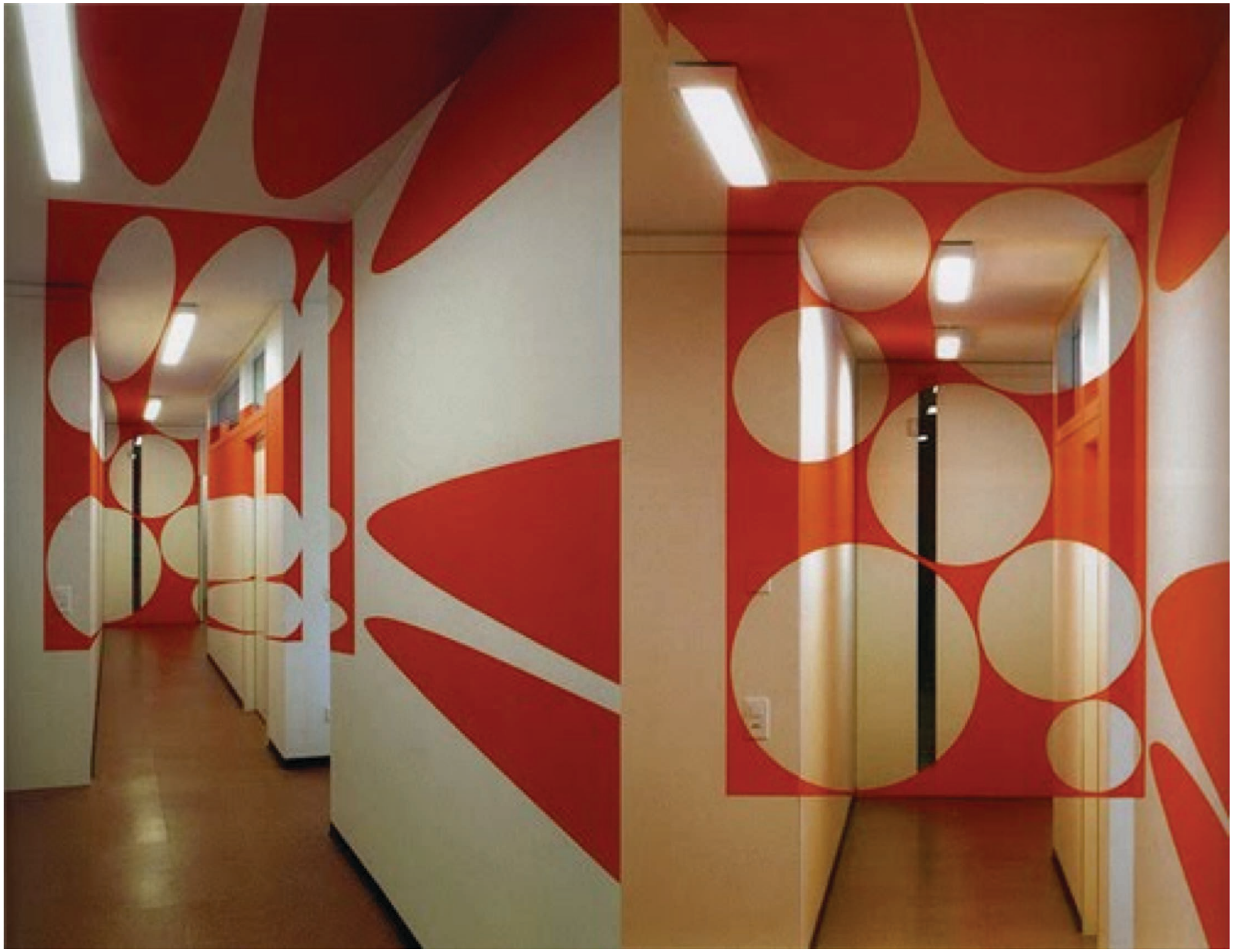
ART + COM https://vimeo.com/40081782

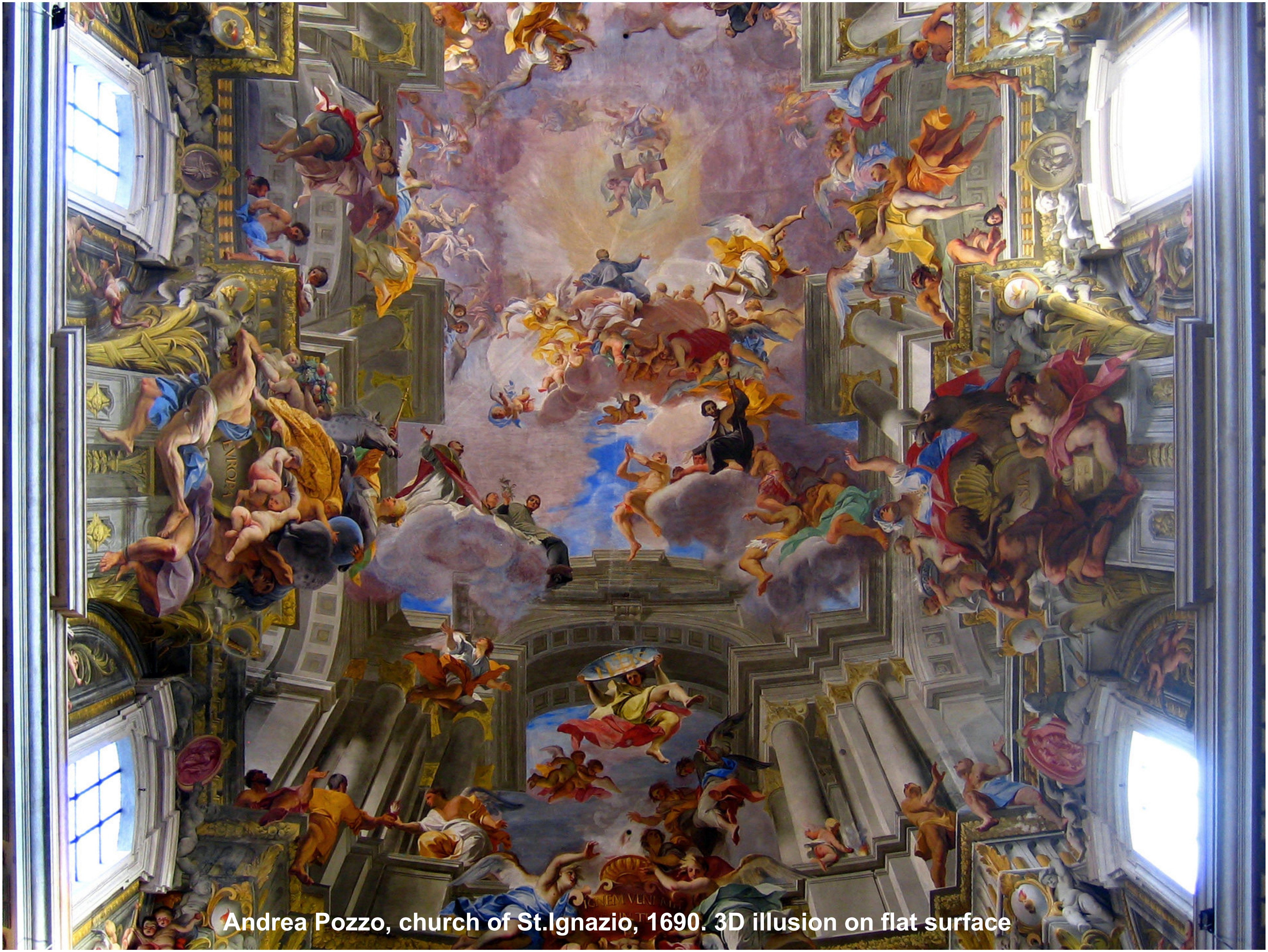






https://www.ecosia.org/images?p=1&q=anamorphic+rooms





Andrea Pozzo, church of St.Ignazio, 1690. 3D illusion on flat surface

Springer Link

Anamorphic Experiences in 3D Space: Shadows, Projections and Other Optical Illusions

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Didactics
First Online: 18 April 2016

Abstract

The paper presents recent research on the reconstruction of Anamorphic effects and other optical illusions, shadows and projections, with the use of CAD systems. The first part of the paper is a bibliographical overview about the appearance of optical illusions in art, ranging from the work of Niceron to the extravagant sculptures of contemporary artists such as Markus Raetz. The second part of the paper reports on an educational approach that introduces anamorphic geometries into the teaching of digital methods of representation at Graz University of Technology. There is an overview of the experiments and methodology for constructing optical illusions in a CAD environment as well as examples drawn from student projects. The paper concludes with some observations and remarks relating to the aforementioned educational experience.

