Using Space Effectively: 3D

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CS 294-10: Visualization
Spring 2010

Final project

Design new visualization method
- Pose problem, Implement creative solution

Deliverables
- Implementation of solution
- 8-12 page paper in format of conference paper submission
- 2 design discussion presentations

Schedule
- Project proposal: 3/29
- Initial problem presentation: 3/31
- Midpoint design discussion: TBD
- Final paper and presentation: TBD

Grading
- Groups of up to 3 people, graded individually
- Clearly report responsibilities of each member

Multivariate Color Sequences

Multi-dimensional Scatter plot

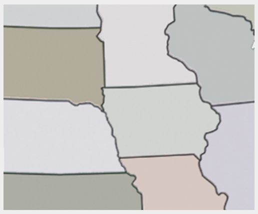
Variable 1, 2 → X, Y
Variable 3, 4, 5 → R, G, B

Do people interpret color blends as sums of variables?

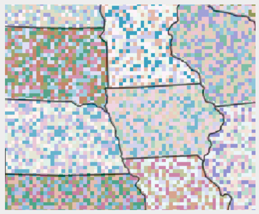
Using Color Dimensions to Display Data Dimensions
Beatty and Ware

Color Weaves

6 variables = 6 hues, which vary in brightness



Additive mixture (blend)



Spatial texture (weave)

Weaving versus Blending (APGV06 and SIGGRAPH poster)
Haleh Hagh-Shenas, Victoria Interrante, Christopher Healey and Sunghee Kim

Controlling Value

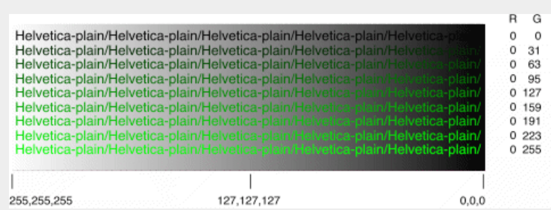
Get it right in black & white

Value
- Perceived lightness/darkness
- Controlling value primary rule for design

Value defines shape
- No edge without lightness difference
- No shading without lightness variation

Value difference (contrast)
- Defines legibility
- Controls attention
- Creates layering

Controls Legibility



colorusage.arc.nasa.gov

Legibility

Drop Shadows

Drop Shadow

Drop shadow adds edge

Primary colors on black
Primary colors on black
Primary colors on black
Primary colors on black
Primary colors on black
Primary colors on black

Primary colors on white
Primary colors on white
Primary colors on white
Primary colors on white
Primary colors on white
Primary colors on white

Readability

If you can't use color wisely,
it is best to avoid it entirely
Above all, do no harm

If you can't use color wisely,
it is best to avoid it entirely
Above all, do no harm.

Why does the logo work?

Value Control

Legibility and Contrast

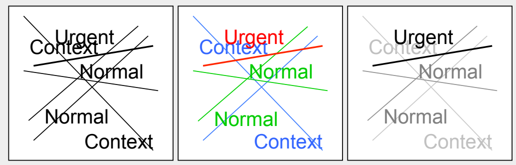
Legibility
- Function of contrast and spatial frequency
- “Psychophysics of Reading” Legge, et. al.

Legibility standards
- 5:1 contrast for legibility (ISO standard)
- 3:1 minimum legibility
- 10:1 recommended for small text

How do we specify contrast?
- Ratios of foreground to background luminance
- Different specifications for different patterns

Contrast and Layering

Value contrast creates layering



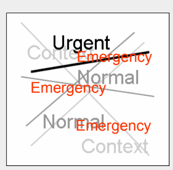
colorusage.arc.nasa.gov

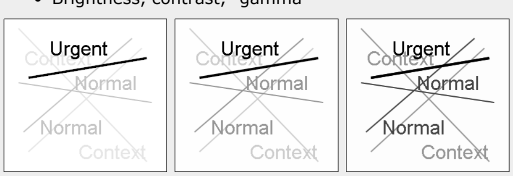
What Defines Layering?

