Diagnostic Medical Image Processing

Acquisition Specific Pre-Processing

WS 2010/11

Joachim Hornegger, Dietrich Paulus, Markus Kowarschik

Lehrstuhl für Mustererkennung (Informatik 5)

Friedrich-Alexander-Universität Erlangen-Nürnberg

Diagnostic Medical Image Processing

1 Motivation of Image Pre-Processing
- Definition of Pre-Processing
- Pre-processing Examples
- Take Home Messages
- Further Readings

Image Pre- and Post-Processing

Definition

Image pre-processing subsumes all image-to-image transforms that are done during image acquisition, i.e. in between the detector resp. sensor and the monitor resp. hard disk.

Definition

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

Motivation of Image Pre-Processing

There are obvious reasons for the need of image pre-processing:

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

Motivation of Image Pre-Processing

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 Pre-Processing

The need of image pre-processing is illustrated by the following image examples. 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)

Diagnostic Medical Image Processing

1 Motivation of Image Pre-Processing
- Definition of Pre-Processing
- Pre-processing Examples
- Take Home Messages
- Further Readings

Image Pre-processing in X-ray Imaging

Figure 1: Original image acquired by X–ray device: colon filled with contrast agent (courtesy of Stefan Böhm, Siemens Medical Solutions)

Image Pre-processing in X-ray Imaging

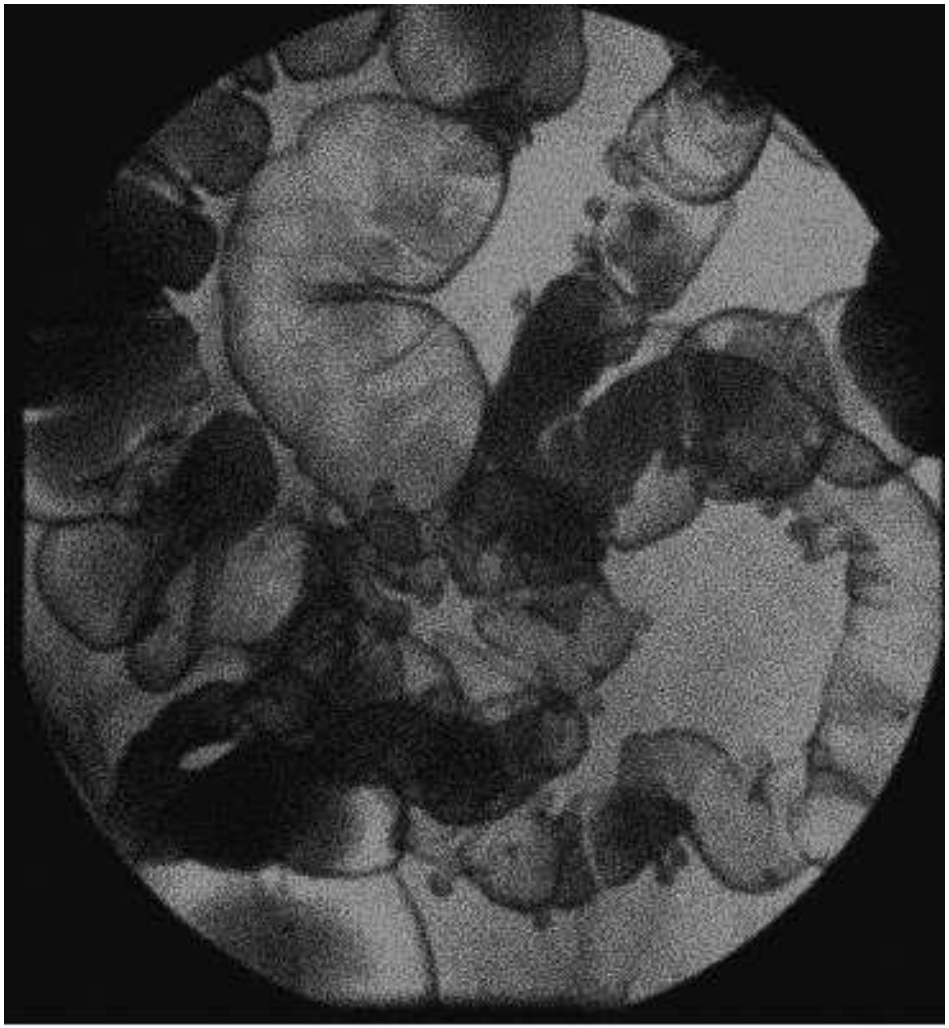


Figure 2: Image Enhancement 1: corrupted image lines eliminated by interpolation (courtesy of Stefan Böhm, Siemens Medical Solutions)

