Medical Image Processing for Diagnostic Applications

Preprocessing Introduction

Online Course – Unit 8

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Topics

Image Pre- and Postprocessing

Definition

increase image quality — user never sees the original image

Image preprocessing subsumes all image-to-image transforms that are done during image acquisition, i. e., in between the measurement at the detector (or other sensor) and the output on the monitor (or to hard disk).

Definition

users see both, the processed and the original image

All image-to-image transforms and image segmentation methods that are applied to images stored in the image data base are categorized to ***image postprocessing***.

Motivation of Image Preprocessing

There are **obvious reasons** for the need of image preprocessing:

- improvement of image quality to meet the requirements of the physician,
- noise reduction,
- contrast enhancement,
- correction of missing or wrong pixel (or voxel) values,
- optimal preparation of the data for post-processing,
- elimination of acquisition-specific artifacts.

Motivation of Image Preprocessing

Our task in the following lectures is to study:

- image acquisition procedures,
- their implications in terms of image artifacts, and
- the design of algorithms to eliminate image artifacts that are caused by certain image acquisition procedures.

Motivation of Image Preprocessing

The need of image preprocessing is illustrated by the image examples on the following slides.
We consider artifacts as they appear in:

- X-ray imaging (e. g., image distortion, defect pixels, heel effect),
- magnetic resonance imaging (e. g., elimination of intensity inhomogeneities in magnetic resonance imaging),
- endoscopy (e. g., heterogeneous illumination, specular reflection),
- molecular imaging (e. g., noise reduction).

Image Preprocessing in X-ray Imaging

Figure 1: Original image from X-ray device: colon filled with contrast agent (Stefan Böhm, Siemens Medical Solutions)

Image Preprocessing in X-ray Imaging

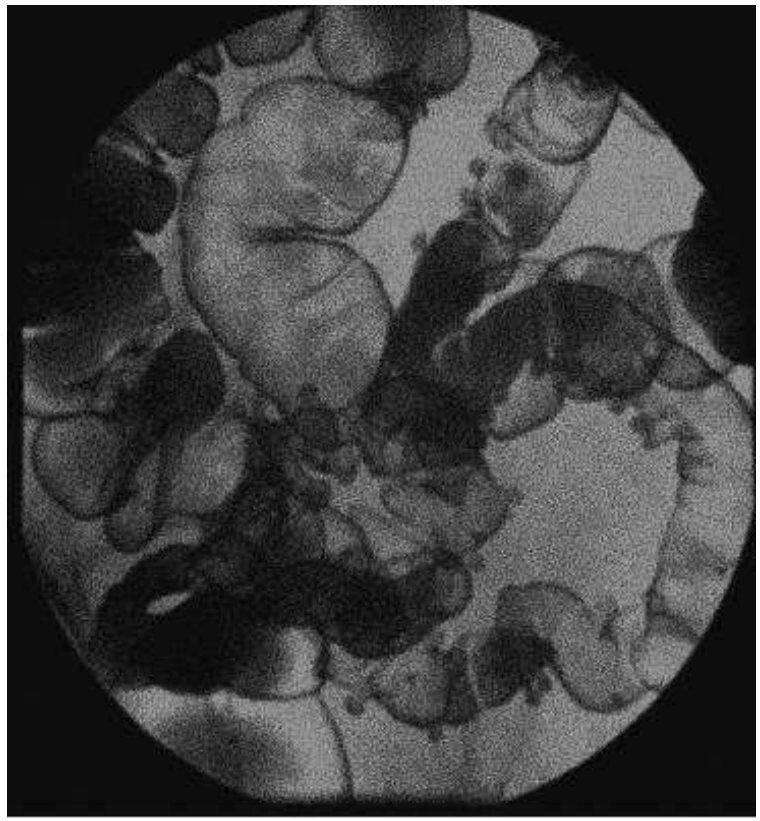

Figure 2: Image enhancement, step 1: corrupted image lines eliminated by interpolation (Stefan Böhm, Siemens Medical Solutions)

Image Preprocessing in X-ray Imaging

Figure 3: Image enhancement, step 2: contrast enhancement (Stefan Böhm, Siemens Medical Solutions)