Perceptual features
- Contrast (especially lightness)
- Color, shape and texture

Task and attention
- Attention affects perception

Display characteristics
- Brightness, contrast, “gamma”



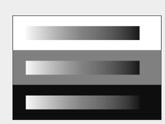


Contrast

General formulation
- Luminance difference (L_f , L_b)
- Depends on adaptation and size

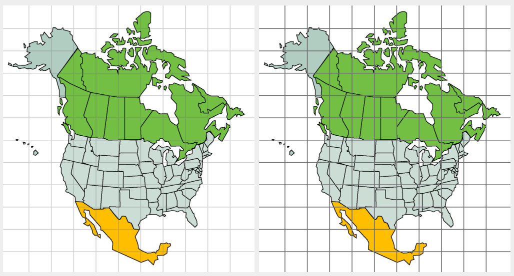
Small symbols, solid background (Weber)
- $C = (L_f - L_b)/L_b$
- Adapted to background

Textures, high frequency patterns (Michelson)
- $C = (L_f - L_b)/(L_f + L_b)$
- Adapted to average



Luminance is intensity
modulated by wavelength sensitivity

Grid Example



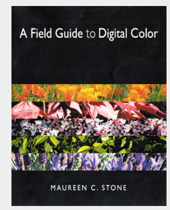
Grid sits unobtrusively in the background   Grid sits in foreground, obscuring map

Great Grids: How and Why? (APGV06 and SIGGRAPH poster)
Maureen Stone, Lyn Bartram and Diane Gromala

Additional Resources

My website
- http://www.stonesc.com/Vis06
- Final copy of slides, references

A Field Guide to Digital Color
- A.K. Peters



Using Space Effectively: 3D

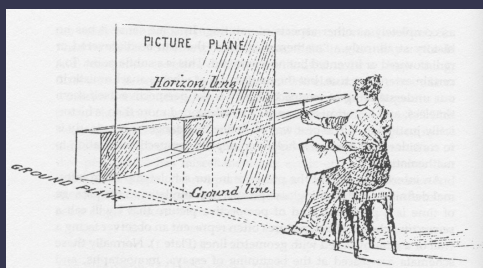
Topics

Linear projections
Non-linear projections
Cartographic projections

Primary geometry

Description in 3D object-space

e.g. trace rays from object through image plane into they eye

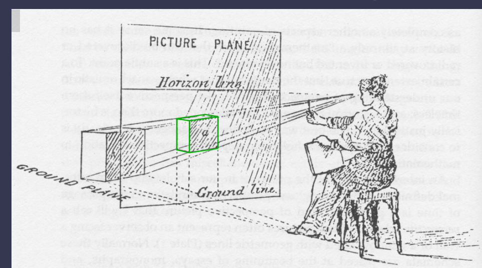


Secondary geometry

Description in 2D image-space

e.g. true shape of front face, side faces recede to vanishing point, …

Often better corresponds to drawing approach



Linear Projections

Linear projections

Straight lines and alignments are preserved

Parallel

Perspective

British standard classification

Primary geometry

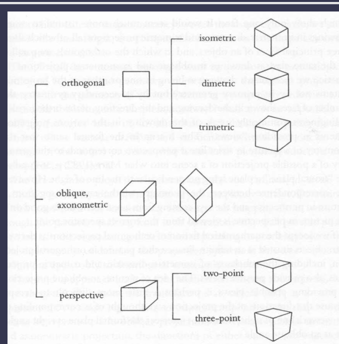


FIG. 2.1. Classification scheme for projection systems, based on primary geometry. Adapted from British Standard 1192 (1969).

Willats' classification

Secondary geometry

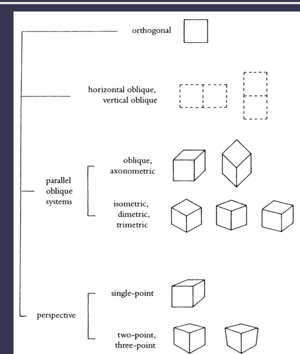


FIG. 2.2. Classification scheme for projection systems, based on secondary geometry.

Parallel projections

No vanishing points or foreshortening

Can represent some aspects of true shape

Can shrink or stretch lengths

Projection direction

- Orthogonal to image plane or not
- Along principal axes of object or not

Parallel projections

Orthogonal 

Fold-out oblique

- Horizontal oblique
- Vertical oblique

Non orthogonal

- Oblique 
- Axonometric 

Orthographic

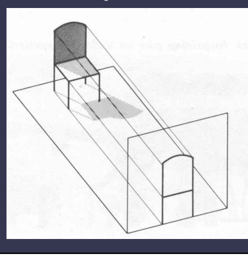
- Isometric 
- Others 

Orthogonal

Direction

- Perpendicular to image plane
- Along one principal direction

True shape for faces parallel to image plane



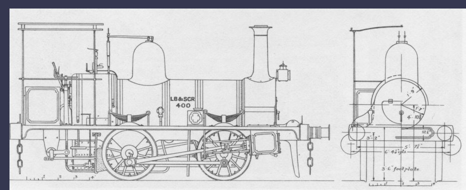
Orthogonal

Direction

- Perpendicular to image plane
- Along one principal direction

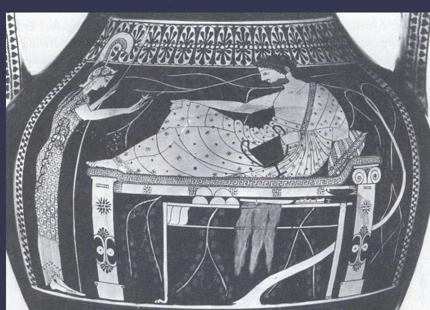
True shape for objects parallel to image plane

