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Circular photograph of Oude Kerk Amsterdam fish eye. The chromatic aberration can be clearly seen towards the outer edges. The Fisheye TÃ © rhine was brought into 1906 by the American physician and the Inventor Robert W. Wood based on how a fish would see a hemisply view of Ultrawide from underwater (a phenomenon known as Snell window). [1] [5]: Ã ¢ â‚ ¬ "145 Å, their first practical use was in the DÃ © each of 1920 for use in meteorología [3] [6] to study the cloud formation, Giving them the name "glasses of the whole sky". The angle of view of a fish eye lens generally has between 100 and 180 degrees [4], while the focal lengths depend on the film format with which They are designed. The fish-produced fish lenses produced for the photograph appeared for the first time at the beginning of the years sixty [7] and are generally used for their unique distorted appearance. For the popular 35 mm film, the typical focal lengths of fish-eye lenses are between 8 mm and 10 mm for circular images, and 15 â¬ 16 mm for full-frame images. For digital cameras with smaller electronic images, such as 1 ”4” and 1 ”3” CCD format or CMOS sensors, the focal length of “Miniature” “Miniature” The lenses can be as short as 1 to 2 mm. These types of lenses also have other applications, such as reexploitation images that were originally filmed through a fish eye lens, or created through computer generated graphics, on screens Hemispheres. Fish eye lenses are also used for scientific photograph, such as the recording of aurora and meteors, and to study the geometry of canopy plants and to calculate the near solar radiation. You may be more commonly like Peephole's door spectators to give the user a wide field of vision. Panoramas of History and Development with Fish Eye Distordsion Pleasure Photography and Fish Eye Lens. In 1779, Horace BÃƒÂ © nÃƒ © Saussure published his eye eye view down the Alps: "All objects are drawn in the perspective of the center." [8] "Vue Circullaire des Montagnes Qu'on DÃ © Couvre du Sommet du Glacier de Butet", Horace-Benedict of Saussure [9] Wood's Pail (Top) and the enhanced chamber (from below) (1906) The first Known image of fish eye recorded in 1905 using wood's cube apparatus (1906) Bond's hemispherical lens (1922) In 1906, wood published a paper detailing an experiment in which he built a camera in a full bucket of water starting with a photographic plate at the bottom, a short focus lens with a hole diaphragm. Located approximately half of the cube, and a sheet of glass on the edge to suppress the waves in the water. The experiment was the attempt of the wood "to determine how the outer world appears for the fish" and, therefore, the title of the document was "views of the fish eyes and vision underwater". [1] Subsequently, the wood built an improved "horizontal" version of the chamber that omitted the lens, instead of using a perforated hole on the side of a tank, which was filled with water and a photogram plate. In the text, A third "fish eye" chamber built using the brass blade, the main advantages are that this was more portable than the other two cameras, and was "absolutely leaks". [1] In its conclusion, the wood thought that "the device will be all the sky [so] could be made a sun recorder about this principle, which would not require any latitude or month adjustment, "but also" the views used for the illustration of this tasty paper a little of the images 'freak' of the magazines "[1] WN Bond described an improvement in the wooden apparatus in 1922, which replaced the water tank with a simple hemispherical glass lens, which makes the Camera is significantly more portable. The focal length depended on the refraction index and the radius of the hemispherical lens., And the