Image Preprocessing in X-ray Imaging

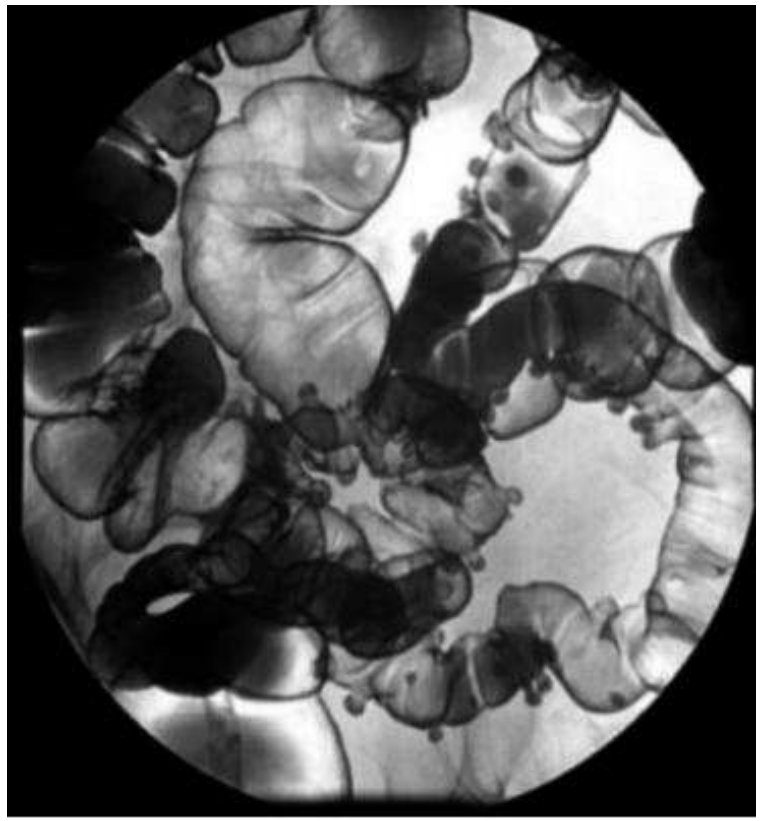

Figure 4: Image enhancement, step 3: image denoising (Stefan Böhm, Siemens Medical Solutions)

Image Preprocessing in X-ray Imaging

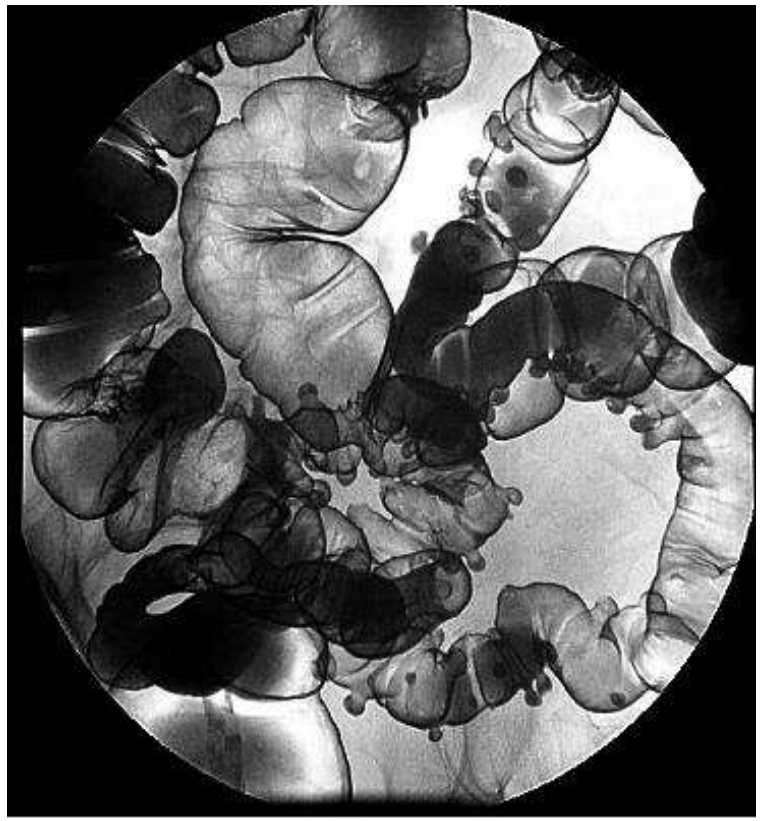

Figure 5: Image enhancement, step 4: edge enhancement (Stefan Böhm, Siemens Medical Solutions)

Image Preprocessing in MRI

Inhomogeneities in the magnetic field lead to images with intensity bias:

Figure 6: Image with inhomogeneities (left), and the intensity corrected preprocessing result (right) (Florian Jäger, Pattern Recognition Lab, FAU)