Keywords

Projections Optical illusions CAD Didactics Art Anamorphosis Digital representations

Introduction

The understanding of space through diverse projections and the study of shadow has ordinarily formed part of the curriculum of architectural education. Courses of descriptive geometry traditionally taught with compass and straightedge, are currently enriched with digital media, introducing the ever-growing field of computational geometry. Based on this propaedia we are now moving a step further, utilizing a new vocabulary of anamorphic effects, optical illusions and anagrams which can result in fascinating spatial experiences. In this a game of perception a spectator in either physical or digital space might experience confusion or surprise walking through spaces that look different than what they really are! Nevertheless, the so-called "illusion" always comes down to simple geometric rules. All the aforementioned effects have a concrete geometric explanation. This paper presents research into examples of optical illusion and their digital reconstruction, and an educational process that attempts to understand, analyze, and construct optical illusions and visually ambiguous spaces.

Fig. 7

Digital 3D reconstruction of the *Hurwitz Singularity*, an anamorphic sculpture by Jonty Hurwitz modeled by the author

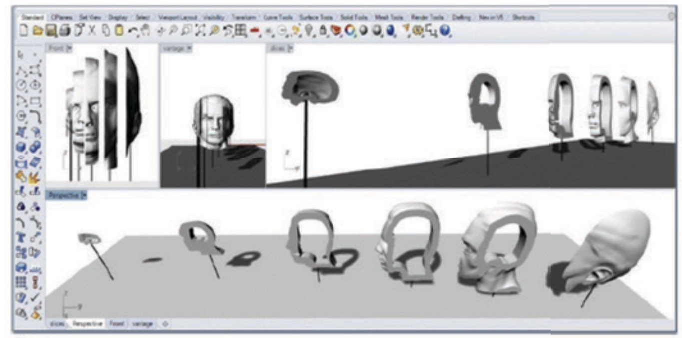

Fig. 8

Modeling process of the *Hurwitz Singularity* in Rhinoceros 3D. On the viewports we can observe the differences between the front view (a) and the perspective view through the *Vantage Point* (b), as well as side view (c) and tilted top view (d), where one can observe the reduction of size of the slices, so that the face is correctly seen from the *Vantage Point*

Another important aspect of optical illusions, and which also resulted in a series of exercises during this course, was the understanding of the geometry of shadow and the implementation of shadows in an architectural context to accentuate the volumetric configuration of a building. The study of shadows has traditionally formed part of the architectural curriculum, though before the introduction of digital media, the exercises undertaken by compass and straightedge were usually limited to simple volumes and common architectural elements such as columns, beams, inclined roofs, etc (Figs. 9, 10). It would require an extremely high level in descriptive geometry to calculate the shadow of a complex free-form structure onto an equally nonstandard background. However with the use of digital media, such calculations and geometric constructions can be done quickly and accurately. As the aim was to learn about the geometric construction of shadows and implement them in their projects, a new design motivation emerged. The students would calculate the shadows that a certain object casts on a non-standard background, and will utilize the shadow as a primitive for developing their own design from it.

