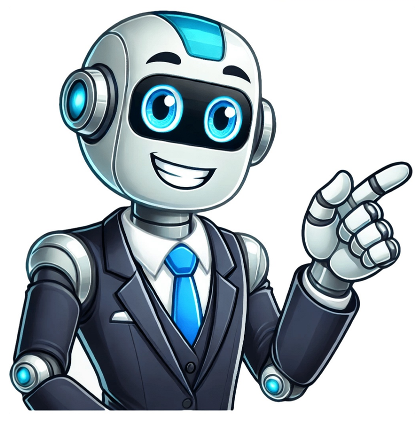

Orthographic projection, a fundamental technique used in technical drawing and engineering design, offers a systematic way to represent three-dimensional objects in two dimensions. While widely employed in various industries, orthographic projection also comes with its set of advantages and disadvantages. We'll delve into the pros and cons of orthographic projection, shedding light on its practical applications and limitations. Advantages of Orthographic Projection 1. Clarity and Precision One of the primary advantages of orthographic projection is its ability to depict objects with clarity and precision. By representing each side of an object separately and in true proportion, orthographic drawings provide detailed and accurate information about the object's dimensions, shapes, and features. This clarity is particularly beneficial in technical fields such as engineering, architecture, and manufacturing, where precise measurements are essential. 2. Standardization and Communication Orthographic projection follows standardized conventions and principles, making it universally understood by professionals across different disciplines and industries. This standardization facilitates clear communication and collaboration among team members, as orthographic drawings serve as a common language for conveying design ideas, specifications, and instructions. Additionally, orthographic projections can be easily interpreted by individuals with varying levels of technical expertise, enhancing communication efficiency. 3. Multiview Representation Orthographic projection allows for the creation of multiview drawings, wherein an object is depicted from multiple viewpoints (e.g., front, top, side). This comprehensive representation enables designers and engineers to visualize the object's form and spatial relationships from different angles, aiding in the analysis, evaluation, and refinement of design concepts. Multiview drawings provide valuable insights into how components fit together and function within a larger assembly, facilitating the design process. 4. Dimensional Analysis and Tolerancing Orthographic drawings facilitate dimensional analysis and tolerancing, essential aspects of quality control and manufacturing processes. Engineers and manufacturers can use orthographic projections to specify precise dimensions, tolerances, and geometric tolerancing symbols, ensuring that components are manufactured to the required specifications and fit together accurately. This capability helps minimize errors, reduce waste, and optimize the efficiency of production processes. Disadvantages of Orthographic Projection 1. Limited Visualization of 3D Objects While orthographic projection accurately represents the size and shape of objects in two dimensions, it lacks the ability to convey depth perception and spatial relationships effectively. As a result, orthographic drawings may not fully capture the three-dimensional characteristics of complex objects, leading to potential ambiguities or misinterpretations, especially for individuals unfamiliar with technical drawing conventions. 2. Time and Effort Creating orthographic drawings can be time-consuming and labor-intensive, particularly for objects with intricate geometries or numerous components. Drafting each view separately and ensuring alignment and consistency among multiple views require meticulous attention to detail and may prolong the design process. Additionally, revisions and modifications to orthographic drawings can be cumbersome, as changes must be applied to each view individually, increasing the likelihood of errors. 3. Skill and Training Requirements Proficiency in orthographic projection requires specialized knowledge and skills in technical drawing, geometry, and drafting techniques. Designers and engineers must undergo extensive training to master the principles of orthographic projection and adhere to industry standards and conventions. As a result, there may be a learning curve for individuals new to technical drawing, and inexperienced drafters may struggle to produce accurate and professional-quality orthographic drawings. Orthographic projection offers numerous advantages in technical drawing and engineering design, including clarity, standardization, multiview representation, and dimensional analysis. However, it also presents certain disadvantages, such as limited visualization of 3D objects, time and effort requirements, and skill and training prerequisites. By understanding the strengths and limitations of orthographic projection, professionals can effectively leverage this technique to communicate design intent, facilitate collaboration, and ensure the accuracy and integrity of engineering drawings and specifications. Orthographic projection is a type of projection or drawing method. Commercial drone companies like Fulcrum Air use it to create an image where the accompanying plane, such as a piece of paper or monitor screen, is parallel with the projected objects. Let's explore the different types of orthographic projection. The one-point perspective shows only one vanishing point on the horizon line. It uses mostly horizontal and vertical lines to give it a realistic look and feel because this type of projection best represents reality in images with all straight edges and 90-degree angles. One-point perspective is typically used for work viewed at eye level or below, which doesn't need much depth. This type would be beneficial to commercial drone companies such as architects and designers because they use a one-point perspective in their drawings of buildings. The two-point perspective has two vanishing points on the horizon line, with both on either side of the observer. This type of projection is best used for scenes above or below eye level, producing more dramatic results than one point perspective. If the viewer is looking up and down on an object which uses this method, it can look distorted because it's not meant to be viewed from a specific angle. An example would be if someone were standing over a square table and drawing it from above at an angle – a two-point perspective would be most beneficial for this situation. The three-point perspective consists of three vanishing situated along the horizon line, with one on either side of the observer just like the two-point perspective. This type is ideal for scenes above or below eye level but is set at an angle, such as looking at the front face of a cube standing up from its corner instead of straight on. This type shows true measurements of the object being drawn. It's best used by commercial drone companies to show how something would look if it were cut in half at any given axis, which may be represented by a vertical, horizontal, or diagonal line depending on what would make it easiest to read. This type uses three axes known as X, Y, and Z lines with fixed angles to give accurate measures while keeping all dimensions realistic based on how they'll be shown in the final product. Dimetric projection only has two axes known as X and Y, with fixed angles, unlike axonometric projection. This type is great for images where the object looks relatively similar from any angle, such as a wagon wheel or a table leg. It's most beneficial because it doesn't distort the image like one point perspective does when an object is viewed from an angle (such as looking at the front face of a cube standing up instead of straight on.) Parallel projections are the most common type of orthographic projection because they depict all six sides of an object in one view. The first step for drawing a parallel projection is to write down what you see. It should be noted that this projection does not show depth; it only shows what the front side looks like. Once this information has been written down, draw two perpendicular lines (at right angles) to each other. When working with large projectors, these two lines will act as guides for placing images on the screen. You can use a ruler to create guidelines for drawing blocks of colour on the paper with smaller objects. This type of orthographic projection is also called an oblique view or isometric view. An oblique direction is anywhere that isn't perpendicular (90 degrees) from