Image Preprocessing in MRI

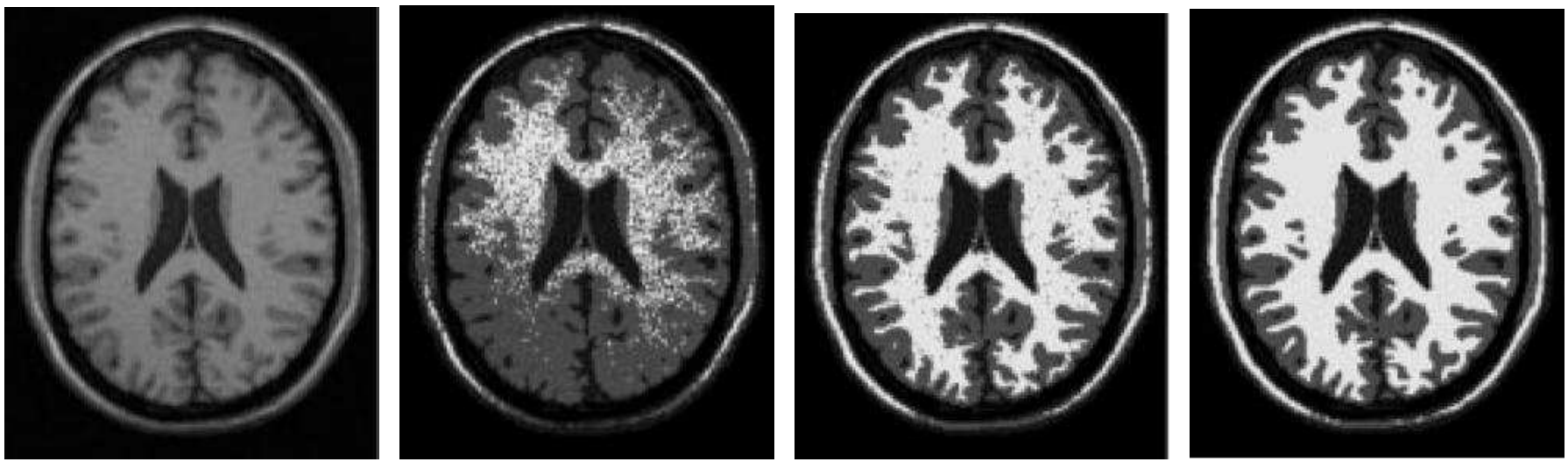

Figure 7: Image with bias field is corrected by different bias correction methods (Michael Balda, Pattern Recognition Lab, FAU).

Image Preprocessing in Endoscopy

One problem in imaging is the appearance of particles. By temporal in addition to spatial filtering images can be enhanced significantly.