Image Pre-processing in X-ray Imaging

Figure 3: Image Enhancement 2: contrast enhancement (courtesy of Stefan Böhm, Siemens Medical Solutions)

Image Pre-processing in X-ray Imaging

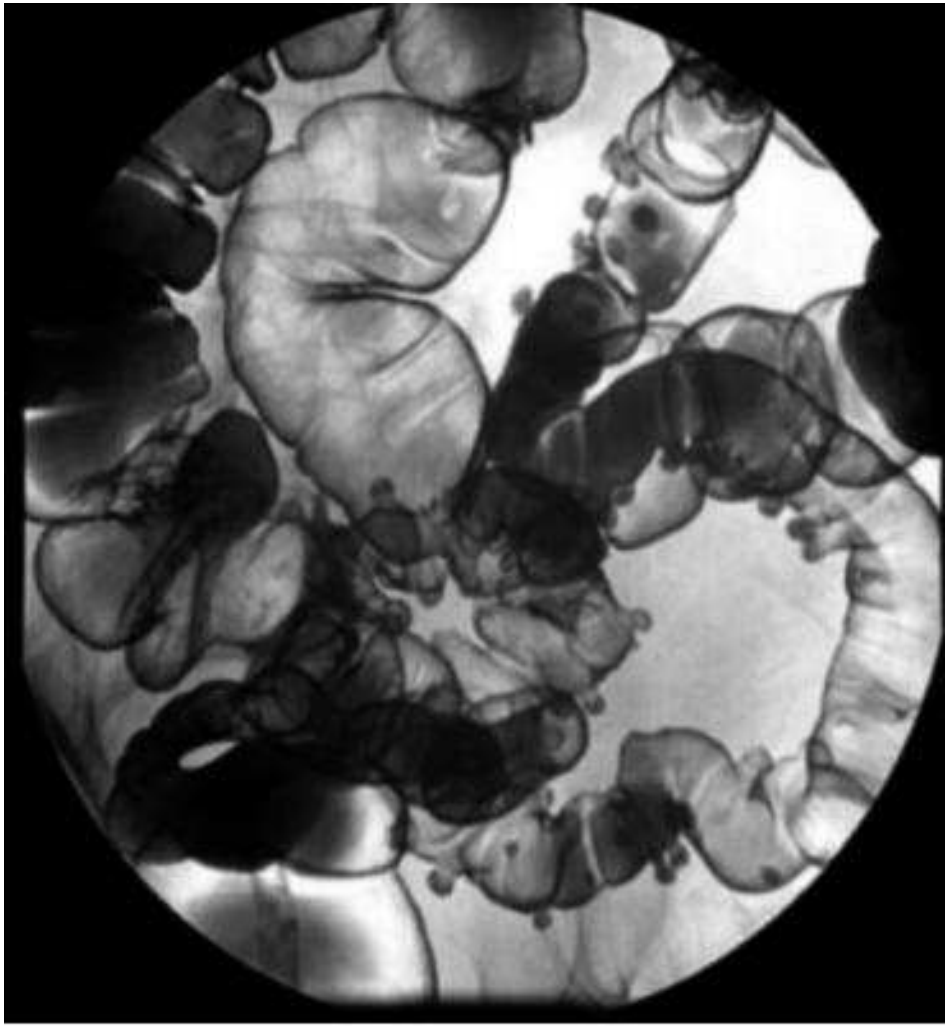


Figure 4: Image Enhancement 3: image denoising (courtesy of Stefan Böhm, Siemens Medical Solutions)

Image Pre-processing in X-Ray Imaging

Figure 5: Image Enhancement 4: edge enhancement (courtesy of Stefan Böhm, Siemens Medical Solutions)

Image Pre-processing in MRI

In MRI inhomogenities are due to heterogenous magnetic fields. This leads to images with intensity bias.