maximum opening was approximately F / 50; It was not corrected by aberración chromá. Tica and projected a curved field on a flat plate. Link Sent that the new lens could be used to record the cloud cover or lightning strikes in a certain location. [2] The hemispheric lens of Bond also N reduced the need for aperture of holes to ensure a sharp approach, So the exposure times were also reduced. [10] Hill Sky Lens Hill / Beck "Sky Lens" (1923, GB 225,398) [11] In 1924, Robin Hill First D wrote a lens with 180 ° coverage that had been used for a cloud survey in September 1923 [3] The lens, designed by Hill and R. & J. Beck, Ltd., was patented in December 1923. [11] The Sky Hill lens now is credited as the first fish eye lens . [5]: Ã ¢ â‚ ¬ Å! Hill also described three different mapping functions from a designed lens to capture a complete hemisphere (stereographic, equidistant and orthographic) . [3] [12] The distortion is inevitable in a lens that encompasses an angle of view of more than 125 °, but Hill and Beck affirm in the patent that the stereographic or equidistant projection was the preferred mapping functions. [11] The design designer of three groups of three groups uses a very divergent meniscus lens, since the first element to bring to light on a wide view followed a system of convergent lenses to project the view onto a flat photo plate. [11] The hill sky lens fitted an entire sky camera, usually used in a pair separated by 500 meters (1,600 feet) for stereo images, and and with a red filter for contrast; In its original form, the objective had a focal length of 0.84 inches (21 mm) and projected a 2.5-inch image (64 mm) of diameter to f / 8. [13] Conrad Beck described the camera system in an article published in 1925. [14] At least one has been rebuilt [15]. German development and Japanese Schulz / Aeg Weitwinkelobjektiv (1932, DeÃ, 620 538) [16] In 1932, the German firm Allgemeine ElekricitÃƒÂ¤ts-Gesellschaft AG (AEG) requested a patent on the weitwinkelobjektiv (Great Angular Objective), a development of 5 elements and 4 target groups Hill Sky. [16] Compared with the Hill Sky Lens of 1923, the 1932 Weitwinkektiv presented two divergent meniscus elements in front of the stop and used a cemented acromatic group in the convergent section. [16] Miyamoto attributes to Dr. Hans Schulz the designer of the Weitwinkelobjektiv [12]. The basic patented designer occurred for cloud recording as a target of 17 mm F / 6.3, [17] and the artist known as Umbo used the AEG target for artistic purposes, with photographs published in a number of 1937 from Volk und Welt. [18] The AEG Weitwinkelobjektiv formed the base of the Fish-Eye-Nikkor 16ã, MM F / 8 of 1938, which was used for military and scientific purposes. [17] Nikon, who had a contract to provide optic to the Japanese Imperial Navy, possibly obtained access to the AEG design under the Steel Covenant. [19] After the war, the target was coupled to a medium-format camera and occurred slightly modified (the focal length increased slightly at 16.3 mm) as the «Imaging Recording Camera Celestial genes »In March 1957 for the Japanese government, [20] followed by a commercial launch like the Nikon Fisheye Camera (also known as the Â« Nikon Sky Camera »or Â« Nikon Cloud Camera ») in September of 1960, which had a sale price of ém.200,000 yen (equivalent to ã,1,130,000 in 2019). [21] The revised goal created an image 50Å, mm (2.0, inches) of diameter and covered a complete hemispheric field of 180Â °. [22] Only 30 copies of the Nikon Nikon Cameras were manufactured, of which 18 were sold to customers, mainly in the United States; Nikon probably destroyed the remaining stocks to avoid tax penalties.[23] In 1957, Life published a photograph of the Bob Gutowski polo vault taken by the Fisheye camera.