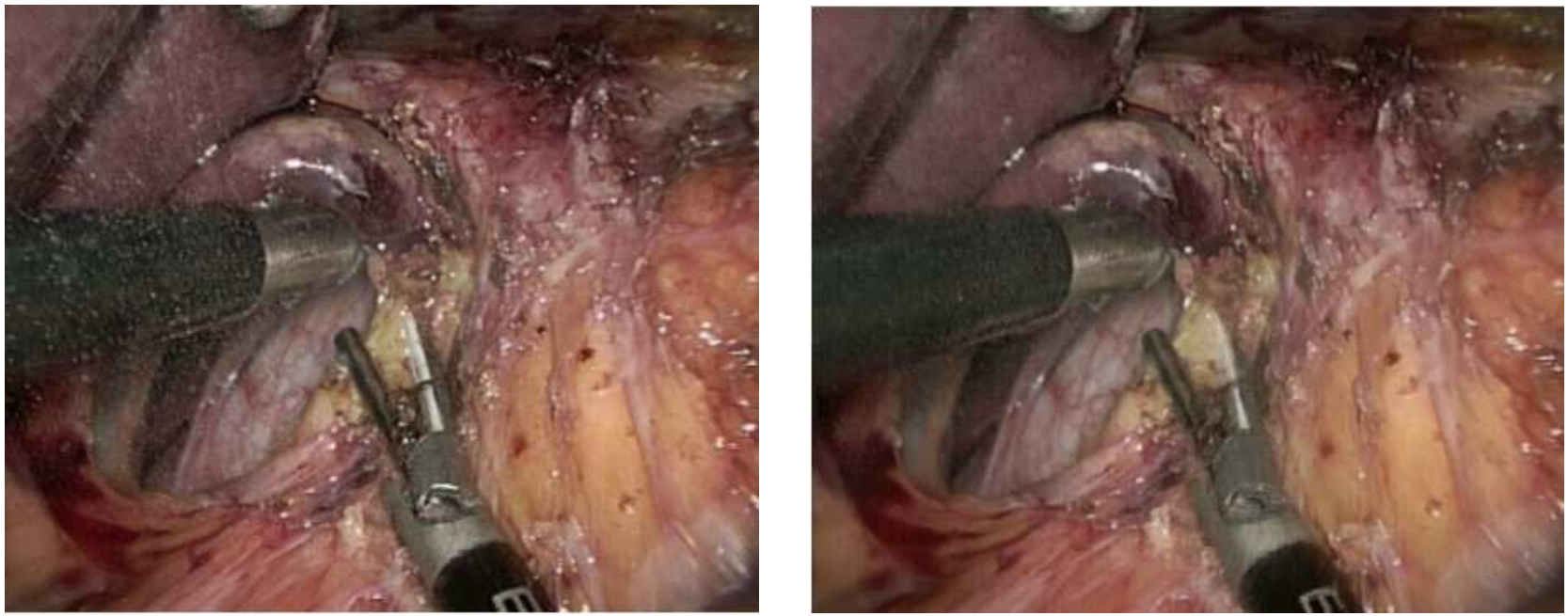

Figure 8: Images corrupted by flying particles (left), and the enhanced image (right) (Florian Vogt, Pattern Recognition Lab, FAU)

Artifacts

Common artifacts are caused by

- scattering,
- truncation,
- reconstruction algorithms, or
- beam hardening.

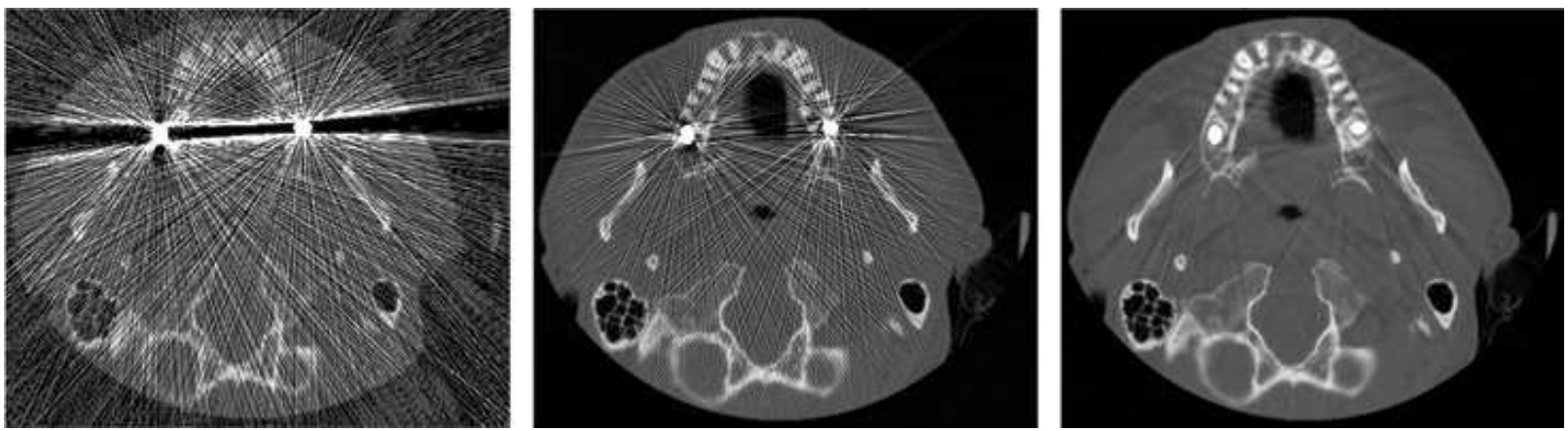

Figure 9: Reduction of streak artifacts (image courtesy of Stanford University)

Topics

Take Home Messages

Image preprocessing ...

- ... is done **before** the image appears on the monitor (“hidden algorithms”).
- ... is an art and an algorithmic challenge.
- ... requires the use of special hardware in most cases.
- ... is a trade-off (e. g., dose, run-time, hardware, ease of use, image quality).
- ... is driving business decisions (“to buy or not to buy”).
- ... is not an option, it is **mandatory**.

Further Readings

A book that covers many image preprocessing methods applied in medical imaging systems is:

> Jiří Jan. *Medical Image Processing, Reconstruction, and Restoration: Concepts and Methods*. Signal Processing and Communications. CRC Press, Taylor & Francis Group, Nov. 2005

This book is rather expensive. It is not required to buy this book to follow the lectures.