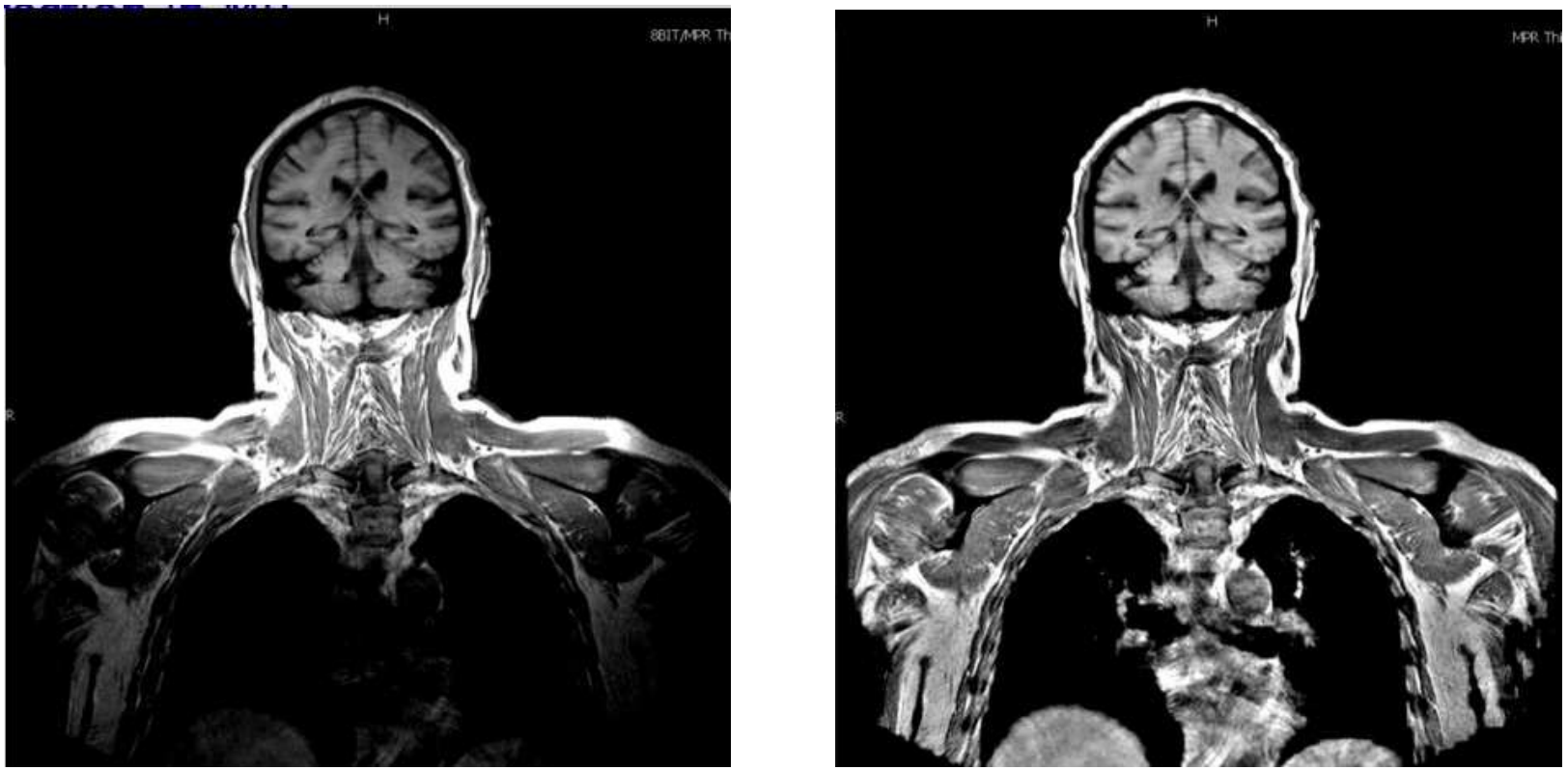


Figure 6: Image with inhomogenities and the intensity corrected pre-processing result (images: Florian Jäger, LME)