Typically engineering



Orthogonal

Amphora, 6th century BC



Orthogonal

Telephoto

As the hijack bargaining goes on under the sweltering sun . . .

An armed guerrilla stands guard (right) as an airfield technician links up the supply line to the hijacked Jumbo from an air conditioning truck

FIG. 2.4. Newspaper photograph of a hijacked aircraft. Courtesy of *Express Newspapers.*

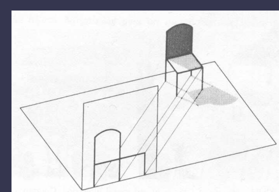
Orthogonal

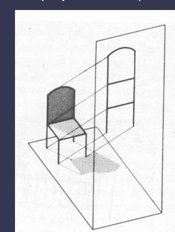
Child drawing

Fold-out oblique

Horizontal oblique
Vertical oblique
Direction

- 45º, parallel to one principal face (top or side)





Fold-out oblique

Horizontal oblique
Vertical oblique
Direction

- 45º, parallel to one principal face (top or side)

True shape for 2 faces with 45º projection rays

- Horizontal: Shrink/stretch ***top*** face at other angles
- Vertical: Shrink/stretch ***side*** face at other angles

Mainly interesting for secondary geometry

Horizontal oblique

Folk art

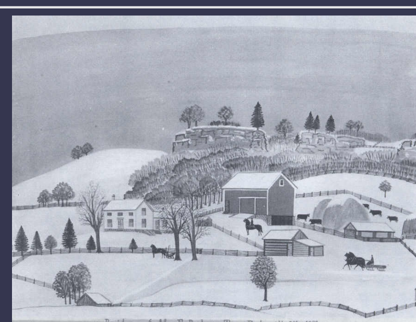


FIG. 2.8. Paul A. Seifert, *Residence of Mr. E. R. Jones*, 1881. Watercolor, 54.6 × 69.9 cm. New York State Historical Association, Cooperstown, New York.

Horizontal oblique

Icons

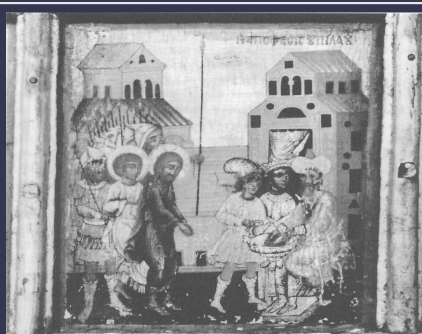


FIG. 8.13. Icon painting from a catafalque, Island Museum, Symi, Greece. Photograph by the author.

Horizontal oblique

Child drawing

Vertical oblique

Soriguerola, 13th

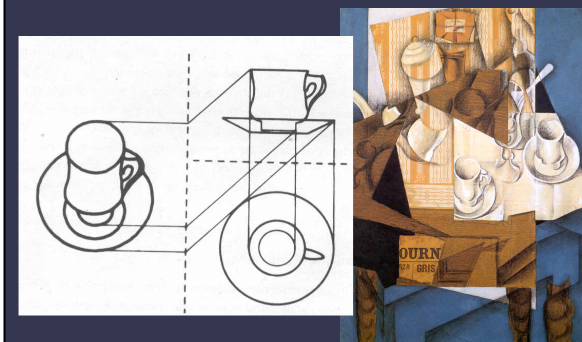
Vertical oblique

Soriguerola, 13th

Vertical oblique

Juan Gris, *Breakfast*, 1914

Vertical oblique



Vertical oblique

Andre Kertesz,
Tulipe Melancolique

Non orthogonal

Direction
- non orthogonal to picture plane

Oblique

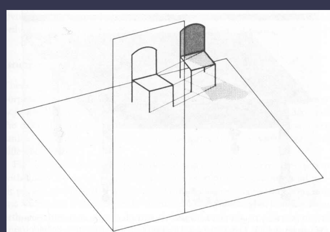
- Picture plane parallel to front
- True shape for front face

Axonometric
- True shape for top face
- True length for up direction
- Direction 45° of the picture plane

