

Image processing: enhancement and restoration

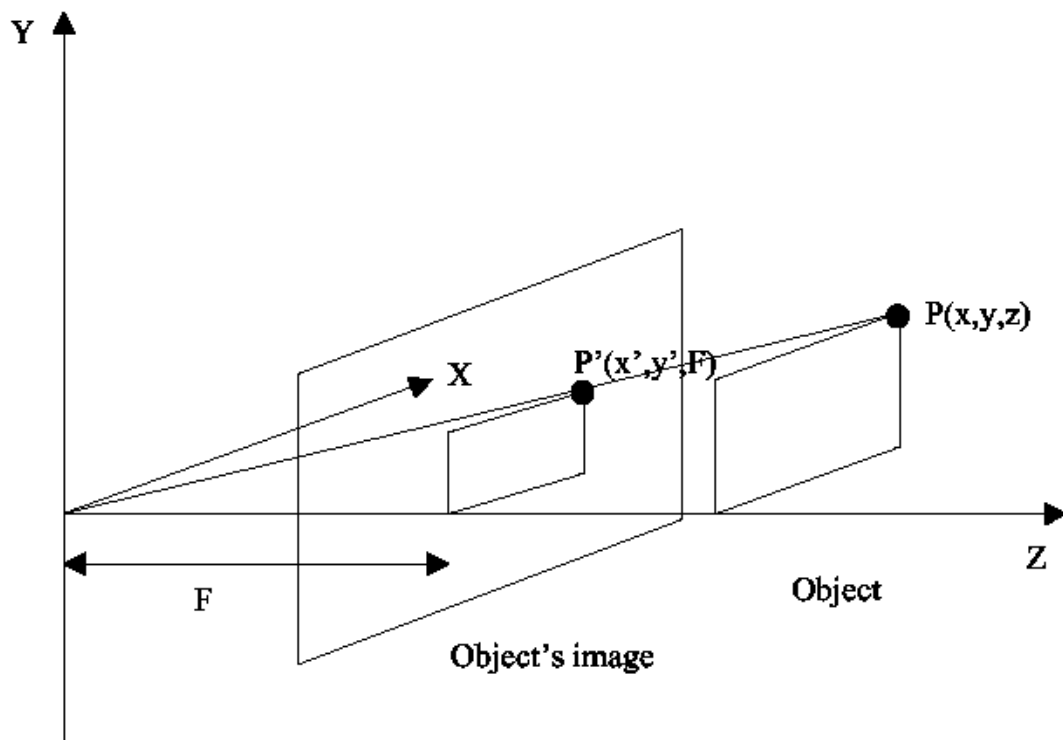
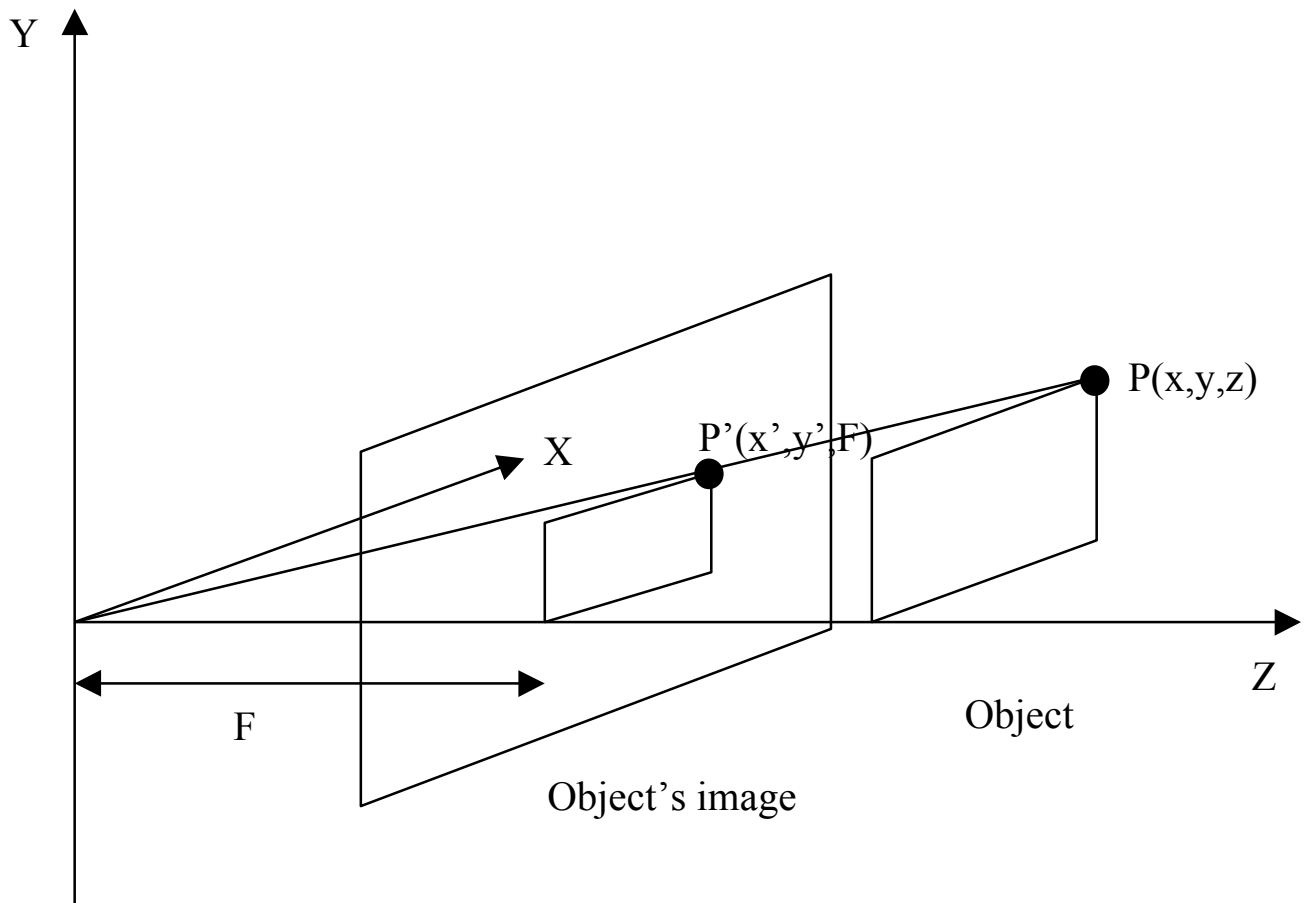
Purposes