Image Pre-processing in MRI

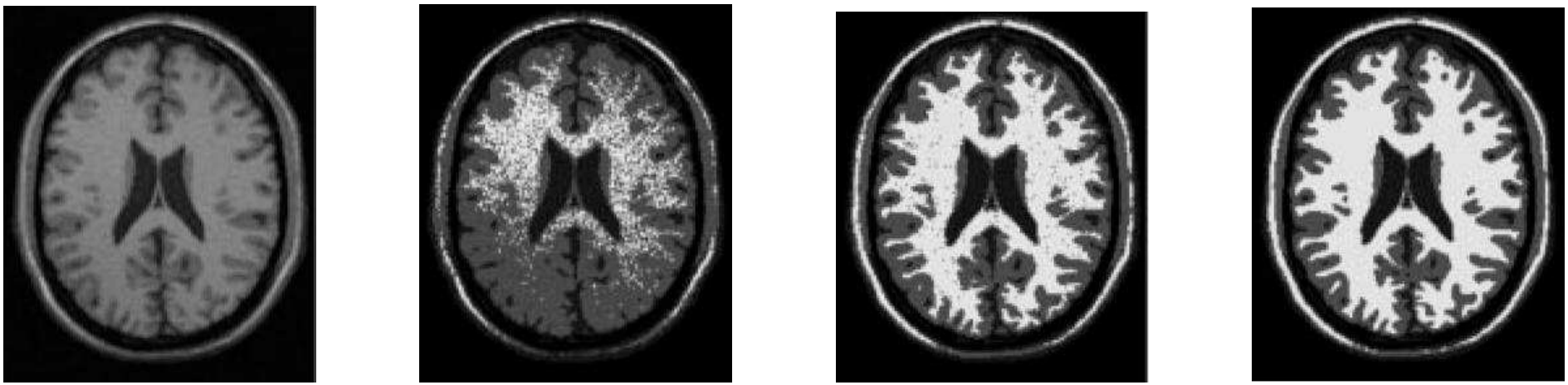
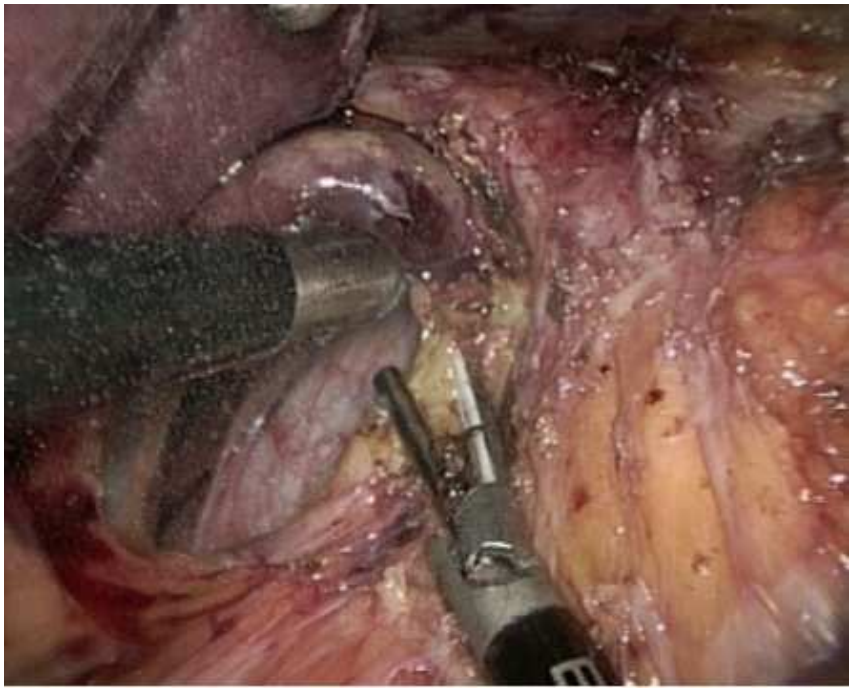


Figure 7: MRI image with bias field is corrected by different bias correction methods (images: Michael Balda, LME)