Oblique

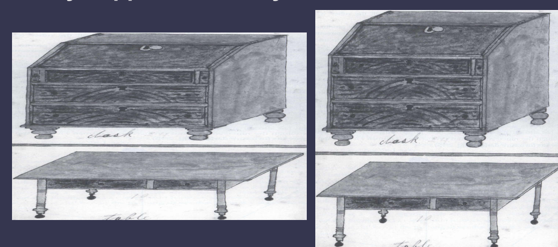
Picture plane parallel to front
True shape for front face

Can use true length for 3rd direction



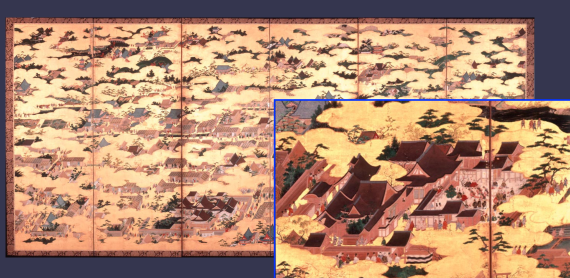
Oblique

Henry Lapp, 19th century



Oblique

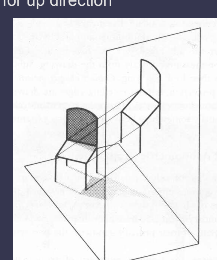
Chinese paintings 12th century



Axonometric

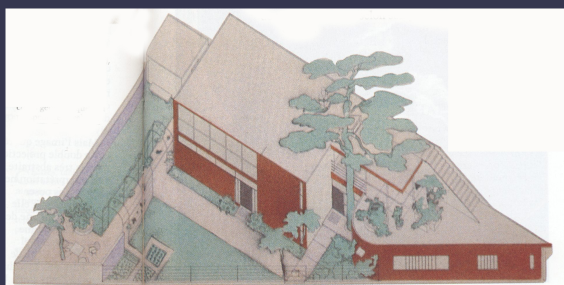
Axonometric

- Like vertical oblique, but object turned 45º to picture plane
- True shape for top face
- True length for up direction



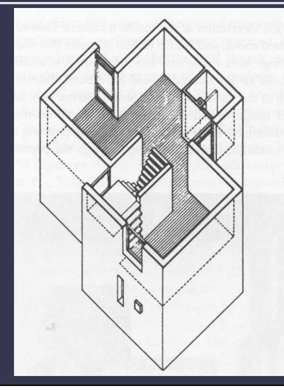
Axonometric

Le Corbusier was a big fan



Axonometric

James Stirling, 1953



Orthographic

Direction

- Orthogonal to picture plane
- Along no principal axes

Isometric

- Direction along the average of the principal axes
- True lengths along 3 axes

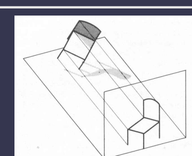
Others

- Generic orthographic
- Nothing preserved, rarely used

Isometric vs. axonometric

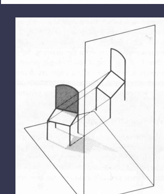
Isometric

- No true shape
- True lengths in 3 directions
- Less distortion



Axonometric

- True shape for top face
- True length for up direction



Isometric

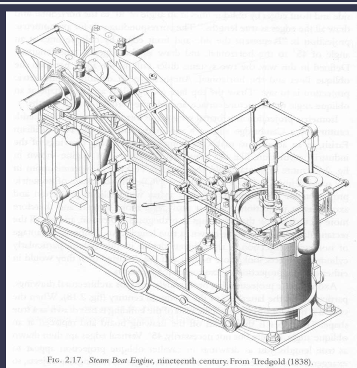
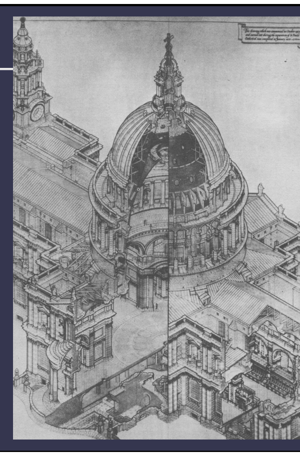


Fig. 2.17. *Steam Boat Engine*, nineteenth century. From Tredgold (1838).