another line. This means that all sides of an object are represented in one drawing at 30/60/90 degree angles to each other. The lines do not have to be exactly 30/60/90 degrees; they represent their relationship. Summary In conclusion, different types of orthographic projections are used for different purposes, such as one-point perspective for drawings that will be viewed at eye level or below and axonometric projection for drawings that would benefit from the most accurate measurements. The main purpose of using an orthographic projection is to accurately represent reality with straight edges and 90-degree angles. The standard orthographic projection method used in both the United States and Canada today is third-angle projection. This system is fundamental in engineering, manufacturing, and design, forming the basis for technical drawings used in production and communication. Understanding third-angle projection is crucial for anyone involved in these fields, as it dictates how different views of a three-dimensional object are represented on a two-dimensional plane. Understanding Third-Angle Projection In third-angle projection, imagine placing the object within a glass box, situated in the third quadrant of a coordinate system. The viewer's perspective is that of looking through the planes of this imaginary box, directly at the object. This means the projection planes come between the object and the observer. Each view is effectively projected onto the plane that is closest to it. This method results in the top view being placed above the front view, and the right-side view being placed to the right of the front view. The planes are considered transparent, allowing for the views to be projected as if the viewer is directly looking at the object from each face of the box. The key difference between third-angle and first-angle projection (common in Europe) lies in the placement of the object relative to the projection planes and the observer. In third angle projection, the planes are between the viewer and the object, resulting in a more intuitive representation where the top view is placed above the front view and the right side view is placed to the right of the front view, matching how one might naturally expect to see an object unfolded. This makes it easier to visualize the final object because the layout of the views corresponds with how the object would naturally appear when unfolded. Why Third-Angle Projection? The preference for third-angle projection in the US and Canada is largely rooted in its logical and intuitive layout. The placement of views – top above front, right side to the right – aligns with a natural understanding of object orientation. It is thought to be more user-friendly, particularly for those new to technical drawings and the communication of designs. While first angle may have historical roots in Europe, the third-angle system provides clarity and has ultimately become the favored standard in North America. Applications of Third-Angle Projection Third-angle projection is indispensable in various sectors: Engineering: Used for creating detailed drawings of machine parts, assemblies, and structures, allowing for accurate manufacturing and assembly. Manufacturing: Guides the fabrication process by providing precise dimensions and specifications for creating products. Architecture: Helps visualize building plans and layouts in a clear manner. Product Design: Assists designers in representing their products with accurate dimensions and views. Orthographic Projection vs. Other Projection Types It's essential to understand the distinction between orthographic projection and other projection methods. Orthographic Projection: This method uses parallel lines to project the object onto the plane, showing true shape and dimension but not depth. It is used for multi-view drawings that show the object from different viewpoints (top, front, side, etc.) and provides complete size, shape and feature details. Perspective Projection: Unlike orthographic, perspective projection takes into account vanishing points to create the illusion of depth. It closely mimics human vision but is not well suited for conveying precise dimensions. Isometric Projection: While technically a type of orthographic projection, isometric projection is a single-view method that shows three sides of an object with all axes equally scaled. It is used to communicate basic object details, but it can be less detailed than standard multi-view orthographic drawings. Standard Views in the US and Canada In the United States and Canada, when using third-angle projection, the standard orthographic views are typically the top view, front view, and the right-side view. This combination provides a comprehensive understanding of the object's three-dimensional shape. While there are six principal views (top, bottom, front, rear, left, and right), using the three standard views is often sufficient for clear communication in engineering drawings. Frequently Asked Questions (FAQs) 1. What is the difference between first and third-angle projection? The main difference lies in the placement of the object relative to the projection planes and the observer. In first-angle projection, the object is between the observer and the projection plane, resulting in the top view being placed below the front view. In third-angle projection, the projection plane is between the viewer and the object, resulting in the top view being placed above the front view. 2. Which angle projection is more common worldwide? While third-angle projection is the standard in the United States and Canada, first-angle projection is more common in Europe and many other parts of the world. 3. Why did the US choose third-angle projection? The preference for third-angle projection in the US is largely due to its logical and intuitive view layout. This makes it easier to understand and visualize the object being depicted. 4. What are the primary applications of orthographic projection? Orthographic projection is used extensively in engineering, manufacturing, architecture, and product design for creating detailed and dimensionally accurate technical drawings and diagrams. 5. Is orthographic projection conformal? No, orthographic projection is not conformal. It generally distorts shapes, areas, distances, directions, and angles, except at the center of the drawing. This makes it well-suited to communicating accurate dimensions but not necessarily to illustrating an overall layout where scale and shape need to be preserved. 6. What is the relationship between CAD and orthographic views? In CAD (Computer-Aided Design), orthographic views are fundamental for creating 3D models and 2D drawings. These views facilitate accurate design and manufacturing processes by providing precise and measurable representations of an object. 7. How many views are typically used in an orthographic drawing? While there are six possible views, the three standard views (top, front, and right side) are most commonly used in technical drawings within the United States and Canada for clarity and ease of communication. 8. Why are the projection planes considered transparent in third-angle projection? The concept of transparent projection planes helps visualize the view as if the object is being looked at directly through the plane. This simplifies how the different object faces are projected to form the overall drawing. 9. What does a '3 view drawing' refer to? A '3 view drawing' refers to an orthographic drawing that typically includes the top, front, and right-side views of an object, which are the standard views in the US and Canada, allowing for the object to be represented in enough detail for manufacturing purposes. 10. Is depth preserved in orthographic projection? No, orthographic projection does not preserve depth. The purpose of orthographic projection is to convey the true size and shape of the object from different viewpoints, but depth is not a primary focus. 11. What is the difference between orthographic and perspective viewpoints in CAD? Orthographic viewpoints do not use vanishing points and do not demonstrate depth, focusing on the accurate representation of dimensions. Perspective viewpoints, on the other hand, do use vanishing points and provide the illusion of depth, being closer to how the human eye perceives things. 