Image Pre-processing in Endoscopy

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



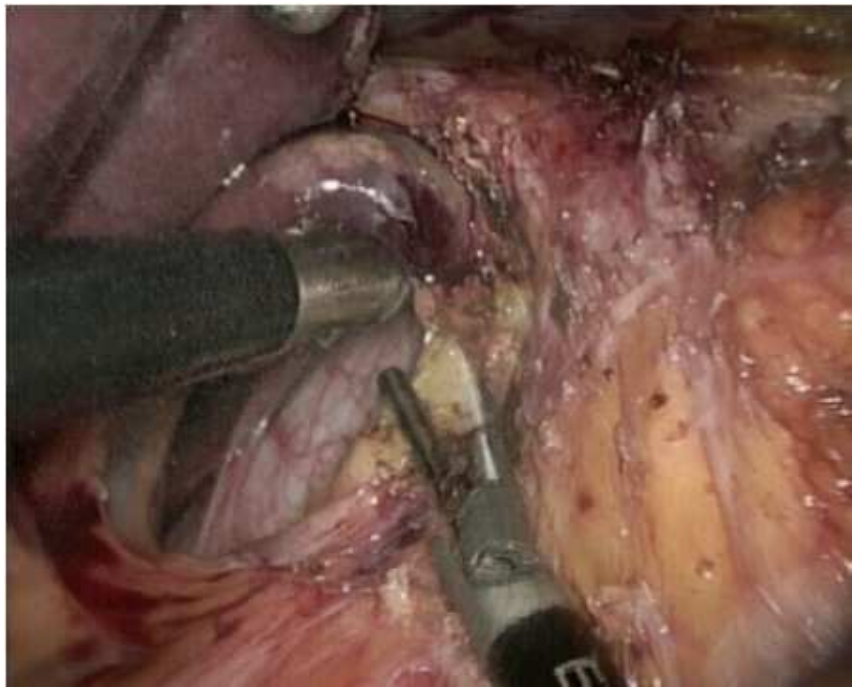


Figure 8: Images corrupted by flying particles (left) and the enhanced image (right) (images: Florian Vogt, LME)

Image Pre-processing in CT

In CT common artifacts are caused by scattering, truncation, reconstruction algorithms or beam hardening.

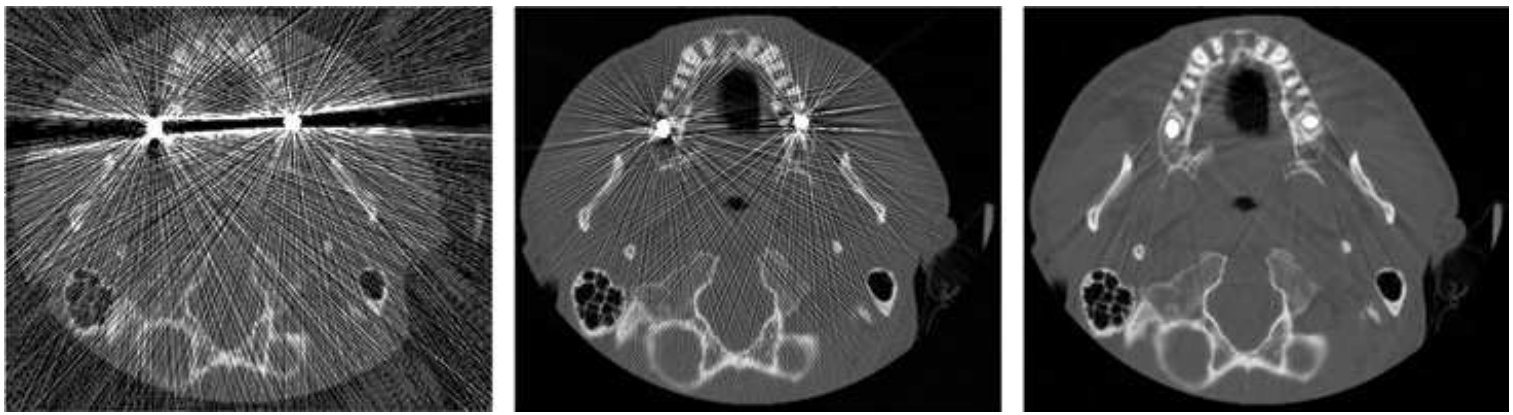


Figure 9: Reduction of streak artifacts in CT (images: Stanford Univ.)

Diagnostic Medical Image Processing

1 Motivation of Image Pre-Processing
- Definition of Pre-Processing
- Pre-processing Examples
- Take Home Messages
- Further Readings

Take Home Messages

Image Pre-Processing

- is done **before** image appears on 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: “buy or not to buy”
- is not an option, it is **mandatory**.

Diagnostic Medical Image Processing

1 Motivation of Image Pre-Processing
- Definition of Pre-Processing
- Pre-processing Examples
- Take Home Messages
- Further Readings

Further Readings

- A book that covers most image pre-processing methods applied in today's imaging systems is:
  Jiri Jan, Medical Image Processing, Reconstruction and Restoration, Signal Processing and Communications, Marcel Dekker, 1st edition, 2005. (amazon here)
  This book is rather expensive. It is not required to buy this book to follow the lectures.