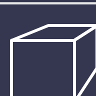
Isometric

Brooks-Greaves
St Paul's Cathedral
1928



Linear perspective

Foreshortening
The spectator is "immersed"



One point
Two points
Three points

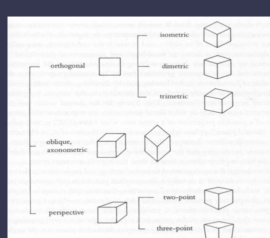
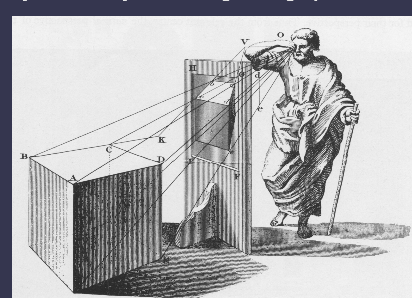


Fig. 2.1. Classification scheme for projection systems, based on primary geometry. Adapted from British Standard 1192 (1969).

Primary geometry

Trace rays from object, through image plane, into eye



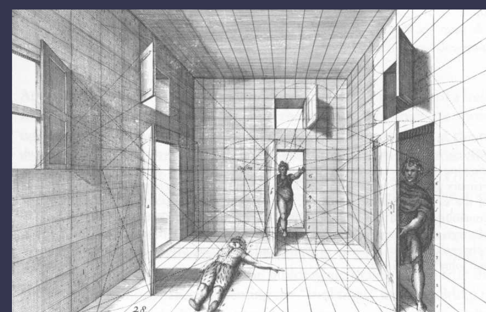
1-point perspective

Central focus

Preserves horizontals
and verticals

1-point perspective

Jean Vredeman de Vries,1604



1-point perspective

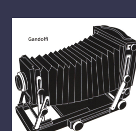
Unknown artist Ideal city, 15th

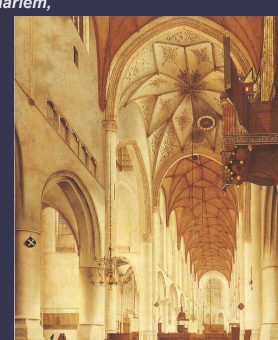
1-point perspective

Interior of St Bavo's church at Haarlem,
Pieter Jansz Saenredam,
1648

Optical center is not always
the center of the image

Requires view camera to adjust
angle of film plane

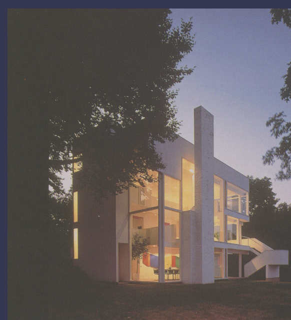




2-point perspective

Objects stand out of the picture

Preserves verticals

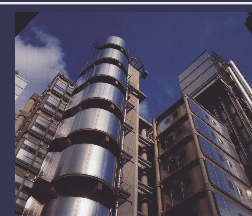


3-point perspective

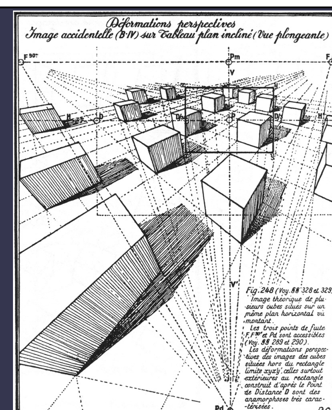
Dramatic 3D effect

The generic case,
nothing preserved

Historically, seldom used
in art or technical
drawing



Perspective Distortion

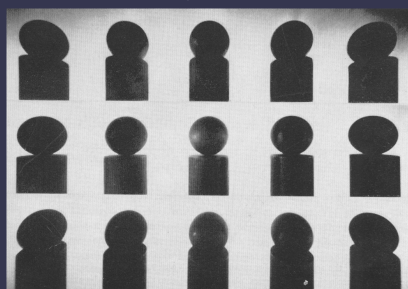


Marginal distortions in perspective projection, Olmer [from Kubovy 03]

Perspective distortion

Wide angle projection

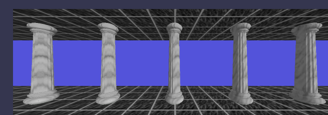
Does not preserve subjective size

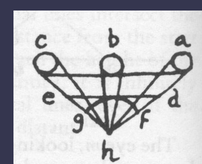


Perspective distortion

Wide angle projection

Does not preserve subjective size

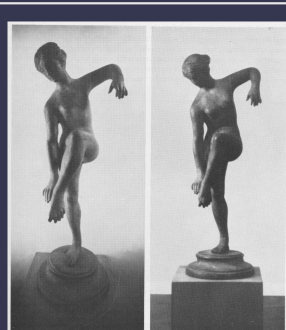




Perspective distortion

Wide angle projection

Distorts shape



Perspective distortion

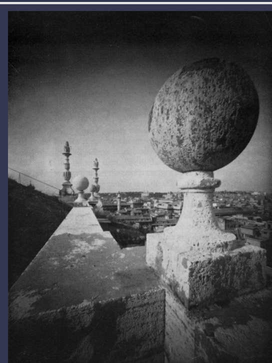
Portrait: distortion with wide angle and telephoto