12. Is third-angle projection used for maps? No, third-angle projection is not used for map projections. Map projections use different methods, such as Lambert conformal conic and transverse Mercator projections, which are designed to minimize distortion on the curved surface of the earth when represented on a flat plane. 13. How is the object positioned in third-angle projection? In third-angle projection, the object is positioned in the third quadrant, behind the vertical planes and below the horizontal plane in the imaginary box. 14. What do the construction lines in orthographic projection do? Construction lines help to precisely align the different views by showing where areas join together. This ensures that the drawing is accurate from all angles and helps with accurate dimensioning. 15. Why is a clear understanding of projection systems important in design? A clear understanding of both first and third angle projection systems is crucial to accurately communicate design ideas in technical drawings. This understanding ensures that designs are correctly interpreted by manufacturers and other relevant parties. Using the wrong projection method can lead to misinterpretations, which can be costly in both time and materials. Orthographic projection is a fundamental method of graphical representation used in engineering and technical drawings to accurately depict a three-dimensional object on a two-dimensional surface. In this projection system, the object is viewed along parallel lines that are perpendicular (normal) to the drawing plane, ensuring that the dimensions and proportions of the object are preserved without distortion. This approach allows each face of the object to be displayed in its true shape and size, making orthographic projection ideal for conveying precise geometric and dimensional information. Orthographic Projection (Third Angle) The essence of orthographic projection lies in the use of multiple views to represent the object. Commonly, this involves projecting the object onto three principal planes—typically referred to as the front, top, and side views. These views are arranged systematically on the drawing sheet, each offering a different perspective of the object. The front view shows the object's features as seen from the front, the top view displays how it looks from above, and the side view provides the profile. Together, these views provide a comprehensive understanding of the object's shape, size, and spatial relationships, allowing someone to visualize the complete form of the object without ambiguity. Resulting Views from the Above Orthographic Projection (Third Angle) An important aspect of orthographic projection is its adherence to conventions regarding the arrangement and alignment of views. For instance, in third-angle projection (commonly used in the United States), the top view is placed directly above the front view, while the right-side view is placed directly to the right of the front view. In first-angle projection (widely used in Europe and other parts of the world), the arrangement differs, with the views positioned in specific locations around the front view. These conventions are crucial for ensuring that the drawings are interpreted correctly, as they establish a standard reference for how the different views relate to one another. Third Angle Projection (Object in the Third Quadrant) One of the key advantages of orthographic projection is its ability to represent complex shapes with high accuracy. Since the lines of projection are parallel and perpendicular to the drawing plane, features such as edges, holes, and other details are depicted in their true dimensions. This accuracy is essential for manufacturing and construction processes, where precise measurements are critical for ensuring that parts fit together correctly. Orthographic projection also allows for the inclusion of detailed annotations, such as dimensions, tolerances, and surface finishes, further enhancing its utility as a technical communication tool. First Angle Projection (Not typically used in the United States). Overall, orthographic projection provides a clear and detailed representation of an object by breaking it down into multiple views, each showing a different aspect of its geometry. By avoiding perspective distortion and preserving true dimensions, orthographic projection ensures that the object's design intent is communicated accurately and unambiguously, making it an indispensable tool in engineering, architecture, and design. Lecture Slides Third-angle projection is a specific convention used in orthographic projection, primarily in the United States and other countries where American engineering standards are followed. It is one of the two main systems (the other being first-angle projection) for arranging the different views of an object on a drawing sheet to ensure a consistent and understandable...First-angle projection is another convention used in orthographic projection, predominantly in Europe and many other parts of the world. It is one of the two principal systems (the other being third-angle projection) for arranging views of an object on a drawing sheet. In first-angle projection, the way views are arranged is different from the third-angle...A miter (mitre, British) line in orthographic projection is a geometric construction tool used to help transfer measurements and alignments between different views, typically between the top and side views of an object. It facilitates the accurate placement of features such as edges, holes, or other design elements across multiple views, ensuring consistency in the...These worksheets are designed to be done by hand or instrument drawing on graph paper or in CAD. Complete the front, top, and right side view of the assigned component. Orthographic Projection Sheet 1Download Orthographic Projection Sheet 2Download Orthographic Projection Sheet 3Download Third-angle projection is a specific convention used in orthographic projection , primarily in the United... First-angle projection is another convention used in orthographic projection , predominantly in Europe... A miter (mitre, British) line in orthographic projection is a geometric construction tool used to help... These worksheets are designed to be done by hand or instrument drawing on graph paper or in CAD. Complete... Means of projecting three-dimensional objects in two dimensions For the orthographic projection as a map projection, see Orthographic map projection. For mathematical discussion in terms of linear algebra, see Projection (linear algebra). Part of a series onGraphical projection Planar projections Parallel projection Orthographic projection Isometric projection Oblique projection Perspective projection Curvilinear perspective Reverse perspective Views Bird's-eye view Cross section Cutaway drawing Exploded-view drawing Fisheye lens Multiviews Panorama Worm's-eye view Zoom lens Topics 3D projection Anamorphosis Axonometry Computer graphics Computer-aided design Descriptive geometry Engineering drawing Map projection Picture plane Plan (drawing) Projection (linear algebra) Projection plane Projective geometry Stereoscopy Technical drawing True length Vanishing point Video game graphics Viewing frustum vte Orthographic projection (also orthogonal projection and analemma)[a] is a means of representing three-dimensional objects in two dimensions. Orthographic projection is a form of parallel projection in which all the projection lines are orthogonal to the projection plane,[2] resulting in every plane of the scene appearing in affine transformation on the viewing surface. The obverse of an orthographic projection is an oblique projection, which is a parallel projection in which the projection lines are not orthogonal to the projection plane. The term orthographic sometimes means a technique in multiview projection in which principal axes or the planes of the subject are also parallel with the projection plane to create the primary views.