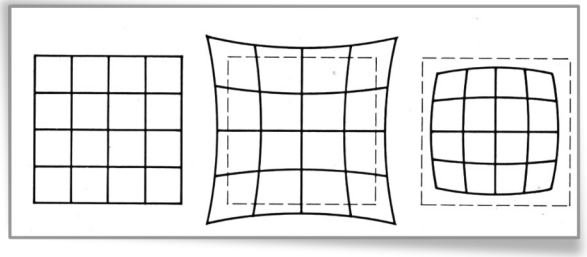


Folien zur Vorlesung am 01.04.2025

3D Computer Vision

BILDVERZERRUNG

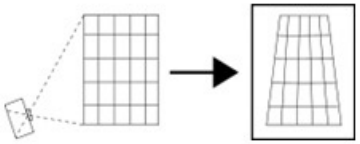
Perspective distortion

- Problem for architectural photography: converging verticals

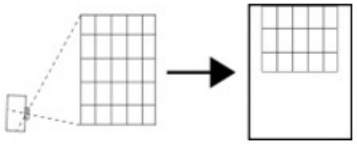
Source: F. Durand

Perspective distortion

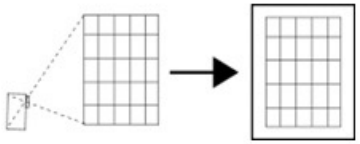
- Problem for architectural photography: converging verticals



Tilting the camera upwards results in converging verticals

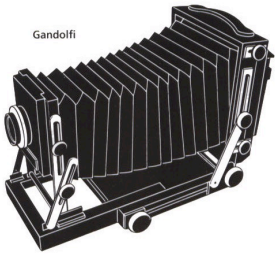


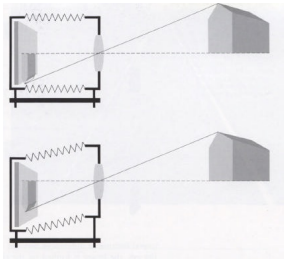
Keeping the camera level, with an ordinary lens, captures only the bottom portion of the building



Shifting the lens upwards results in a picture of the entire subject

- Solution: view camera (lens shifted w.r.t. film)



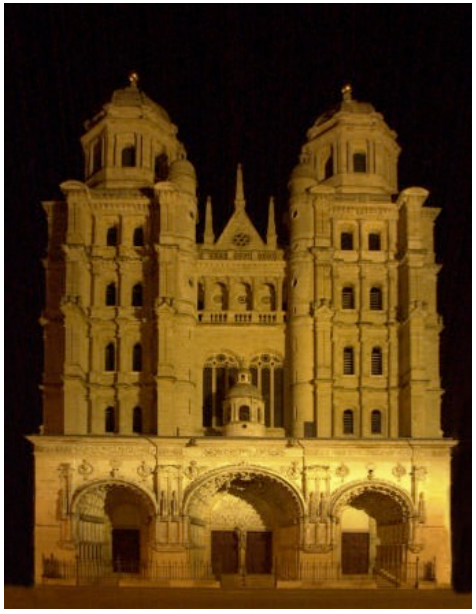


http://en.wikipedia.org/wiki/Perspective_correction_lens

Source: F. Durand

Perspective distortion

- Problem for architectural photography: converging verticals
- Result:



Source: F. Durand

Perspective distortion

- What does a sphere project to?