- elimination or significant reduction of distortion of image functions caused by imperfect image generation process
- improvement of visual qualities of an image (for viewing)

Problems

- Geometric distortions
- Contrast distortions
- Noise
- Blur

Image geometry



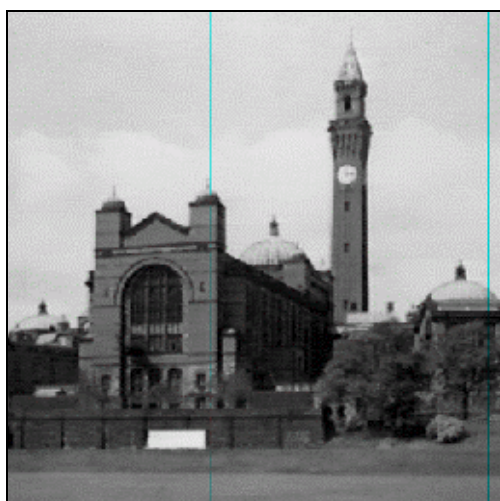
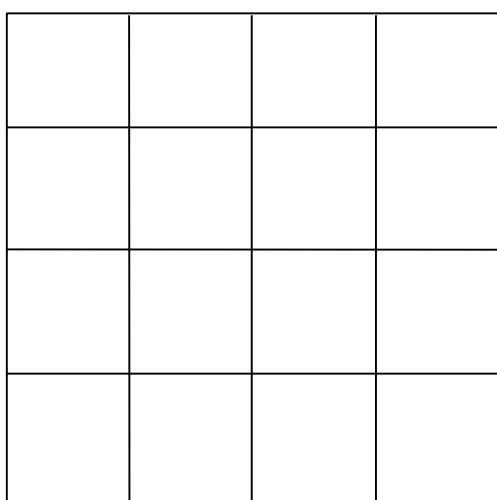
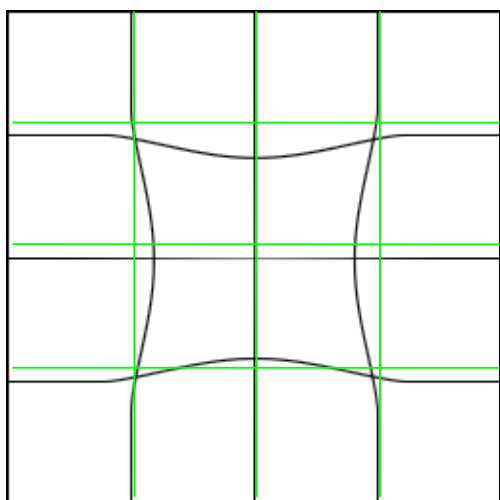
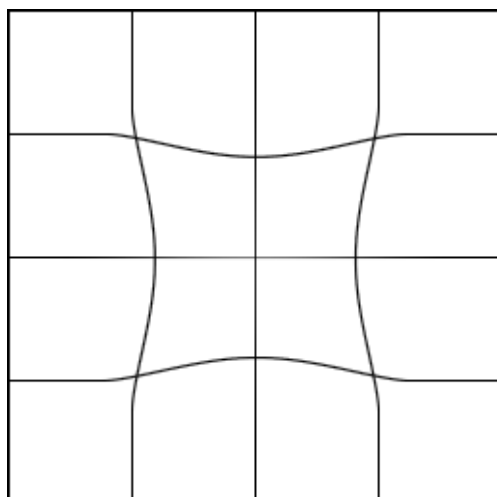
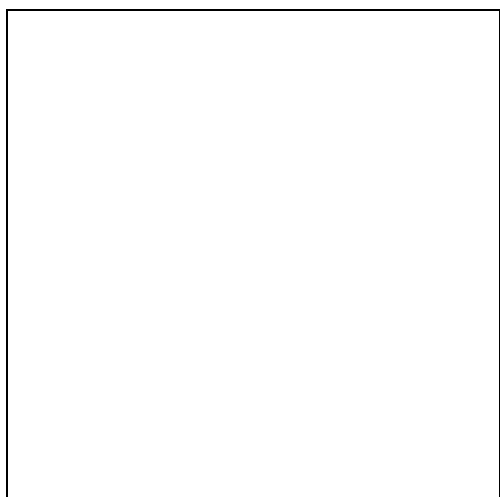
Geometric distortions

