Medical Image Processing for Diagnostic Applications

Image Undistortion for Image Intensifiers

Online Course – Unit 10

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Topics

Image Intensifier

Distortion Correction
- Image Distortion
- Distortion Correction – Design Considerations

Summary
- Take Home Messages
- Further Readings

Image Intensifier

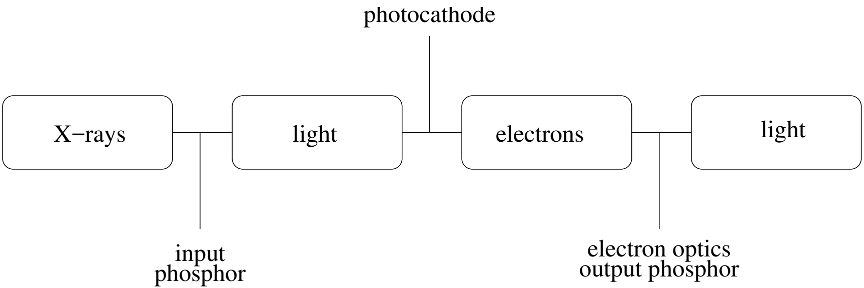

Figure 1: Basic principle of an image intensifier

Image Intensifier

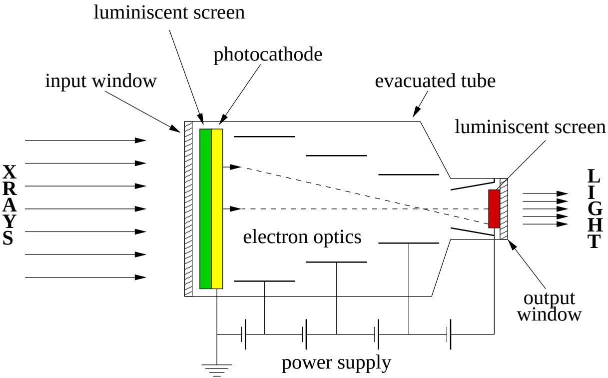

Figure 2: Internal structure of an image intensifier

X-Ray to Intensity Conversion

Materials used in image intensifiers:

input luminescent screen:	CsI:Na
photocathode:	$SbCs_3$
output luminescent screen:	ZnCdS:Ag

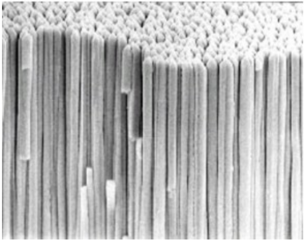

Figure 3: Due to its crystal structure, CsI minimizes lateral diffusion and scattering, i. e., it helps preserving spatial resolution.

Topics

Image Intensifier (II) and Image Distortion

Image distortion using II technology is caused by several phenomena:

- a magnetic field affects the accelerated electrons in the vacuum tube,
  - like the earth magnetic field, or
  - an artificial magnetic field (e. g., MR scanner, or Niobe system),
- scattering (veiling glare),
- convex entrance screen.

Image Distortion

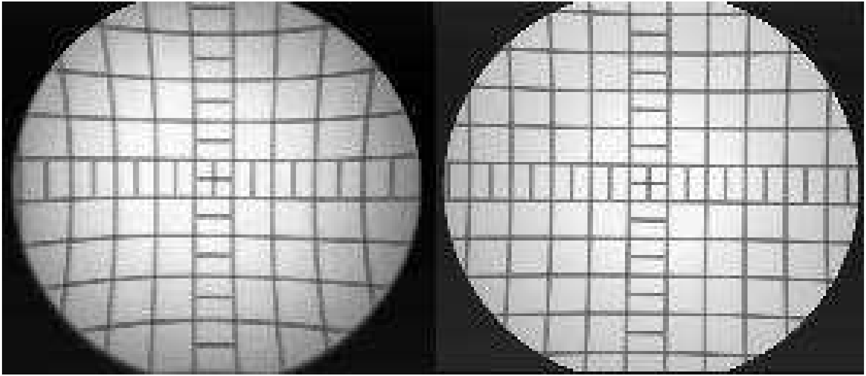

Figure 4: Example of a distorted (left) and an undistorted (right) image (image courtesy of RMIT University, Melbourne)