Wide angle | Standard | Telephoto

Perspective distortion

The sphere is projected
as an ellipse

Symmetry is not preserved



Perspective distortion

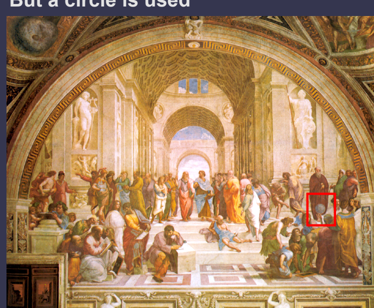
The sphere is projected
as an ellipse

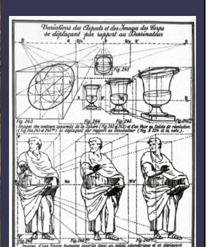
Symmetry is not preserved

Perspective distortion

The sphere should be projected as an ellipse

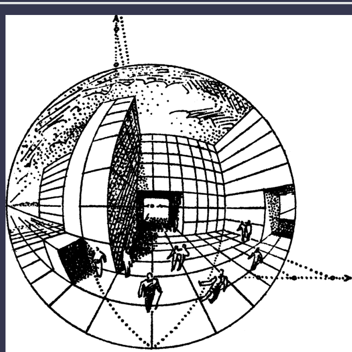
But a circle is used





Non-Linear Projections

Fish-eye

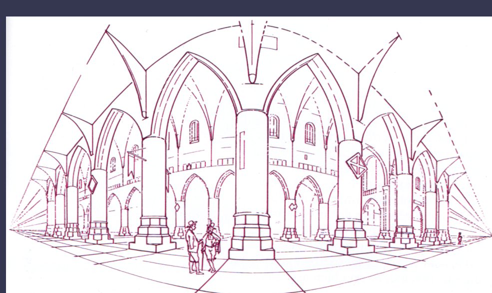


Fish-eye vs. wide angle

Curved perspective

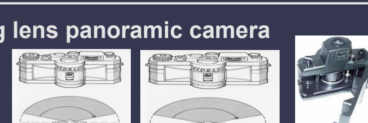
Panorama

- Preserve verticals

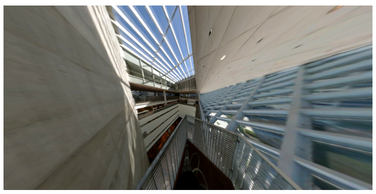


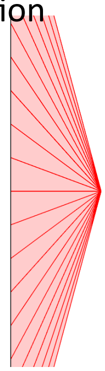
Curved perspective

Rotating lens panoramic camera



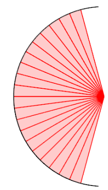
Perspective Projection





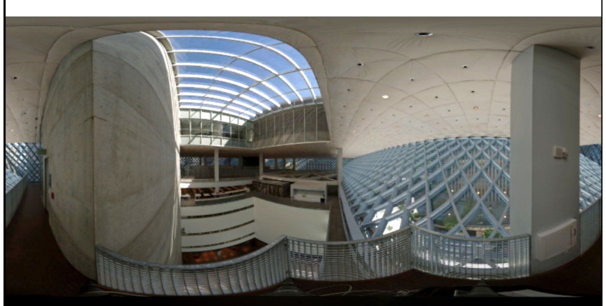
[from Kopf 07]

Cylindrical Projection



[from Kopf 07]

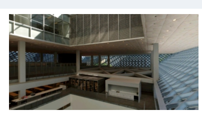
Spherical Projection

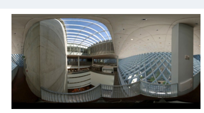


[from Kopf 07]

Perspective vs. Cylindrical/Spherical

Perspective	Cylindrical / Spherical
• Close to human perception	• Straight lines → curved
• Straight lines → straight	• Feels flat
• Wide angle distorted	• Whole FOV possible
= Best for narrow angles	= Best for wide angles