[24] Richter/Zeiss Pleon (1938, US 2,247,068) [25] Also in 1938, Robert Richter of Carl Zeiss AG patented the 6-element, 5-group Pleon target,[25] which was used for aerial surveillance during World War II. The converging rear group of the Pleon was symmetrical, reminiscent of the 4 element Topogon design, also designed by Richter for Zeiss in 1933. Tests performed on a target captured after the war showed that the Pleon provided an equidistant projection to cover a field of approximately 130Â°, and the negatives were printed using a special rectifying amplifier to eliminate distortion.[5]:Ã¢Å¦149Å¢Å¦Å¦ [26] The Pleon provided an equidistant projection to cover a field of approximately 130Â°. had a focal length of approximately 72.5 mm with a maximum aperture of f/8 and used a conical plane. Front element 300 mm (12 in) in diameter; the image on the negative was approximately 85 mm (3.3 in) in diameter.[26] MertÃÂ©/Zeiss Sphaerogon (1935, DEÃ¨ 672Ã¨ 393[27] and USÃ¨¨¨¨¨ 2.126,126) [28] 35 mm development At about the same time that Schulz was developing the Weitwinkelobjektiv at AEG, Willy MertÃÂ© de Zeiss was developing the Sphaerogon, which was also designed to cover a 180° view field.[27] Unlike the Weitwinkelobjektiv, the MertÃÂ©’s Sphaerogon was not limited to medium format cameras; prototype versions of the Sphaerogon were built for the Contax I miniature format camera. The first prototype of built Sphaerogon lenses had a maximum aperture of f/8, but later examples were computed half a point faster, at f/6.8.[29] Several prototypes of Sphaerogon lenses were recovered as part of the Zeiss lenses confiscated by the Army Signals Corps as a war reparation in 1945;[30] the collection, which Zeiss had kept as a record of their designs, was subsequently documented. documented. MertÃ Â©, the former head of optical calculus for CZJ, working under the signal officer of the signal Edward Kaprelian. [31] [32] The Nikon Fisheye camera was suspended in September 1961, [20] and Nikon subsequently introduced the first fishfish lens of regular production for miniature cameras in 1962, [12] the fish eye-nikkor 8 mm F / 8, [33] required by the Spepe reflection on your Nikon F and Nikkormat cameras that will lock before mounting the lens. Before the early 1960s, fish-eye lenses were mainly used by professional and scientific photographers, but the advent of the fish-eye for the 135 format increased their popular use. [34] The Nikkor 8 mm F/8 has a 180° field of view and uses 9 elements in 5 groups; It is fixed focus and has built-in filters for black and white photography. Research indicates that fewer than 1,400 lenses were built. [35] Takumar 11/18mm Fishing-Eye on a Modern Pentax K-1 DSLR Nikon subsequently released several more milestone circular eye lenses on Nikon F Mount through the 60s and 70s: 10mm F/5.6 OP (1968), the first fish eye to present orthographic projection which was also the first lens to have an aspheric element [36] 6 mm F / 5.6 (1969), the first fish eye to have a field of view of 220 Â°; [7] Interestingly, the patent that accompanies this lens includes a design. For a lens with a field of view of 270 Â°. [37] Later there was a surface of 6.2 mm F / 5.6 SAP in limited numbers with an aspherical surface, covering a field of view of 230 Â°. [38] 8 mm F/2.8 (1970), the first circular fish eye with variable focus, automatic opening and reflection display (mirror lock no longer required). [7] Meanwhile, other Japanese manufacturers were developing the so-called full-frame or diagonal-frame fish, which captured approximately a 180 Â° field of view at of the diagonal of the film frame. The first diagonal diagonal fisheye was the 10 mm F / 11 fish eye Takumar, released by Pentax (ASAHI OPTICO) in 1962, [38] [39] [40] followed by the slightly slightly