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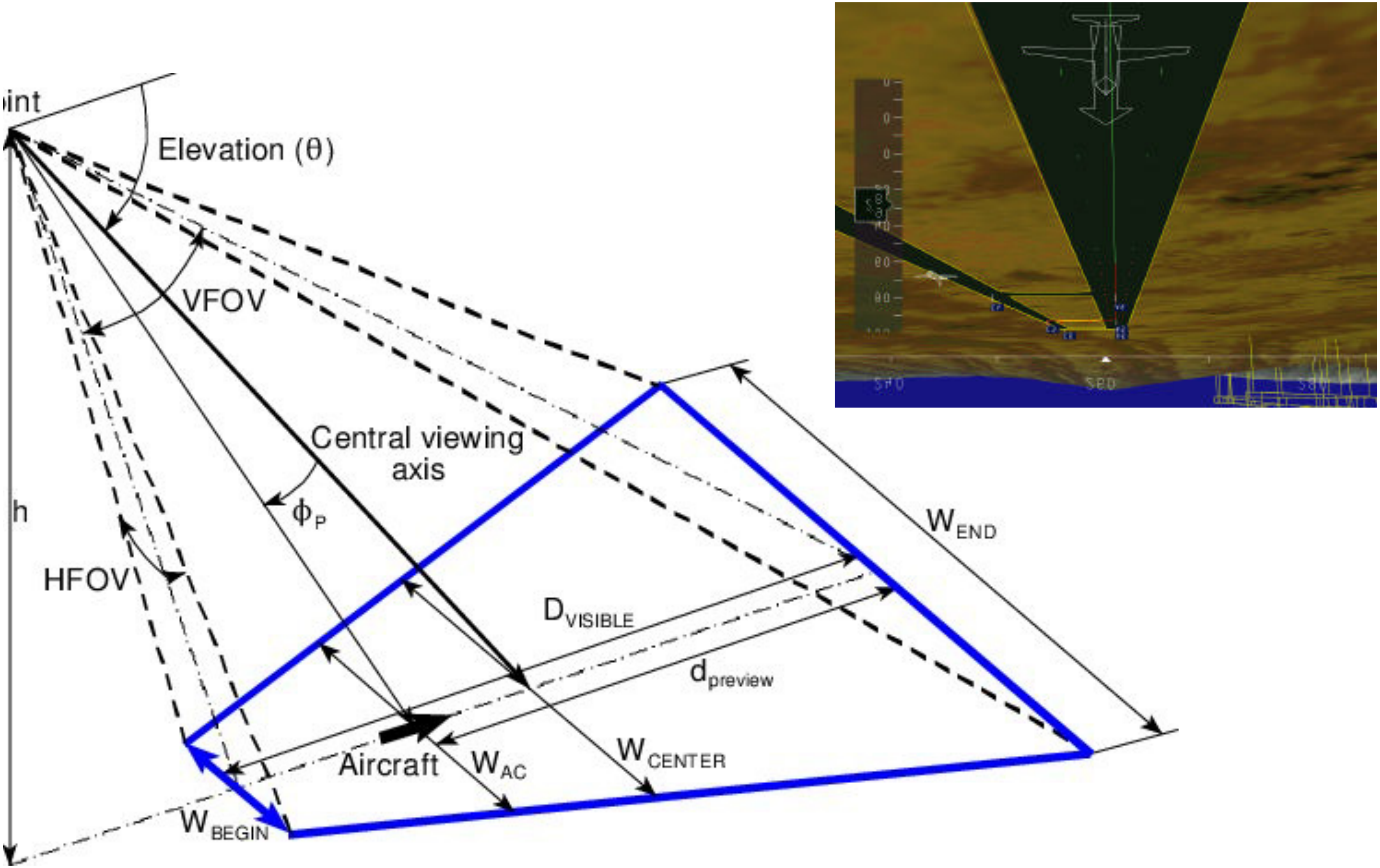
Constructed Scenes – Kilograph, Chaos Group

Exocentric Perspective (focused or centered on something outside of itself)



Example of an exocentric frame of reference. The shape and size of the visualized area can be controlled through the viewing distance, direction and the field of view (FOV).