[2] If the principal planes or axes of an object in an orthographic projection are not parallel with the projection plane, the depiction is called axonometric or an auxiliary views. (Axonometric projection is synonymous with parallel projection.) Sub-types of primary views include plans, elevations, and sections; sub-types of auxiliary views include isometric, dimetric, and trimetric projections. A lens that provides an orthographic projection is an object-space telecentric lens. Comparison of several types of graphical projection Various projections and how they are produced The three views. The percentages show the amount of foreshortening. A simple orthographic projection onto the plane z = 0 can be defined by the following matrix: P = [1 0 0 0 1 0 0 0 0] {\displaystyle P={\begin{bmatrix}1&0&0\\0&1&0\\0&0&0\\\end{bmatrix}}} For each point v = (vx, vy, vz), the transformed point Pv would be P v = [1 0 0 0 1 0 0 0 0] [v x v y v z] = [v x v y 0] {\displaystyle Pv={\begin{bmatrix}1&0&0\\0&1&0\\0&0&0\\\end{bmatrix}}{\begin{bmatrix}v_{x}\\v_{y}\\v_{z}\end{bmatrix}}={\begin{bmatrix}v_{x}\\v_{y}\\0\end{bmatrix}}} Often, it is more useful to use homogeneous coordinates. The transformation above can be represented for homogeneous coordinates as P = [1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1] {\displaystyle P={\begin{bmatrix}1&0&0&0\\0&1&0&0\\0&0&0&0\\0&0&0&1\end{bmatrix}}} For each homogeneous vector v = (vx, vy, vz, 1), the transformed vector Pv would be P v = [1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1] [v x v y v z 1] = [v x v y 0 1] {\displaystyle Pv={\begin{bmatrix}1&0&0&0\\0&1&0&0\\0&0&0&0\\0&0&0&1\end{bmatrix}}{\begin{bmatrix}v_{x}\\v_{y}\\v_{z}\\1\end{bmatrix}}={\begin{bmatrix}v_{x}\\v_{y}\\0\\1\end{bmatrix}}} In computer graphics, one of the most common matrices used for orthographic projection can be defined by a 6-tuple, (left, right, bottom, top, near, far), which defines the clipping planes. These planes form a box with the minimum corner at (left, bottom, -near) and the maximum corner at (right, top, -far).[3] The box is translated so that its center is at the origin, then it is scaled to the unit cube which is defined by having a minimum corner at (−1,−1,−1) and a maximum corner at (1,1,1). The orthographic transform can be given by the following matrix: P = [2 right − left 0 0 − right + left right − left 0 2 top − bottom 0 − top + bottom top − bottom 0 0 − 2 far − near − far + near far − near 0 0 0 1] {\displaystyle P={\begin{bmatrix}{\frac {2}{{\text{right}}-{\text{left}}}}&0&0&-{\frac {{\text{right}}+{\text{left}}}{{\text{right}}-{\text{left}}}}\\0&{\frac {2}{{\text{top}}-{\text{bottom}}}}&0&-{\frac {{\text{top}}+{\text{bottom}}}{{\text{top}}-{\text{bottom}}}}\\0&0&{\frac {-2}{{\text{far}}-{\text{near}}}}&-{\frac {{\text{far}}+{\text{near}}}{{\text{far}}-{\text{near}}}}\\0&0&0&1\end{bmatrix}}} which can be given as a scaling S followed by a translation T of the form P = S T = [2 right − left 0 0 0 0 2 top − bottom 0 0 0 0 2 far − near 0 0 0 0 1] [1 0 0 − left + right 2 0 1 0 − top + bottom 2 0 0 − 1 − far + near 2 0 0 0 1] {\displaystyle P=ST={\begin{bmatrix}{\frac {2}{{\text{right}}-{\text{left}}}}&0&0&0\\0&{\frac {2}{{\text{top}}-{\text{bottom}}}}&0&0\\0&0&{\frac {2}{{\text{far}}-{\text{near}}}}&0\\0&0&0&1\end{bmatrix}}{\begin{bmatrix}1&0&0&-{\frac {{\text{left}}+{\text{right}}}{2}}\\0&1&0&-{\frac {{\text{top}}+{\text{bottom}}}{2}}\\0&0&-1&-{\frac {{\text{far}}+{\text{near}}}{2}}\\0&0&0&1\end{bmatrix}}} The inversion of the projection matrix P−1, which can be used as the unprojection matrix is defined: P − 1 = [right − left 2 0 0 left + right 2 0 top − bottom 2 0 top + bottom 2 0 0 far − near − 2 − far + near 2 0 0 0 1] {\displaystyle P^{-1}={\begin{bmatrix}{\frac {{\text{right}}-{\text{left}}}{2}}&0&0&{\frac {{\text{left}}+{\text{right}}}{2}}\\0&{\frac {{\text{top}}-{\text{bottom}}}{2}}&0&{\frac {{\text{top}}+{\text{bottom}}}{2}}\\0&0&{\frac {{\text{far}}-{\text{near}}}{-2}}&-{\frac {{\text{far}}+{\text{near}}}{2}}\\0&0&0&1\end{bmatrix}}} Classification of Orthographic projection and some 3D projections Three sub-types of orthographic projection are isometric projection, dimetric projection, and trimetric projection, depending on the exact angle at which the view deviates from the orthogonal.[2][4] Typically in axonometric drawing, as in other types of pictorials, one axis of space is shown to be vertical. In isometric projection, the most commonly used form of axonometric projection in engineering drawing,[5] the direction of viewing is such that the three axes of space appear equally foreshortened, and there is a common angle of 120° between them. As the distortion caused by foreshortening is uniform, the proportionality between lengths is preserved, and the axes share a common scale; this eases one's ability to take measurements directly from the drawing. Another advantage is that 120° angles are easily constructed using only a compass and straightedge. In dimetric projection, the direction of viewing is such that two of the three axes of space appear equally foreshortened, of which the attendant scale and angles of presentation are determined according to the angle of viewing; the scale of the third direction is determined separately. In trimetric projection, the direction of viewing is such that all of the three axes of space appear unequally foreshortened. The scale along each of the three axes and the angles among them are determined separately as dictated by the angle of viewing. Trimetric perspective is seldom used in technical drawings.[4] Symbols used to define whether a multiview projection is either third-angle (right) or first-angle (left) Main article: Multiview projection In multiview projection, up to six pictures of an object are produced, called primary views, with each projection plane parallel to one of the coordinate axes of the object. The views are positioned relative to each other according to either of two schemes: first-angle or third-angle projection. In each, the appearances of views may be thought of as being projected onto planes that form a six-sided box around the object. Although six different sides can be drawn, usually three views of a drawing give enough information to make a three-dimensional object. These views are known as front view (also elevation), top view (also plan) and end view (also section). When the plane or axis of the object depicted is not parallel to the projection plane, and where multiple sides of an object are visible in the same image, it is called an auxiliary view. Thus isometric projection, dimetric projection and trimetric projection would be considered auxiliary views in multiview projection. A typical characteristic of multiview projection is that one axis of space is usually displayed as vertical. Main article: Orthographic projection in cartography Orthographic projection (equatorial aspect) of eastern hemisphere 30°W–150°E An orthographic projection map is a map projection of cartography. Like the stereographic projection and gnomonic projection, orthographic projection is a perspective (or azimuthal) projection, in which the sphere is projected onto a tangent plane or secant plane. The point of perspective for the orthographic projection is at infinite distance. It depicts a hemisphere of the globe as it appears from outer space, where the horizon is a great circle. The shapes and areas are distorted, particularly near the edges.[6][7] The orthographic projection has been known since antiquity, with its cartographic uses being well documented. Hipparchus used the projection in the 2nd century BC to determine the places of star-rise and star-set. In about 14 BC, Roman engineer Marcus Vitruvius Pollio used the projection to construct sundials and to compute sun positions.[7] Vitruvius also seems to have devised the term orthographic – from the Greek orthos ("straight") and graphē ("drawing") – for the projection. However, the name analemma, which also meant a sundial showing latitude and longitude, was the common name until François d'Aguilon of Antwerp promoted its present name in 1613.[7] The earliest surviving maps on the projection appear as woodcut drawings of terrestrial globes of 1509 (anonymous), 1533 and 1551 (Johannes Schöner), and 1524 and 1551 (Apian).[7] ^ This usage is obsolete; the common meaning of "analemma" is a diagram of the position of the Sun from the Earth.