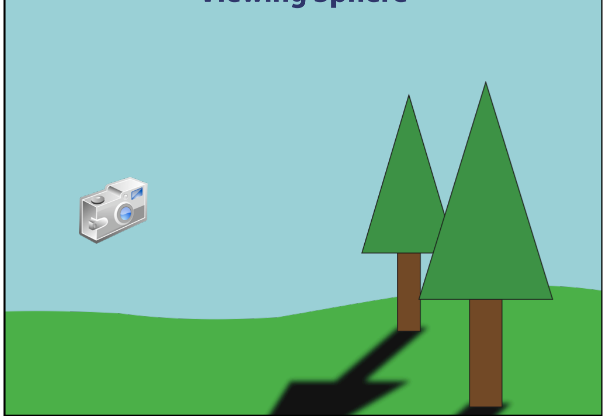
[from Kopf 07]

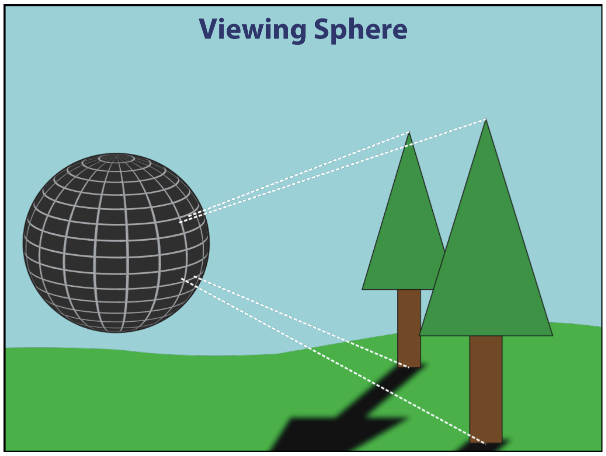
HD View

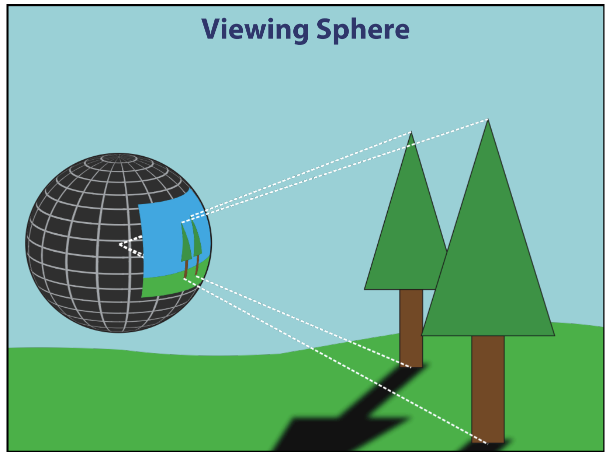
http://research.microsoft.com/ivm/HDView/HDGigapixel.htm