Image Distortion

We distinguish between two different types of image distortion:

- ***Geometric distortion:***
  - The acquisition device modifies the geometry of the mapped object.
  - In simple terms, we expect that in undistorted images straight lines in 3-D end up as straight lines in the 2-D image plane.
- ***Intensity distortion:***
  - The acquisition device induces changes in intensities.
  - In simple terms, we expect that in undistorted images identical tissue classes are mapped to identical intensities.
  - The heel effect is an example of intensity distortion.
  - Color normalization or homogenization of illumination can be used to tackle this type of distortion.

Distortion Correction

Definition

Image undistortion (or ***distortion correction***) is an image-to-image mapping that eliminates the distortions implied by the image acquisition device in the image plane.

Distortion Correction

How can we correct geometric image distortion?

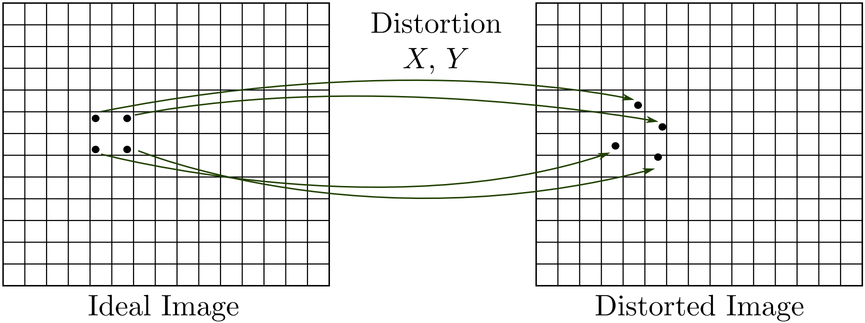

Figure 5: Image (un-)distortion $\leftrightarrow$ mapping of pixels or image points

Geometric Image Undistortion: Core Problems

These **problems** have to be solved for implementation of a geometric image undistortion algorithm:

- definition of a parametric or non-parametric **mapping** between undistorted and distorted image,
- **interpolation** of intensities of neighboring pixels, because lattice points of the undistorted image are not necessarily mapped to lattice points in the distorted image,
- a **robust and reliable estimation** of parameters or displacement vectors of the mapping,
- development of **efficient and robust algorithms** to run distortion correction (e. g., real-time image undistortion in cardiology with 30 frames per second).

Geometric Image Undistortion: Stages

Geometric image undistortion is a **three-stage process**:

- model design,
- estimation of model parameters (calibration),
- inference.

Geometric Image Undistortion: Model Design

Remarks on design issues:

- **Rule of thumb:** *always* sample in the space of your output!
- Consider parametric vs. non-parametric models.
- The dimension of the parameter space should be selected carefully (recall the curse of dimensionality!).
- Consider linear vs. non-linear estimators.
- Make optimal use of available hardware (e. g., manycore architectures, graphics card (GPU computing), cell processor, etc.).

Topics

Take Home Messages

- You have learned how an image intensifier works and that image distortions are a common problem that has to be dealt with.
- Geometric distortions and intensity distortions can occur during image acquisition.
- Several steps have to be considered to correct distortion in images. Hardware and algorithm design have an impact on the efficiency and usefulness of the distortion correction.

Further Readings

An excellent overview of different detectors used in X-ray equipment can be found in

> Heinz Morneburg, ed. *Bildgebende Systeme für die medizinische Diagnostik: Röntgendiagnostik und Angiographie, Computertomographie, Nuklearmedizin, Magnetresonanztomographie, Sonographie, integrierte Informationssysteme*. 3rd ed. Publicis MCD Verlag, June 1995 (in German).

Information on the distortion correction products can be found on the vendors' homepages. Try, for instance, www.healthcare.siemens.com.