[1] ^ Sawyer, F., Of Analemmas, Mean Time and the Analemmatic Sundial ^ a b c Maynard, Patric (2005). Drawing Distinctions: The Varieties of Graphic Expression. Cornell University Press. p. 22. ISBN 0-8014-7280-6. ^ Thormählen, Thorsten (November 26, 2021). "Graphics Programming – Cameras: Parallel Projection – Part 6, Chapter 2". Mathematik Uni Marburg. pp. 8 ff. Retrieved 2022-04-22. ^ a b McReynolds, Tom; David Blythe (2005). Advanced graphics programming using openGL. Elsevier. p. 502. ISBN 1-55860-659-9. ^ Godse, Atul P. (1984). Computer graphics. Technical Publications. p. 29. ISBN 81-8431-558-9. ^ Snyder, J. P. (1987). Map Projections—A Working Manual (US Geologic Survey Professional Paper 1395). Washington, D.C.: US Government Printing Office. pp. 145–153. ^ a b c d Snyder, John P. (1993). Flattening the Earth: Two Thousand Years of Map Projections pp. 16–18. Chicago and London: The University of Chicago Press. ISBN 0-226-76746-9. Wikimedia Commons has media related to Orthographic projections. Normale (orthogonale) Axonometrie (in German) Orthographic Projection Video and mathematics Retrieved from " 2Design technique For other uses, see Projection (disambiguation). This article's lead section may be too short to adequately summarize the key points. Please consider expanding the lead to provide an accessible overview of all important aspects of the article. (July 2019) Classification of some 3D projectionsPart of a series onGraphical projection Planar projections Parallel projection Orthographic projection Isometric projection Oblique projection Perspective projection Curvilinear perspective Reverse perspective Views Bird's-eye view Cross section Cutaway drawing Exploded-view drawing Fisheye lens Multiviews Panorama Worm's-eye view Zoom lens Topics 3D projection Anamorphosis Axonometry Computer graphics Computer-aided design Descriptive geometry Engineering drawing Map projection Picture plane Plan (drawing) Projection (linear algebra) Projection plane Projective geometry Stereoscopy Technical drawing True length Vanishing point Video game graphics Viewing frustum vte A 3D projection (or graphical projection) is a design technique used to display a three-dimensional (3D) object on a two-dimensional (2D) surface. These projections rely on visual perspective and aspect analysis to project a complex object for viewing capability on a simpler plane. 3D projections use the primary qualities of an object's basic shape to create a map of points, that are then connected to one another to create a visual element. The result is a graphic that contains conceptual properties to interpret the figure or image as not actually flat (2D), but rather, as a solid object (3D) being viewed on a 2D display. 3D objects are largely displayed on two-dimensional mediums (such as paper and computer monitors). As such, graphical projections are a commonly used design element; notably, in engineering drawing, drafting, and computer graphics. Projections can be calculated through employment of mathematical analysis and formulae, or by using various geometric and optical techniques. Several types of graphical projection compared Various projections and how they are produced In order to display a three-dimensional (3D) object on a two-dimensional (2D) surface, a projection transformation is applied to the 3D object using a projection matrix. This transformation removes information in the third dimension while preserving it in the first two. See Projective Geometry for more details. If the size and shape of the 3D object should not be distorted by its relative position to the 2D surface, a parallel projection may be used. Examples of parallel projections: Multiview projection (elevation) Isometric projection Military projection Cabinet projection If the 3D perspective of an object should be preserved on a 2D surface, the transformation must include scaling and translation based on the object's relative position to the 2D surface. This process is called perspective projection. Examples of perspective projections: One-point perspective Two-point perspective Three-point perspective Main article: Parallel projection Parallel projection corresponds to a perspective projection with a hypothetical viewpoint; i.e. one where the camera lies an infinite distance away from the object and has an infinite focal length, or "zoom". In parallel projection, the lines of sight from the object to the projection plane are parallel to each other. Thus, lines that are parallel in three-dimensional space remain parallel in the two-dimensional projected image. Parallel projection also corresponds to a perspective projection with an infinite focal length (the distance from a camera's lens and focal point), or "zoom". Images drawn in parallel projection rely upon the technique of axonometry ("to measure along axes"), as described in Pohlke's theorem. In general, the resulting image is oblique (the rays are not perpendicular to the image plane); but in special cases the result is orthographic (the rays are perpendicular to the image plane). Axonometry should not be confused with axonometric projection, as in English literature the latter usually refers only to a specific class of pictorials (see below). Main article: Orthographic projection See also: Geometric transformation The orthographic projection is derived from the principles of descriptive geometry and is a two-dimensional representation of a three-dimensional object. It is a parallel projection (the lines of projection are parallel both in reality and in the projection plane). It is the projection type of choice for working drawings. If the normal of the viewing plane (the camera direction) is parallel to one of the primary axes (which is the x, y, or z axis), the mathematical transformation is as follows; To project the 3D point a x {\displaystyle a_{x}} , a y {\displaystyle a_{y}} , a z {\displaystyle a_{z}} onto the 2D point b x {\displaystyle b_{x}} , b y {\displaystyle b_{y}} using an orthographic projection parallel to the y axis (where positive y represents forward direction - profile view), the following equations can be used: b x = s x a x + c x {\displaystyle b_{x}=s_{x}a_{x}+c_{x}} b y = s z a z + c z {\displaystyle b_{y}=s_{z}a_{z}+c_{z}} where the vector s is an arbitrary scale factor, and c is an arbitrary offset. These constants are optional, and can be used to properly align the viewport. Using matrix multiplication, the equations become: [b x b y] = [s x 0 0 0 0 s z] [a x a y a z] + [c x c z] . {\displaystyle {\begin{bmatrix}b_{x}\\b_{y}\end{bmatrix}}={\begin{bmatrix}s_{x}&0&0\\0&0&s_{z}\end{bmatrix}}{\begin{bmatrix}a_{x}\\a_{y}\\a_{z}\end{bmatrix}}+{\begin{bmatrix}c_{x}\\c_{z}\end{bmatrix}}.} While orthographically projected images represent the three dimensional nature of the object projected, they do not represent the object as it would be recorded photographically or perceived by a viewer observing it directly. In particular, parallel lengths at all points in an orthographically projected image are of the same scale regardless of whether they are far away or near to the virtual viewer. As a result, lengths are not foreshortened as they would be in a perspective projection. Main article: Multiview projection Symbols used to define whether a multiview projection is either First Angle (left) or Third Angle (right). With multiview projections, up to six pictures (called primary views) of an object are produced, with each projection plane parallel to one of the coordinate axes of the object. The views are positioned relative to each other according to either of two schemes: first-angle or third-angle projection. In each, the appearances of views may be thought of as being projected onto planes that form a 6-sided box around the object. Although six different sides can be drawn, usually three views of a drawing give enough information to make a 3D object. These views are known as front view, top view, and end view. The terms elevation, plan and section are also used. Main article: Oblique projection Potting bench drawn in cabinet projection with an angle of 45° and a ratio of 2/3Stone arch drawn in military perspective In oblique projections the parallel projection rays are not perpendicular to the viewing plane as with orthographic projection, but strike the projection plane at an