slightly UW Rokkor-PG 18 mm F / 9.5 from Minolta in 1966. [41] Both were reflex vision and fixed focus, and Pentax and Minolta followed with faster lenses with variable focus in 1967 (superfish-takumar 17 mm f / 4) [42] and 1969 (Rokkor-OK 16Ã¨m F F /2.8),[43â[44] respectively. The 16 mm Rokkor were later adopted by Leica as FishEye-Elmarit-R (1974) and later converted into AutoFocus (1986) for the alpha system. As of 2018 [UPDATE], the same basic optical design is still sold as the SONY SAL16F28. Design Format Types Circle Circular Circle Circle Complete Circle 3: 2 52% to Sensor 78% to Fov, 92% Sensor 59% to FOV 4: 3 59% Sensor 86% to FOV, 90% to Sensor 61% FOV CIRCULAR CIRCULARYEY FOR THE PISCO 35 MMS FRUCH FULL WITH THE Rudimental LENITY CAPULA: ESO’s VLT image taken with a circular fish-eye lens. 35 mm circular Fisheye with full frame fisheye of the DX format camera that is used in a closed space (Nikkor 10.5msm) on a circular fish-eye lens, the circle of the image is inscribed on the film or sensor area; In a full-frame fisheye lens, the image circle is circumscribed around the film or sensor area. In addition, different fish-eye lenses distort the images differently, and the way of distortion is known as its assignment function. A common type for consumer use is an equisolid angle. Although digital fish-eye effects are available on both the camera and computer software, they cannot extend the angle of view from the original images to the very large angle of a real fish-eye lens. Focal length The focal length is determined by the angular coverage, the specific assignment function used and the required dimensions of the final image. The focal lengths for the popular sizes of the amateur camera are calculated as: Calculated fish eye focal lengths Ã© Stereographic Equidistant Equisilid Angle Reverse Mapping Function [45] F = R 2 TAN Ã Â¡Ã¸ 2 {\ DisplayStyle F = {\ dfrac { r} {2 \ tan {\ dfrac {\ theta} {2}}}}} f = r Ã¸ {\ displaystyle f = {\ frac {r} {\ theta}}} F = R 2 sin¸ 2 {\ displaystyle f = {\ dfrac {r} {2 \ without {\ dfrac dfrac }{2}}}} f = r without Ã¢ Î§ {\displaystyle f={\frac {r}{\without \theta }}} Circular[b] APS-C (r {\displaystyle r} = 8.4 mm) 4.2 5.3 5.9 8.4135 (r {\displaystyle r} = 12 mm) 6.0 7.6 8.5 12.0 6ÃÂ6 display r} = 28 mm) 14.0 17.8 19.8 28.0 Full-frame[c] APS-C (r {\view styles r} = 15.1 mm) 7.5 9.6 10.6 15.1135 (r {\view styles r} = 21.7 mm) 10.8 13.8 15.3 21.7 6Â6 (r {\displaystyle r} = 39.6 mm) 19.8 25.2 28.0 39.6 Notes ^ Assumes a maximum viewing angle of 180°Â° for the mapping function, Î§ = Ã 2 {\displaystyle \theta ={\frac {\pi }{2}}} ^ For circular fish, the maximum size r {\displa Style r} is half the length of the shortest side. ^ For full square fish, the maximum dimension r {\displaystyle r} is half the length of the diagonal. Circular Fish Eyes The first types of fish-eye lenses that were developed were circular fish-eye lenses that took a hemisphere of 180Â° and projected it as a circle within the frame of the film. Some circular fish were available in orthographic projection models for scientific applications. These have a vertical viewing angle of 180Â°, and the horizontal and diagonal viewing angles are also 180Â°. By design, most circular fish-eye lenses cover a smaller image circle than rectilinear lenses, so the corners of the frame will be completely dark. Sigma currently manufactures a 4.5 mm fish-eye lens that captures a 180Â° field of view on a culture body.