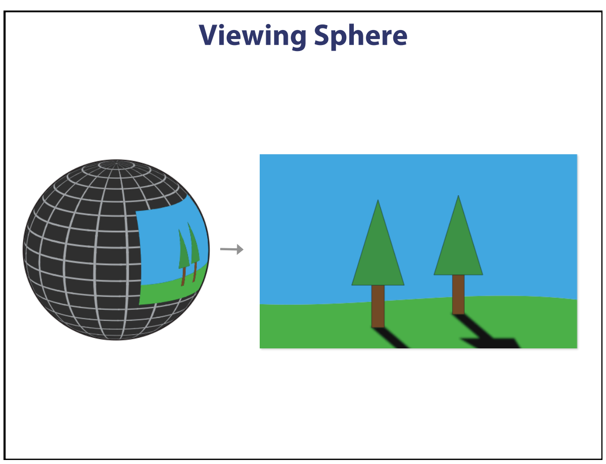
Optimizing the Projection

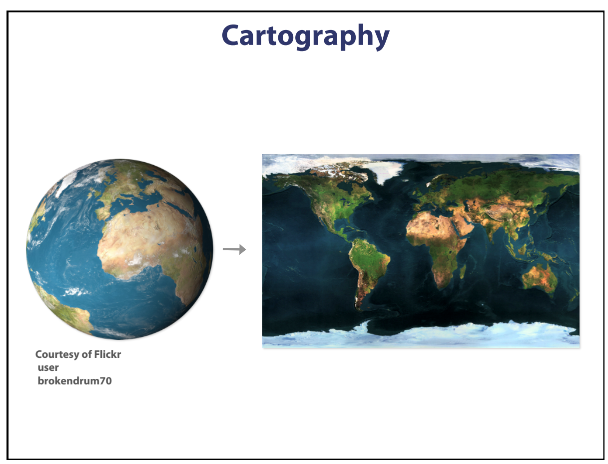
Viewing Sphere

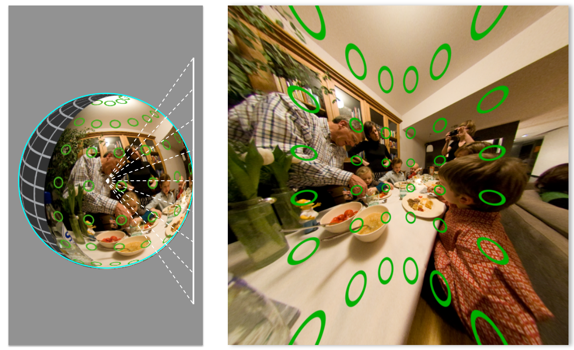



Viewing Sphere


Viewing Sphere

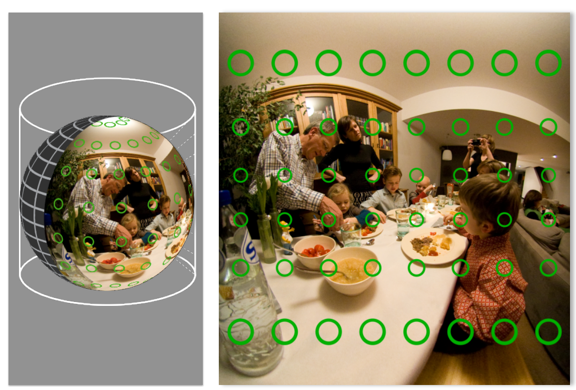

Viewing Sphere


Cartography
Courtesy of Flickr user brokendrum70



Linear Perspective Projection

Stereographic Projection



Cylindrical Projection

Optimized Projection

Goal

Given a wide-angle image, produce a projection that preserves straight lines in the scene and the shapes of objects

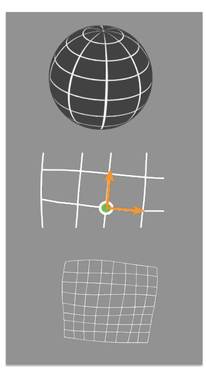
Our Approach

1. Mesh the viewing sphere

2. Define mapping constraints

3. Optimize energy function

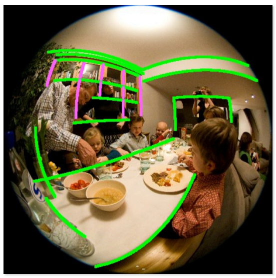
Conformality
Straight lines
Smoothness



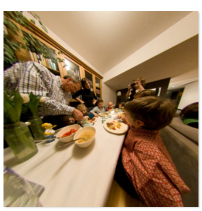
Optimizing Content-Preserving Projections for Wide-Angle Images

Robert Carroll
University of California, Berkeley
Maneesh Agrawala
University of California, Berkeley
Aseem Agarwala
Adobe Systems, Inc.

Input/Output

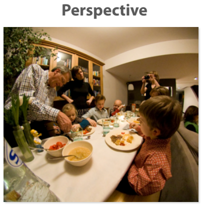


Input/Output

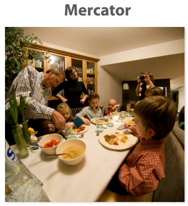


Perspective

Mercator



Stereographic



Our Result

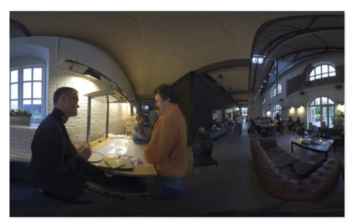
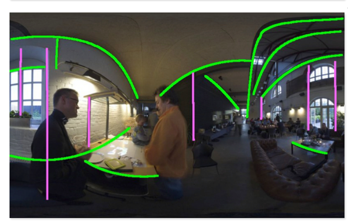
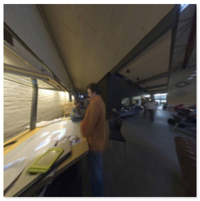


Image
Courtesy
Flickr user
Aldo

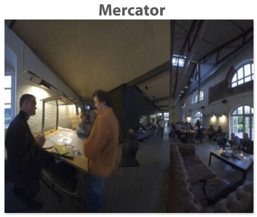




Perspective

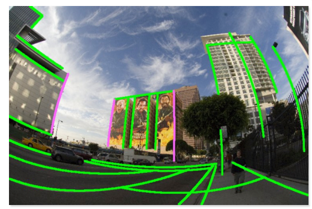
Mercator

Stereographic



Our Result

Image Courtesy Jeff Chien



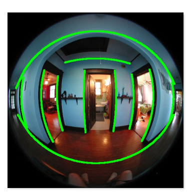
Perspective

Mercator

Stereographic

Our Result

Limitations



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