Explanatory and Illustrative Visualization of Special and General Relativity

Daniel Weiskopf, *Member*, *IEEE Computer Society*, Marc Borchers,
Thomas Ertl, *Member*, *IEEE Computer Society*, Martin Falk, Oliver Fechtig, Regine Frank,
Frank Grave, Andreas King, Ute Kraus, Thomas Müller, Hans-Peter Nollert, Isabel Rica Mendez,
Hanns Ruder, Tobias Schafhitzel, Sonja Schär, Corvin Zahn, and Michael Zatloukal

Abstract—This paper describes methods for explanatory and illustrative visualizations used to communicate aspects of Einstein's theories of special and general relativity, their geometric structure, and of the related fields of cosmology and astrophysics. Our illustrations target a general audience of laypersons interested in relativity. We discuss visualization strategies, motivated by physics education and the didactics of mathematics, and describe what kind of visualization methods have proven to be useful for different types of media, such as still images in popular science magazines, film contributions to TV shows, oral presentations, or interactive museum installations. Our primary approach is to adopt an egocentric point of view: The recipients of a visualization participate in a visually enriched thought experiment that allows them to experience or explore a relativistic scenario. In addition, we often combine egocentric visualizations with more abstract illustrations based on an outside view in order to provide several presentations of the same phenomenon. Although our visualization tools often build upon existing methods and implementations, the underlying techniques have been improved by several novel technical contributions like image-based special relativistic rendering on GPUs, special relativistic 4D ray tracing for accelerating scene objects, an extension of general relativistic ray tracing to manifolds described by multiple charts, GPU-based interactive visualization of gravitational light deflection, as well as planetary terrain rendering. The usefulness and effectiveness of our visualizations are demonstrated by reporting on experiences with, and feedback from, recipients of visualizations and collaborators.

Index Terms—Visualization, explanatory computer graphics, illustrative visualization, special relativity, general relativity, astrophysics, visualization of mathematics, terrain rendering.

1 Introduction

Albert Einstein (1879-1955) was the first truly international pop star of science, and his popularity has never been matched by any other scientist since. In part, his popularity is certainly due to his extraordinary personality, appearance, and political engagement. Even more importantly, though, special and general relativity are concerned with concepts that everybody experiences in daily life, such as space, time, and light—at the same time engendering an aura of scientific complexity and paradoxical effects. Therefore, most people are both attracted to and appalled by Einstein's theories, which show that properties of space, time, and light in relativistic physics are dramatically different from those of our familiar environment governed by classical physics.

A major and typical problem in explaining special and general relativity to nonphysicists is a lack of mathematical background, especially in differential geometry. We strongly believe that visualization can be used to address this problem because it is an excellent means of conveying important aspects of Einstein's theories without the need for mathematical formalism. Our goal is to develop visualizations that are explanatory, illustrative, and pedagogical in nature. Our approach does not target data exploration, but the communication of ideas, theories, and phenomena to others. Although data and information exploration is the focus of most research efforts in the visualization community, we think that visual communication is an equally important aspect of visualization. Relativistic and astrophysical visualization is heavily based on mathematics, physics, and computer graphics and, therefore, is rooted in the tradition of scientific visualization.

We have shown a long-term commitment for relativistic visualization, with our group having started related research at the end of the 1980s [1], [2]. Over the years, we have been improving technical methods and didactical approaches for relativistic visualization. This paper reports on our experiences and it also contributes technical descriptions of algorithms. Our experiences are based on numerous visualization projects such as accompanying illustrations for

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For information on obtaining reprints of this article, please send e-mail to: tvcg@computer.org, and reference IEEECS Log Number TVCGSI-ERTL-1105.

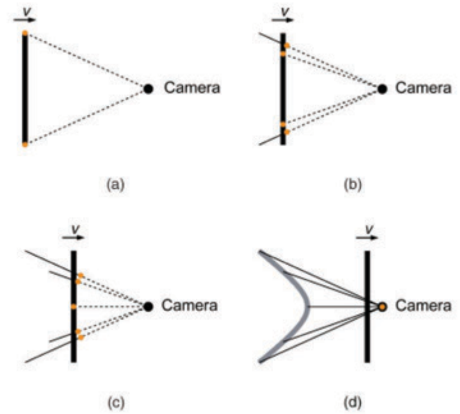

Fig. 9. Exocentric visualization of light propagation in a special relativistic setting. A rod is moving at constant speed to the right. The four images are snapshots of an animation that shows the position of the rod (thick vertical line) and the camera, as measured in the reference frame of the camera. Note that the measurement is performed simultaneously at different locations within the respective reference frame. Light propagation is illustrated for exemplary light rays: A thin, solid line indicates the distance covered by a light ray, an orange-colored dot marks the current position along a ray, a dashed line indicates the future positions. In image (d), the light rays are recorded at the same time by the camera, i.e., here the physical image construction takes place. By connecting the emission positions for the light rays, we can reconstruct the hyperbolic shape of the object as seen by the camera (thick light-gray line in image (d)). A related egocentric visualization is shown in Fig. 10. Based on a figure © 2002 U. Kraus.