[46] Sunex also manufactures a 5.6 mm fish-eye lens that captures a 185Â° circular field of view on a 1.5x Nikon digital SLR camera. and 1.6x Canon. Fish eye-Nikkor 6mm f/2.8 mounted on a Nikon F2 at the Nikon Museum. Nikon produced a 6 mm circular fish eye lens that was originally designed for an expedition to Antarctica. It presented a field of view of 220Â°, designed Capture all the sky and the surrounding soil when aims upwards. This objective is no longer manufactured by Nikon, [47] and is now used in day to produce virtual reality interactive images such as QuickTime VR and IPIX. Because of its very very It is very large and cumbersome, weighs 5.2 kilograms (11 pounds), has a diameter of 236 millimeters (9.3 inches), a length of 171 millimeters (6.7 inches) and an angle of view of 220 degrees. It eclipses a normal 35 mm SLR camera[48] and has its own tripod mount point, a feature that is usually seen on large long focus lenses or telephoto lens to reduce the tension on the lens mount, as the lens is heavier than the camera. The lens is extremely rare.[49] The Laowa Fish Eye Lens 4 mm f/2.8 from the manufacturer Venus Optics However, there are new developments from the Japanese manufacturer Entaniya for the Micro Four Thirds standard, which offer a 250-degree angle of view with lenses that have a focal length of 2, 3 millimetres (0.091 in) to 3.6 millimetres (0.14 in), an aperture of f/2.8 to f f f f f f f f / 4.0, a weight of 1.6 kilograms (3.5 pounds), a diameter of 120 millimetres (4.7 inches) and a length of less than 100 millimetres (3.9 inches). [50] In 2018, Venus Optics introduced a 210Â° fish-eye lens for the Micro Four Thirds system.[51] An 8 mm fish-eye lens, also manufactured by Nikon, has proven its usefulness for scientific purposes due to its equidistant (equiangular) projection, in which the distance along the length of the lens is equal to the length of the lens. radius of the circular image is proportional to the zenith angle. Full-Frame Fish Eye As fish-eye lenses gained popularity in general photography, camera companies began making fish-eye lenses that enlarged the image circle to cover the entire rectangular frame, called the “full-frame fish-eye.” “[52] The angle of view produced by these lenses is only 180 degrees when measured from corner to corner: they have a diagonal angle of view of 180Â°, while the horizontal and vertical angles of view will be smaller; for a full-frame fish eye of 15Â mm, the horizontal AOV will be 147° and the vertical AOV will be 94°.[53] One of the first full-frame fish eye lenses to be mass-produced was the Fisheye-Nikkor 16mm f/3.5, manufactured by Nikon in the early 1970s. Digital cameras with APS-C APS-C The sensors require a 10.5 mm lens (or, for Canon APS-C cameras, a 10 mm target) to obtain the same effect as a 16 mm lens on a camera with full frame sensor . [54] Miniature fish eye lenses Miniature digital cameras, especially when used as security cameras, usually have fish eye lenses to maximize coverage. Miniature fish eye lenses are designed for small format CCD / CMOS images that are commonly used in consumption and safety cameras. [55] [56] The sizes of the most popular image sensors used include 1Ã ¢ â), 1Ã ¢ â € | "and 1Ã ¢ â) № |" Depending on the active area of the image sensor , the same goal can form a circular image in a more large image sensor (for example, 1 ¢ â € |), and a full frame in one more small (for example, 1 â € | 4Å »). Examples and Specific models Fish eye lenses for APS-C cameras The APS-C imaging sensor used in Canon frames measures 22.3Å, mm ÃƒÂ-Ã, 14.9ã, mm (0.88Ã, In ÃƒÂ-Ã, 0.59ã, in) or 26.82Ã, mm (1.056Ã, in) on the diagonal, which is slightly less than the size of the sensor used by other popular camera manufacturers with APS- Sensors C, such as Fuji, Minolta, Nikon, Pentax and Sony. The other habitual APS-C sensors range from 23.6 to 23.7 mm (0.93 to 0.93 inches) in the long and 15.6 mm (0.61 inches) dimension on the shorter side, For a diagonal measurement between 28.2 and 28.4 mm (1.11 to 1.12 inches). APS-C circular lenses Sigma Fish Eyes 4.5ã, mm f / 2.8 for APS-C sensors Lensbaby 