angle other than ninety degrees. In both orthographic and oblique projection, parallel lines in space appear parallel on the projected image. Because of its simplicity, oblique projection is used exclusively for pictorial purposes rather than for formal, working drawings. In an oblique pictorial drawing, the displayed angles among the axes as well as the foreshortening factors (scale) are arbitrary. The distortion created thereby is usually attenuated by aligning one plane of the imaged object to be parallel with the plane of projection thereby creating a true shape, full-size image of the chosen plane. Special types of oblique projections are: In cavalier projection (sometimes cavalier perspective or high view point) a point of the object is represented by three coordinates, x, y and z. On the drawing, it is represented by only two coordinates, x″ and y″. On the flat drawing, two axes, x and z on the figure, are perpendicular and the length on these axes are drawn with a 1:1 scale; it is thus similar to the dimetric projections, although it is not an axonometric projection, as the third axis, here y, is drawn in diagonal, making an arbitrary angle with the x″ axis, usually 30 or 45°. The length of the third axis is not scaled. The term cabinet projection (sometimes cabinet perspective) stems from its use in illustrations by the furniture industry.[citation needed] Like cavalier perspective, one face of the projected object is parallel to the viewing plane, and the third axis is projected as going off in an angle (typically 30° or 45° or arctan(2) = 63.4°). Unlike cavalier projection, where the third axis keeps its length, with cabinet projection the length of the receding lines is cut in half. A variant of oblique projection is called military projection. In this case, the horizontal sections are isometrically drawn so that the floor plans are not distorted and the verticals are drawn at an angle. The military projection is given by rotation in the xy-plane and a vertical translation an amount z.[1] Main article: Axonometric projection The three axonometric views, here of cabinetry Axonometric projections show an image of an object as viewed from a skew direction in order to reveal all three directions (axes) of space in one picture.[2] Axonometric projections may be either orthographic or oblique. Axonometric instrument drawings are often used to approximate graphical perspective projections, but there is attendant distortion in the approximation. Because pictorial projections innately contain this distortion, in instrument drawings of pictorials great liberties may then be taken for economy of effort and best effect.[clarification needed] Axonometric projection is further subdivided into three categories: isometric projection, dimetric projection, and trimetric projection, depending on the exact angle at which the view deviates from the orthogonal.[3][4] A typical characteristic of orthographic pictorials is that one axis of space is usually displayed as vertical. In isometric pictorials (for methods, see Isometric projection), the direction of viewing is such that the three axes of space appear equally foreshortened, and there is a common angle of 120° between them. The distortion caused by foreshortening is uniform, therefore the proportionality of all sides and lengths are preserved, and the axes share a common scale. This enables measurements to be read or taken directly from the drawing. In dimetric pictorials (for methods, see Dimetric projection), the direction of viewing is such that two of the three axes of space appear equally foreshortened, of which the attendant scale and angles of presentation are determined according to the angle of viewing; the scale of the third direction (vertical) is determined separately. Approximations are common in dimetric drawings. In trimetric pictorials (for methods, see Trimetric projection), the direction of viewing is such that all of the three axes of space appear unequally foreshortened. The scale along each of the three axes and the angles among them are determined separately as dictated by the angle of viewing. Approximations in Trimetric drawings are common. See also: Impossible object An example of the limitations of isometric projection. The height difference between the red and blue balls cannot be determined locally.The Penrose stairs depicts a staircase which seems to ascend (anticlockwise) or descend (clockwise) yet forms a continuous loop. Objects drawn with parallel projection do not appear larger or smaller as they extend closer to or away from the viewer. While advantageous for architectural drawings, where measurements must be taken directly from the image, the result is a perceived distortion, since unlike perspective projection, this is not how our eyes or photography normally work. It also can easily result in situations where depth and altitude are difficult to gauge, as is shown in the illustration to the right. In this isometric drawing, the blue sphere is two units higher than the red one. However, this difference in elevation is not apparent if one covers the right half of the picture, as the boxes (which serve as clues suggesting height) are then obscured. This visual ambiguity has been exploited in op art, as well as "impossible object" drawings. M. C. Escher's Waterfall (1961), while not strictly utilizing parallel projection, is a well-known example, in which a channel of water seems to travel unaided along a downward path, only to then paradoxically fall once again as it returns to its source. The water thus appears to disobey the law of conservation of energy. An extreme example is depicted in the film Inception, where by a forced perspective trick an immobile stairway changes its connectivity. The video game Fez uses tricks of perspective to determine where a player can and cannot move in a puzzle-like fashion. See also: Perspective (graphical), Transformation matrix, and Camera matrix Perspective of a geometric solid using two vanishing points. In this case, the map of the solid (orthogonal projection) is drawn below the perspective, as if bending the ground plane. Axonometric projection of a scheme displaying the relevant elements of a vertical picture plane perspective. The standing point (P.S.) is located on the ground plane π, and the point of view (P.V.) is right above it. P.P. is its projection on the picture plane α. L.O. and L.T. are the horizon and the ground lines (linea d'orizzonte and linea di terra). The bold lines s and q lie on π, and intercept α at Ts and Tq respectively. The parallel lines through P.V. (in red) intercept L.O. in the vanishing points Fs and Fq: thus one can draw the projections s′ and q′, and hence also their intersection R′ on R. Perspective projection or perspective transformation is a projection where three-dimensional objects are projected on a picture plane. This has the effect that distant objects appear smaller than nearer objects. It also means that lines which are parallel in nature (that is, meet at the point at infinity) appear to intersect in the projected image. For example, if railways are pictured with perspective projection, they appear to converge towards a single point, called the vanishing point. Photographic lenses and the human eye work in the same way, therefore the perspective projection looks the most realistic.[5] Perspective projection is usually categorized into one-point, two-point and three-point perspective, depending on the orientation of the projection plane towards the axes of the depicted object.[6] Graphical projection methods rely on the duality between lines and points, whereby two straight lines determine a point while two points determine a straight line. The orthogonal projection of the eye point onto the picture plane is called the principal vanishing point (P.P. in the scheme on the right, from the Italian term punto principale, coined during the renaissance).