A visual answer:
https://www.shadertoy.com/view/XdBGzd

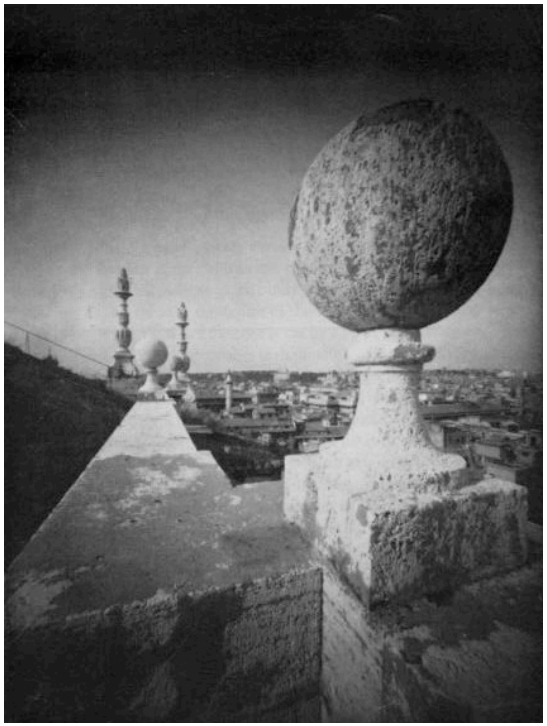
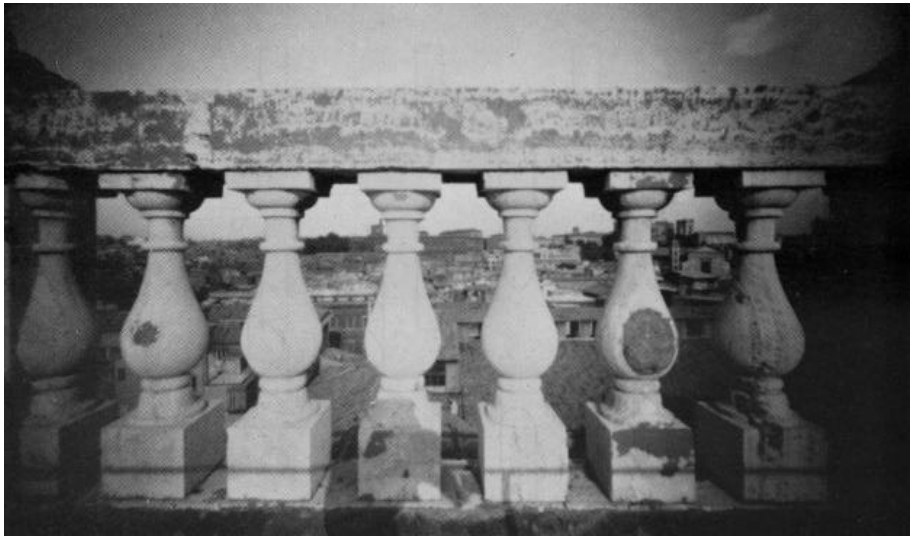
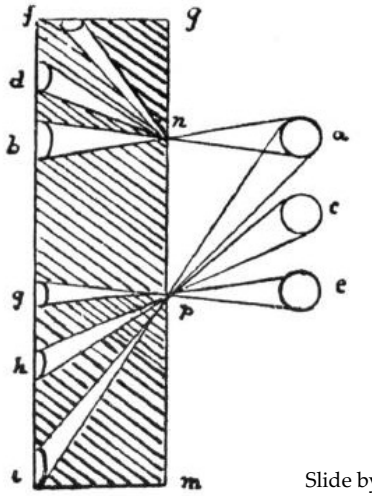


Image source: F. Durand

Perspective distortion

- The exterior columns appear bigger
- The distortion is not due to lens flaws
- Problem pointed out by Da Vinci





Slide by F. Durand

Perspective distortion: Faces

- https://www.danvojtech.cz/blog/2016/07/amazing-how-focal-length-affect-shape-of-the-face/