5.8h, mm f / 3,5 circularfish eyes Fish eye lenses Full box Nikon 10 , 5, MM F / 2.8 Samyang 8ã, mm f / 3.5. It stands out for its stereographic projection Samyang 8Å, MM F / 2.8. For several mirror without mirror. Highlights for its stereographic projection Sigma 10Å, mm f / 2.8 Zoom Eye lenses APS-C Pentax 10Ã «17Ã, mm f / 3.5Ã« 4.5 / Tokina 10Ã «17Ã, mm f / 3.5 Ã â «4.5 (developed jointly) Fish eye lenses for 35 mm circular fish eye A Peleng 8 mm fish eye lens. Peleng 8 mm f/3.5 Sigma 8 mm f/4.0 Sigma 8 mm f/3.5 â replaces the Sigma 8 mm f/4.0 EX DG Full-frame Fish eye Canon EF 15 mm f/2.8 (discontinued) Canon Fisheye FD 15 mm f/2.8 (old lens, does not have in Montura EF) Fuji Photo Film Co. EBC Fujinon Fish Eye 16mm F2.8 (M42 & X-Fujinon Mounts, Discontinued) Minolta AF 16Å, MM F / 2.8 Sigma 15Å, MM F / 2.8 Ex DG Diagonal Fisheye Fisheye-Nikkor AF 16mm F / 2.8 D Fisheye-Nikkor 16mm F / 2.8 AI-S Fish-eye-Nikkor 16mm F / 3.5 Samyang 12Å, MM F / 2.8 ED AS NCS Diagonal Eye SMC Pentax Fish 17mm F4 Tartisan Fish Eye 11mm F / 2.8 Zenitar Fish Eye 16Å, MM F / 2.8 Lens Fish Eye EF Zoom Canon Fish Eye The USM Objective Â ¢ â € ² ²²15Å, mm f / 4l fish eye can be used as much as full frame fish eye Circular fish eye on a full frame of 35, mm or DSLR as 5D cameras (Mark I Ã ¢ â € ² â € ² µV); It can only be used as a trimmed circular or as a full frame fish eye in the DSLRS fish eye with APS-C / H size sensors (includes a zoom lock). Nikon AF-S Nikkor Fish Eye 8 Ã ¢ Å |,1, mm f / 3.5Ã ¢ â) Å|4.5E Ed Ã ¢ Ã ¢ Ã ¢ Ã ¢ Ã ¢ Ã ¢ Å |4.5E Ed Ã ¢ Å | DESIGNED for the DSLR FX Full Frame of Nikon, this goal is a fish eye Circular at the short end of the zoom range and becomes a full-frame fish eye with longer focal distances. TOKINA AT-X 10Å ¢ Å »17mm F3.4-4.5 AF DXÃ ¢ Å» A fish eye zoom lens design for APS-C sensor chambers. It is also sold as a NH version that comes without integrated lens hood, then the fish eye target can be used on full frame chambers. The goal is also sold under the Pentax brand. The target PENTAX F 17Ã «« 28Å, mm 1: 3.5Ã «« 4.5 Å «Peejo» was born for full frame film cameras, to replace the 16th, mm f / 2.8 of the era AF. Start with a fish eye of 17., mm of full frame and reaches the end of the excursion as a fish eye of 28, mm overdisted. It was designed as an objective of "special effect" and never had great sales. [57] [Required Appointment] Pentax gives 3,5-4.5 / 10-17 ED Fish Eye is designed for APS-C cameras, but can be used in full frame after full frame small modification of the hood. Sample Images Image of the entrance to the Louvre Museum taken with the circular lens Fish Eye Nikkor Fish Eye used to capture the entire chapter of the Wells Cathedral Canon Room 8â215Ã¨ mm zoom to 8Ã¨ mm of the BMW M3 Image taken with a 16Ã¨ mm fish-eye lens complete diagram before and after mapping to a perspective.[n 1] Comparison of the conventional (rectilinear) mapping function with four different fish-eye mapping functions, given a constant focal length. Other applications The curves of ESO’s headquarters through a fish-eye lens.[58] Many planetariums now use fish-eye projection lenses to project the night sky or other digital content into a dome. Fish-eye lenses are used in POV pornography to make things look bigger right in front of the camera. Flight simulators and visual combat simulators use fish eye projection lenses in order to create an immersive environment for the training of pilots, air traffic controllers or military personnel. Similarly, the IMAX Dome format (formerly âOMNIMAX') includes photography through a circular fish-eye lens, and projection through it on a hemispheric screen. Scientists and resource managers (e.g., biologists, foresters, and meteorologists) use fish-eye lenses for hemispheric photography to calculate canopy