[7] Two relevant points of a line are: its intersection with the picture plane, and its vanishing point, found at the intersection between the parallel line from the eye point and the picture plane. The principal vanishing point is the vanishing point of all horizontal lines perpendicular to the picture plane. The vanishing points of all horizontal lines lie on the horizon line. If, as is often the case, the picture plane is vertical, all vertical lines are drawn vertically, and have no finite vanishing point on the picture plane. Various graphical methods can be easily envisaged for projecting geometrical scenes. For example, lines traced from the eye point at 45° to the picture plane intersect the latter along a circle whose radius is the distance of the eye point from the plane, thus tracing that circle aids the construction of all the vanishing points of 45° lines; in particular, the intersection of that circle with the horizon line consists of two distance points. They are useful for drawing chessboard floors which, in turn, serve for locating the base of objects on the scene. In the perspective of a geometric solid on the right, after choosing the principal vanishing point —which determines the horizon line— the 45° vanishing point on the left side of the drawing completes the characterization of the (equally distant) point of view. Two lines are drawn from the orthogonal projection of each vertex, one at 45° and one at 90° to the picture plane. After intersecting the ground line, those lines go toward the distance point (for 45°) or the principal point (for 90°). Their new intersection locates the projection of the map. Natural heights are measured above the ground line and then projected in the same way until they meet the vertical from the map. While orthographic projection ignores perspective to allow accurate measurements, perspective projection shows distant objects as smaller to provide additional realism. The perspective projection requires a more involved definition as compared to orthographic projections. A conceptual aid to understanding the mechanics of this projection is to imagine the 2D projection as though the object(s) are being viewed through a camera viewfinder. The camera's position, orientation, and field of view control the behavior of the projection transformation. The following variables are defined to describe this transformation: a x , y , z {\displaystyle \mathbf {a} _{x,y,z}} – the 3D position of a point A that is to be projected c x , y , z {\displaystyle \mathbf {c} _{x,y,z}} – the 3D position of a point C representing the camera θ x , y , z {\displaystyle \mathbf {\theta } _{x,y,z}} – The orientation of the camera (represented by Tait–Bryan angles) e x , y , z {\displaystyle \mathbf {e} _{x,y,z}} – the display surface's position relative to aforementioned c {\displaystyle \mathbf {c} } [8] Most conventions use positive z values (the plane being in front of the pinhole c {\displaystyle \mathbf {c} }), however negative z values are physically more correct, but the image will be inverted both horizontally and vertically. Which results in: b x , y {\displaystyle \mathbf {b} _{x,y}} – the 2D projection of a . {\displaystyle \mathbf {a} .} When c x , y , z = (0 , 0 , 0) , {\displaystyle \mathbf {c} _{x,y,z}=\langle 0,0,0\rangle ,} and θ x , y , z = (0 , 0 , 0) , {\displaystyle \mathbf {\theta } _{x,y,z}=\langle 0,0,0\rangle ,} the 3D vector ⟨ 1 , 2 , 0 ⟩ {\displaystyle \langle 1,2,0\rangle } is projected to the 2D vector ⟨ 1 , 2 ⟩ {\displaystyle \langle 1,2\rangle } . Otherwise, to compute b x , y {\displaystyle \mathbf {b} _{x,y}} we first define a vector d x , y , z {\displaystyle \mathbf {d} _{x,y,z}} as the position of point A with respect to a coordinate system defined by the camera, with origin in C and rotated by θ {\displaystyle \mathbf {\theta } } with respect to the initial coordinate system. This is achieved by subtracting c {\displaystyle \mathbf {c} } from a {\displaystyle \mathbf {a} } and then applying a rotation by − θ {\displaystyle -\mathbf {\theta } } to the result. This transformation is often called a camera transform, and can be expressed as follows, expressing the rotation in terms of rotations about the x, y, and z axes (these calculations assume that the axes are ordered as a left-handed system of axes): [9] [10] [d x d y d z] = [1 0 0 0 cos ⁡ (θ x) sin ⁡ (θ x) 0 − sin ⁡ (θ x) cos ⁡ (θ x)] [cos ⁡ (θ y) 0 − sin ⁡ (θ y) 0 1 0 sin ⁡ (θ y) 0 cos ⁡ (θ y)] [cos ⁡ (θ z) sin ⁡ (θ z) 0 − sin ⁡ (θ z) cos ⁡ (θ z) 0 0 0 1] ([a x a y a z] − [c x c y c z]) {\displaystyle {\begin{bmatrix}\mathbf {d} _{x}\\\mathbf {d} _{y}\\\mathbf {d} _{z}\end{bmatrix}}={\begin{bmatrix}1&0&0\\0&{\cos(\mathbf {\theta } _{x})}&{\sin(\mathbf {\theta } _{x})}\\0&{-\sin(\mathbf {\theta } _{x})}&{\cos(\mathbf {\theta } _{x})}\end{bmatrix}}{\begin{bmatrix}{\cos(\mathbf {\theta } _{y})}&0&{-\sin(\mathbf {\theta } _{y})}\\0&1&0\\{\sin(\mathbf {\theta } _{y})}&0&{\cos(\mathbf {\theta } _{y})}\end{bmatrix}}{\begin{bmatrix}{\cos(\mathbf {\theta } _{z})}&{\sin(\mathbf {\theta } _{z})}&0\\{-\sin(\mathbf {\theta } _{z})}&{\cos(\mathbf {\theta } _{z})}&0\\0&0&1\end{bmatrix}}\left({{\begin{bmatrix}\mathbf {a} _{x}\\\mathbf {a} _{y}\\\mathbf {a} _{z}\\\end{bmatrix}}-{\begin{bmatrix}\mathbf {c} _{x}\\\mathbf {c} _{y}\\\mathbf {c} _{z}\\\end{bmatrix}}}\right)} This representation corresponds to rotating by three Euler angles (more properly, Tait–Bryan angles), using the xyz convention, which can be interpreted either as "rotate about the extrinsic axes (axes of the scene) in the order z, y, x (reading right-to-left)" or "rotate about the intrinsic axes (axes of the camera) in the order x, y, z (reading left-to-right)". If the camera is not rotated (θ x , y , z = ⟨ 0 , 0 , 0 ⟩ {\displaystyle \mathbf {\theta } _{x,y,z}=\langle 0,0,0\rangle }), then the matrices drop out (as identities), and this reduces to simply a shift: d = a − c . {\displaystyle \mathbf {d} =\mathbf {a} -\mathbf {c} .} Alternatively, without using matrices (let us replace a x − c x {\displaystyle a_{x}-c_{x}} with x {\displaystyle \mathbf {x} } and so on, and abbreviate cos ⁡ (θ α) {\displaystyle \cos \left(\theta _{\alpha }\right)} to c o s α {\displaystyle cos_{\alpha }} and sin ⁡ (θ α) {\displaystyle \sin \left(\theta _{\alpha }\right)} to s i n α {\displaystyle sin_{\alpha }}): d x = c o s y (s i n z y + c o s z x) − s i n y z d y = s i n x (c o s y z + s i n y (s i n z y + c o s z x)) + c o s x (c o s z y − s i n z x) d z = c o s x (c o s y z + s i n y (s i n z y + c o s z x)) − s i n x (c o s z y − s i n z x) {\displaystyle {\begin{aligned}\mathbf {d} _{x}&=cos_{y}(sin_{z}\mathbf {y} +cos_{z}\mathbf {x})-sin_{y}\mathbf {z} \\\mathbf {d} _{y}&=sin_{x}(cos_{y}\mathbf {z} +sin_{y}(sin_{z}\mathbf {y} +cos_{z}\mathbf {x}))+cos_{x}(cos_{z}\mathbf {y} -sin_{z}\mathbf {x})\\\mathbf {d} _{z}&=cos_{x}(cos_{y}\mathbf {z} +sin_{y}(sin_{z}\mathbf {y} +cos_{z}\mathbf {x}))-sin_{x}(cos_{z}\mathbf {y} -sin_{z}\mathbf {x})\end{aligned}}} This transformed point can then be projected onto the 2D plane using the formula (here, x/y is used as the projection plane; literature also may use x/z):[11] b x = e z d z d x + e x , b y = e z d z d y + e y . {\displaystyle {\begin{aligned}\mathbf {b} _{x}&={\frac {\mathbf {e} _{z}}{\mathbf {d} _{z}}}\mathbf {d} _{x}+\mathbf {e} _{x},\\[5pt]\mathbf {b} _{y}&={\frac {\mathbf {e} _{z}}{\mathbf {d} _{z}}}\mathbf {d} _{y}+\mathbf {e} _{y}.\end{aligned}}} Or, in matrix form using homogeneous coordinates, the system [f x f y f w] = [1 0 e x e z 0 1 e y e z 0 0 1 e z] [d x d y d z] {\displaystyle {\begin{bmatrix}\mathbf {f} _{x}\\\mathbf {f} _{y}\\\mathbf {f} _{w}\end{bmatrix}}={\begin{bmatrix}1&0&{\frac {\mathbf {e} _{x}}{\mathbf {e} _{z}}}\\0&1&{\frac {\mathbf {e} _{y}}{\mathbf {e} _{z}}}\\0&0&{\frac {1}{\mathbf {e} _{z}}}\end{bmatrix}}{\begin{bmatrix}\mathbf {d} _{x}\\\mathbf {d} _{y}\\\mathbf {d} _{z}\end{bmatrix}}} in conjunction with an argument using similar triangles, leads to division by the homogeneous coordinate, giving b x = f x / f w b y = f y / f w {\displaystyle {\begin{aligned}\mathbf {b} _{x}&=\mathbf {f} _{x}/\mathbf {f} _{w}\\\mathbf {b} _{y}&=\mathbf {f} _{y}/\mathbf {f} _{w}\end{aligned}}} The distance of the viewer from the display surface, e z {\displaystyle \mathbf {e} _{z}} , directly relates to the field of view, where α = 2 ⋅ arctan ⁡ (1 / e z) {\displaystyle \alpha =2\cdot \arctan(1/\mathbf {e} _{z})} is the viewed angle. (Note: This assumes that you map the points (-1,-1) and (1,1) to the corners of your viewing surface) The above equations can also be rewritten as: b x = (d x s x) / (d z r x) r z , b y = (d y s y) / (d z r y) r z . {\displaystyle {\begin{aligned}\mathbf {b} _{x}&=(\mathbf {d} _{x}\mathbf {s} _{x})/(\mathbf {d} _{z}\mathbf {r} _{x})\mathbf {r} _{z},\\\mathbf {b} _{y}&=(\mathbf {d} _{y}\mathbf {s} _{y})/(\mathbf {d} _{z}\mathbf {r} _{y})\mathbf {r} _{z}.