Perspective distortion: People

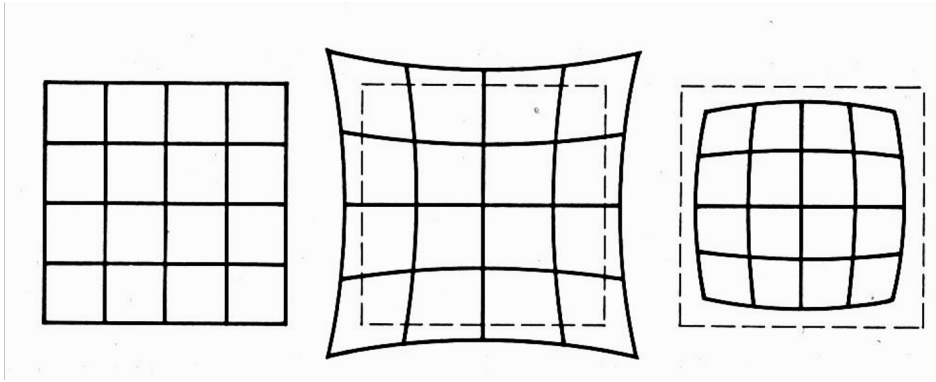
Distortion-Free Wide-Angle Portraits on Camera Phones

(a) A wide-angle photo with distortions on subjects' faces.

(b) Distortion-free photo by our method.

YiChang Shih, Wei-Sheng Lai, and Chia-Kai Liang, Distortion-Free Wide-Angle Portraits on Camera Phones, SIGGRAPH 2019
https://people.csail.mit.edu/yichangshih/wide_angle_portrait/

Lens distortion



- Radial distortion of the image
  - Caused by imperfect lenses
  - Deviations are most noticeable for rays that pass through the edge of the lens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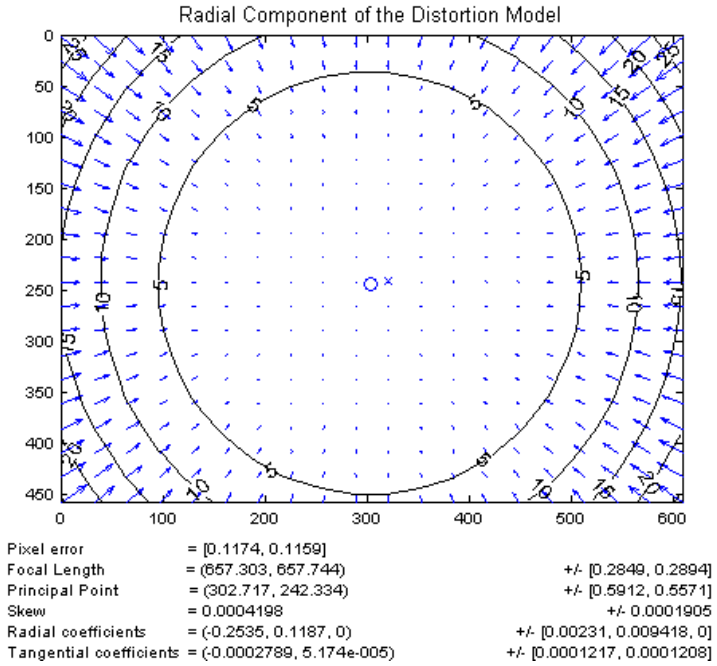
©2004 Vincent Bockaert 123di