Causes

- sensor or camera geometry
- lens geometry (e.g. wide-angle)
- object geometry (e.g. projection of the Earth)

Corrections

- spatial interpolation from a known set of points
- rubber-sheet transformation
- camera calibration



Contrast distortions

Causes

- limited dynamic range of sensors
- exposure error

Contrast enhancement

- exposure correction - statistical methods
“histogram manipulation”
- sharpening (for the human viewer) - filtering
- sensor distortion correction - camera model
“de-illumination”

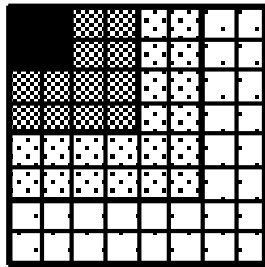
Histogram

A frequency distribution graph; shows how many pixels fall into various grey level boundaries

Histogram properties

- contrast
- dynamic range
- desired characteristics
 - medium or high contrast
 - large dynamic range

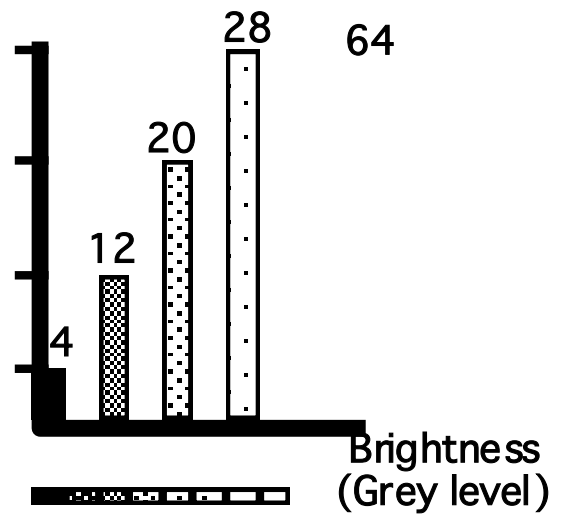
Image



Number
of pixels



Histogram



Histogram manipulations

- Aim: to redistribute the histogram so that contrast and dynamic range are enhanced.
- Uses statistical image model and places little significance on geometrical (spatial) dependence of pixels.
- Each pixel in $I(x,y)$ undergoes the same transformation T .
- T is assumed to be monotonically increasing, single-valued and have the inverse.

- Histogram manipulation is an example of pixel point processing, where the same transformation is applied to each pixel.
- Mapping function:

$$I'(x,y) = C \cdot I(x,y) + B \text{ for each pixel } (x,y)$$

Histogram manipulation operations

Shift

- lightening or darkening of the image by adding or subtracting a constant brightness to all pixels:

$$I'(x,y) = I(x,y) + B$$

- effect: histogram shifted to the right or left

Stretch

- changing the contrast and dynamic range of the image by multiplying all the pixels by a constant value:

$$I'(x,y) = C \cdot I(x,y)$$

- effect: histogram stretched or shrunk

Histogram specification

- technique to change image values so that the resulting image has the histogram as specified by the user.

Histogram equalisation

- The most common application of histogram specification
- Produces an output image with grey levels uniformly distributed

Photometric correction

- Uses the gamma function as the histogram model to compensate for non-linearity of the human perception