\end{aligned}}} In which s x , y {\displaystyle \mathbf {s} _{x,y}} is the display size, r x , y {\displaystyle \mathbf {r} _{x,y}} is the recording surface size (CCD or Photographic film), r z {\displaystyle \mathbf {r} _{z}} is the distance from the recording surface to the entrance pupil (camera center), and d z {\displaystyle \mathbf {d} _{z}} is the distance, from the 3D point being projected, to the entrance pupil. Subsequent clipping and scaling operations may be necessary to map the 2D plane onto any particular display media. A "weak" perspective projection uses the same principles of an orthographic projection, but requires the scaling factor to be specified, thus ensuring that closer objects appear bigger in the projection, and vice versa. It can be seen as a hybrid between an orthographic and a perspective projection, and described either as a perspective projection with individual point depths Z i {\displaystyle Z_{i}} replaced by an average constant depth Z ave {\displaystyle Z_{\text{ave}}} ,[12] or simply as an orthographic projection plus a scaling.[13] The weak-perspective model thus approximates perspective projection while using a simpler model, similar to the pure (unscaled) orthographic perspective. It is a reasonable approximation when the depth of the object along the line of sight is small compared to the distance from the camera, and the field of view is small. With these conditions, it can be assumed that all points on a 3D object are at the same distance Z ave {\displaystyle Z_{\text{ave}}} from the camera without significant errors in the projection (compared to the full perspective model). Equation P x = X Z ave P y = Y Z ave {\displaystyle {\begin{aligned}&P_{x}={\frac {X}{Z_{\text{ave}}}}\\[5pt]&P_{y}={\frac {Y}{Z_{\text{ave}}}}\end{aligned}}} assuming focal length f = 1 {\textstyle f=1} . To determine which screen x-coordinate corresponds to a point at A x , A z {\displaystyle A_{x},A_{z}} multiply the point coordinates by: B x = A x B z A z {\displaystyle B_{x}=A_{x}{\frac {B_{z}}{A_{z}}}} where B x {\displaystyle B_{x}} is the screen x coordinate A x {\displaystyle A_{x}} is the model x coordinate B z {\displaystyle B_{z}} is the focal length—the axial distance from the camera center to the image plane A z {\displaystyle A_{z}} is the subject distance. Since the camera operates in 3D, the same principle applies to the screen's y coordinate— one can substitute y for x in the diagram and equation above. Alternatively, clipping techniques can be used. These involve substituting values of a point outside the field of view (FOV) with interpolated values from a corresponding point inside the camera's view matrix. This approach, often referred to as the inverse camera method, involves performing a perspective projection calculation using known values. It determines the last visible point along the viewing frustum by projecting from an out-of-view (invisible) point after all necessary transformations have been applied. 3D computer graphics Camera matrix Computer graphics Cross section (geometry) Cross-sectional view Curvilinear perspective Cutaway drawing Descriptive geometry Engineering drawing Exploded-view drawing Homogeneous coordinates Homography Map projection (including cylindrical projection) Multiview projection Perspective (graphical) Plan (drawing) Planar projection Technical drawing Tesseract Texture mapping Transform, clipping, and lighting Video card Viewing frustum Virtual globe ^ Treibergs, Andrejs. "The Geometry of Perspective Drawing on the Computer". University of Utah § Department of Mathematics. Archived from the original on Apr 30, 2015. Retrieved 24 April 2015. ^ Mitchell, William; Malcolm McCullough (1994). Digital design media. John Wiley and Sons. p. 169. ISBN 978-0-471-28666-0. ^ Maynard, Patric (2005). Drawing distinctions: the varieties of graphic expression. Cornell University Press. p. 22. ISBN 978-0-8014-7280-0. ^ McReynolds, Tom; David Blythe (2005). Advanced graphics programming using openGL. Elsevier. p. 502. ISBN 978-1-55860-659-3. ^ D. Hearn, & M. Baker (1997). Computer Graphics, C Version. Englewood Cliffs: Prentice Hall], chapter 9 ^ James Foley (1997). Computer Graphics. Boston: Addison-Wesley. ISBN 0-201-84840-6], chapter 6 ^ Kirsti Andersen (2007), The geometry of an art, Springer, p. xxix, ISBN 9780387259611 ^ Ingrid Carlbom, Joseph Paciorek (1978). "Planar Geometric Projections and Viewing Transformations" (PDF). ACM Computing Surveys. 10 (4): 465–502. CiteSeerX 10.1.1.532.4774. doi:10.1145/356744.356750. S2CID 708008. ^ Riley, K F (2006). Mathematical Methods for Physics and Engineering. Cambridge University Press. pp. 931, 942. ISBN 978-0-521-67971-8. ^ Goldstein, Herbert (1980). Classical Mechanics (2nd ed.). Reading, Mass.: Addison-Wesley Pub. Co. pp. 146–148. ISBN 978-0-201-02918-5. ^ Sonka, M; Hlavac, V; Boyle, R (1995). Image Processing, Analysis & Machine Vision (2nd ed.). Chapman and Hall. p. 14. ISBN 978-0-412-45570-4. ^ Subhashis Banerjee (2002-02-18). "The Weak-Perspective Camera". ^ Alter, T. D. (July 1992). 3D Pose from 3 Corresponding Points under Weak-Perspective Projection (PDF) (Technical report). MIT AI Lab. Kenneth C. Finney (2004). 3D Game Programming All in One. Thomson Course. p. 93. ISBN 978-1-59200-136-1. 3D projection. Koehler; Ralph (December 2000). 2D/3D Graphics and Splines with Source Code. Author Solutions Incorporated. ISBN 978-0759611870. Wikimedia Commons has media related to 3D projection. Creating 3D Environments from Digital Photographs Retrieved from " 3 The following pages link to 3D projection External tools (link count transclusion count sorted list) · See help page for transcluding these entries Showing 50 items. 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Among these methods, orthographic projection stands out for its precision and clarity, making it indispensable in technical drawings and blueprints. Orthographic projection is a technique that creates different views of an object, typically including the front, top, and side views. These views are projected onto planes that are perpendicular to each other, ensuring accurate and undistorted representations of the object. – Description: In this method, the object is placed in the first quadrant, meaning the object lies between the observer and the plane of projection. – Usage: Predominantly used in Europe and Asia. – Example: If you look at the front view, it appears on the opposite side of the plane from where you view it. 1st Angle Projection illustration – Description: Here, the object is placed in the third quadrant, meaning the plane of projection lies between the observer and the object. – Usage: Mostly used in the United States and Canada. – Example: The front view appears on the same side as the plane you view it from. 3rd Angle Projection illustration – Accuracy: Provides an exact representation of the object, free from distortion. – Clarity: Different views offer comprehensive details, making it easier to understand complex geometries. – Standardization: Widely accepted and standardized in engineering practices, ensuring consistency across drawings. – Technical Drawings: Essential for creating detailed and precise blueprints. – Manufacturing: Used to convey exact specifications for components and assemblies. – Architecture: Helps in planning and visualizing buildings and structures. Orthographic projection is a cornerstone in the world of technical drawings, valued for its precision, clarity, and standardization. By providing multiple, distortion-free views of an object, it enables engineers, architects, and manufacturers to accurately convey and interpret complex designs. Whether in first angle or third angle projection, this method ensures that every detail is captured with accuracy, facilitating the creation and communication of intricate engineering plans. Browse through our selection of related blogs and topics to expand your knowledge, spark inspiration, and fuel your curiosity.