Radial lens distortion



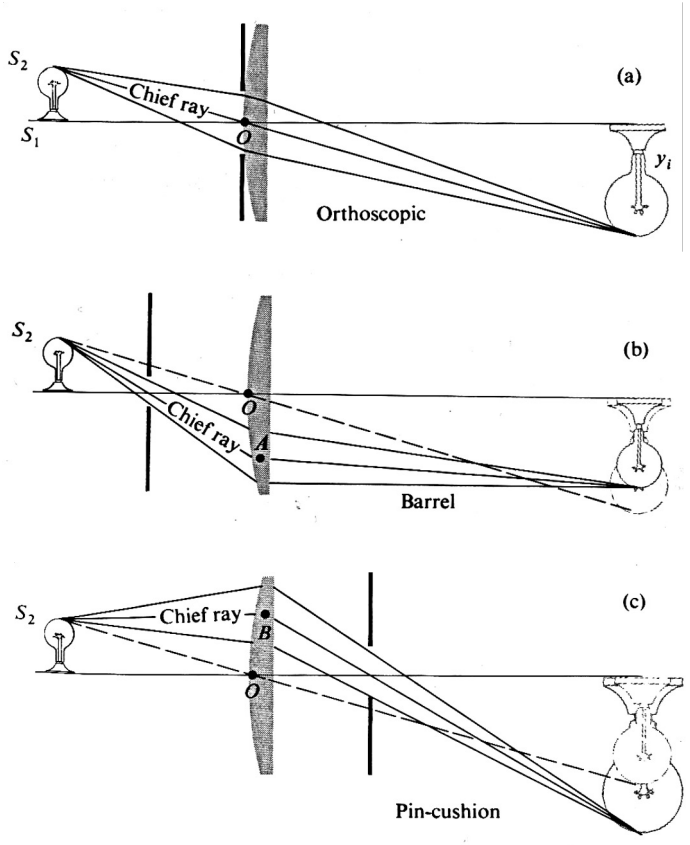
- Arrows show motion of projected points relative to an ideal (distortion-free lens)

[Image credit: J. Bouguet http://www.vision.caltech.edu/bouguetj/calib_doc/htmls/example.html]

Correcting radial lens distortion

from Helmut Dersch

Lens distortion



Modeling lens distortion

Project $(\hat{x}, \hat{y}, \hat{z})$ to "normalized" image coordinates

$$x'_n = \hat{x}/\hat{z}$$
$$y'_n = \hat{y}/\hat{z}$$

$$r^2 = {x'_n}^2 + {y'_n}^2$$

Apply radial distortion

$$x'_d = x'_n(1 + \kappa_1 r^2 + \kappa_2 r^4)$$
$$y'_d = y'_n(1 + \kappa_1 r^2 + \kappa_2 r^4)$$

Apply focal length translate image center

$$x' = f x'_d + x_c$$
$$y' = f y'_d + y_c$$

- To model lens distortion
  - Use above projection operation instead of standard projection matrix multiplication

Other types of projection

- Lots of intriguing variants…
- (I'll just mention a few fun ones)

360 degree field of view…

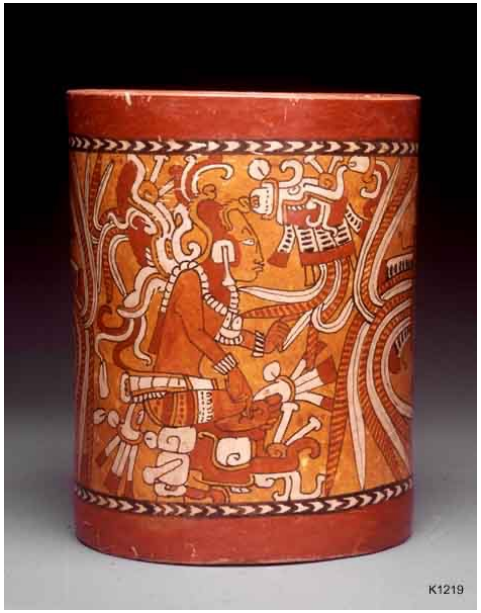
- Basic approach
  - Take a photo of a parabolic mirror with an orthographic lens (Nayar)
  - Or buy one a lens from a variety of omnicam manufacturers…
    - See http://www.cis.upenn.edu/~kostas/omni.html

Tilt-shift

http://www.northlight-images.co.uk/article_pages/tilt_and_shift_ts-e.html

Tilt-shift images from Olivo Barbieri
and Photoshop imitations

Rotating sensor (or object)



Rollout Photographs © Justin Kerr
http://research.famsi.org/kerrmaya.html

Also known as “cyclographs”, “peripheral images”