indices and near-earth solar radiation. Applications include forest health assessment, characterization of winter resting sites for monarch butterflies and vineyard management. Astronomers use fish-eye lenses to capture cloud cover and contamination data Photographers and videographers use fish-eye lenses to be able to bring the camera as close as possible to the action shots while also capturing the context, by skateboarding example to focus on the board and preserve an image of the skater. The “Eye” of the 2001 HAL 9000 Computer: A Space Odyssey was constructed using a 8 mm f/8 Fish-Eye-Nikkor lens.[59] HAL’s point of view was filmed with a Fairchild-Curtis âbug-eye' lens originally designed for movies on the format Cinerama 360. The first music video recorded completely with a fish-eye lens was for the Beastie Boys song “Hold It Now, Hit It” in 1987. In Computer Graphics, circular fish-eye images can be used to create environmental maps of the physical world. One. One. The 180-degree wide-angle fish eye image will be adjusted to half of the cubic mapping space using the right algorithm. Environment maps can be used to represent 3D objects and virtual panoramic scenes. Many online cameras of the personal weather station around the world Uploads pezeye images of the current conditions of the local sky, as well as a sequence of previous time lapse with climatic conditions, such as the quantities of temperature, humidity, wind and rain. [61] Mapping function The subject is placed in the image by the lens according to the mapping function of the lens. The mapping function gives R {\ DisplayStyle R}, the position of the object from the center of the image, as a function of F {\ DisplayStyle F}, the focal length and¸ {\ DisplayStyle \ Theta}, the angle of the optical axis. {\ DisplayStyle \ Theta} is measured in radians. Comparison of mapping functions Subject Elónel original to be photographed, with the camera looking from the interior of the center to the left wall. Normal Fisheye [62] [45] Stereographic Rectilinear [63] Equidistant Equidistant Spectrum Equidistant Spectrum Other Names Gnomic, Perspective, Conventional Panoramic, Conformal, Planisphere linear, Linear-scale orthogonal image mapping function [45] R = F So much {\ DisplayStyle R = F \ TAN \ THETA} R = 2 F TAN equals 2 {\ DisplayStyle R = 2F \ tan {\ frac {\ theTa} {2}}} r = f Ã¸ {\ DisplayStyle R = F \, \ THETA} R = 2 F Sin 2 {\ DisplayStyle R = 2F \ without {\ frac {\ theta} {2}}} [a] r = f sinful¸ {\ DisplayStyle R = F \ without \ Theta} Notes works like the hole camera. Straight lines are kept straight (free distortion). {\DisplayStyle \THETA} has to be less than 90°. The opening angle is obtained symmetrically to the optical axis and has to be less than 180 Â°. Large opening angles are difficult to design and carry at high prices. It keeps angles. This mapping would be ideal photographers because it does not compress so much marginal objects. Samyang is the only manufacturer to produce this type of fish eye lens, but it is available available Different brand names. This mapping is easily implemented by software. It maintains angular distances. Practical for the medicine of Ángles (for example, stellar maps). Panotools uses this type of mapping. It maintains superficial relationships. Each pixel subtaste an equal annex, or an equal area in the unitary sphere. It looks like a mirror image in a ball, a better special effect (little sophisticated distances), suitable for the comparison of areas (determination of clouds). This type is popular, but compresses the marginal objects. The prices of these lenses are high, but not extreme. It maintains flat illuminance. It looks like an orb with the surroundings in an opening angle of

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