GPU implementation on an ATI Radeon X800 XT GPU achieves some 70 fps for the simultaneous visualization on two output screens ($1,280 \times 768$ and $1,024 \times 768$), processing a $1,600 \times 1,200$ video input stream as background image in real time.

The user interface relies on direct manipulation. The black hole can be dragged on the touch-screen by using a finger, as shown in Fig. 8. At the lower part of the touch-screen, different background images can be chosen from a collection of stored astronomical pictures or from a camera covering the installation area. At the left part of the screen, the mass of the black hole can be modified by selecting different sizes of black hole icons. This restrictive and specialized interaction model is used to shift the flexibility-usability trade-off, inherent to any interactive system, toward high usability [28].

5 Exocentric Illustration and Multichannel Visualization

In addition to the egocentric visualization strategy, we selectively use exocentric approaches that are rooted in the tradition of mathematical visualization. An often-used type of exocentric visualization illustrates light propagation within special and general relativity from a third-person point of view. Fig. 9 shows a typical example for this kind of visualization. Here, a rod moves at constant speed toward

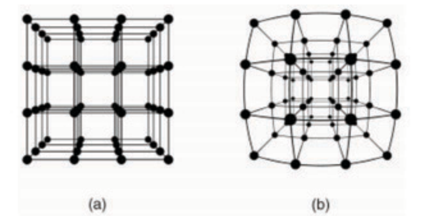

Fig. 10. Egocentric visualization of special relativistic motion of a cube-shaped lattice: (a) the lattice at rest and (b) the lattice approaching at $\beta = 0.9$. A related exocentric explanation of the hyperbolic shapes seen in the right image is given in Fig. 9. © 1999 D. Weiskopf.

the camera. This visualization is more abstract than the egocentric approach from Section 3 because of three reasons: 1) It shows positions of the rod as obtained from measurements, not through visual perception, 2) the pictures are not taken from the position of the camera, and 3) light propagation is shown as light-ray lines. Aspects 2) and 3) are not problematic with respect to the soundness of the visualization because similar abstractions are frequently used in many other illustrations so that the user is already familiar with them. Aspect 1) is more difficult because it involves the ability to distinguish between measurements (which are performed simultaneously at different locations within the same reference frame) and image generation (which is based on light that reaches the camera from the scene objects at the same time).

Therefore, such an exocentric visualization should be accompanied by some additional, explanatory text. Furthermore, we often combine egocentric visualizations with exocentric illustrations to achieve a multichannel visualization with tightly linked, separate views of the same scenario. Fig. 9 (exocentric) and Fig. 10 (egocentric) show a typical example. Through this combined presentation, the viewer can understand the apparent hyperbolic deformations of objects that are perpendicular to the direction of fast motion. Here, a sketchy "look-and-feel" is applied to the visual representation of both the egocentric and exocentric views, facilitating an easy mental connection between both views and emphasizing only the important visual elements. The implementation of this kind of exocentric view can reuse the algorithms for object-space special relativistic rendering (Section 3.1), which computes the same type of light paths.

We use a similar combined visualization of egocentric and exocentric views for other aspects of relativistic light propagation, including Lorentz contraction or time dilation within special relativity as well as gravitational light bending within general relativity. An example for the latter application is given in Fig. 5 and Fig. 8.

While the exocentric visualization of light rays is still very tightly related to the process of image synthesis, we have also explored more abstract visualizations. One example is a method for directly illustrating the concept of a curved space [29]. Traditionally, geometry is an important aspect of mathematical visualization [30], [31], [32]. Our approach is based on the principle of the Regge calculus, where a 4D curved spacetime is subdivided into

To be continued…