# Medical Image Processing for Diagnostic Applications

## Types of Medical Imaging

Online Course – Unit 3

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# Topics

# Morphologic Imaging

## Definition

***Morphologic imaging*** is about the imaging of the physical appearance of the inner human body like shape, structure or density.

Major modalities for morphologic imaging are:

- endoscopy,
- X-ray,
- computed tomography (CT),
- magnetic resonance (MR),
- ultrasound (US).

Figure 1: CT data set visualized with different volume rendering parameters (Image courtesy of Dr. Fishman, Baltimore)

# Morphologic Imaging

Morphologic imaging ...

- ... requires to further increase spatial and contrast resolution.
- ... requires the minimization of artifacts caused, for instance, by respiratory motion.
- ... requires the development of new algorithms and methods for the reconstruction of moving objects like the heart or the thorax while breathing.

**Morphological imaging is still a highly demanding, innovative and challenging research field.**

# Molecular Imaging

## Definition

***Molecular imaging*** is about the imaging and visualization of processes and changes in the organism at the molecular level.

Major modalities used for molecular imaging are:

- positron emission tomography (PET),
- single photon emission computed tomography (SPECT),
- functional magnetic resonance imaging (fMRI).

# Molecular Imaging

Molecular imaging ...

- ... relies on concurrent advances in molecular medicine, nuclear medicine, chemistry, computer science, imaging science and engineering.
- ... allows for the imaging of cellular and molecular processes in vivo.
- ... is expected to serve as the connecting link between radiology and molecular medicine.

**Molecular imaging is considered as the initialization of the next revolution in medical imaging. Things in research and industry are a clear proof!**

# Diagnostic Imaging

## Definition

The process of analyzing a disease by its symptoms and from the results of various measurements and images is called ***diagnosis***.

## Definition

***Diagnostic imaging*** includes the visualization of morphological structures or molecular processes of organs or tissues for the particular diagnostic evaluation.

# Diagnostic Imaging

In diagnostic imaging ...

- ... the image acquisition is usually done by a technician and not by the treating physician.
- ... system parameters can be adjusted without high time pressure.
- ... short acquisition time is important but not crucial.
- ... a system crash is (usually) not life threatening.

# Interventional Imaging

## Definition

In a ***medical intervention*** we act and apply methods in a way to modify a health outcome.

## Definition

***Interventional imaging*** provides real-time imaging guidance to the physician to allow for an effective treatment.

# Interventional Imaging

In interventional imaging ...

- ... the image acquisition is done while the patient gets treated.
- ... the image acquisition is usually done by the treating physician.
- ... the focus is on the patient, not on the system and its user interface.
- ... we have high demands on reliability, i. e. the loss of image information can be life threatening.
- ... real time image acquisition and processing is required that gets to the limit of current hardware performance.
- ... usually requires proprietary hardware accelerators.

# Topics

# Take Home Messages

- You now know the different categories or dimensions of imaging:
  - morphologic imaging,
  - molecular imaging,
  - diagnostic imaging,
  - interventional imaging.
- We introduced the respective fields of application as well as technical and health implications.

# Further Readings

An introduction to the physics for medical imaging is given by the following books:

1. David J. Dowsett, Patrick A. Kenny, and R. Eugene Johnston. *The Physics of Diagnostic Imaging*. 2nd ed. London: Hodder Arnold, Apr. 2006. DOI: 10.1201/b13462-1
2. Arnulf Opelt, ed. *Imaging Systems for Medical Diagnostics: Fundamentals, Technical Solutions and Applications for Systems Applying Ionizing Radiation, Nuclear Magnetic Resonance and Ultrasound*. 2nd ed. Erlangen: Publicis, 2005

The mathematical details of medical imaging are described in:

Charles L. Epstein. *Mathematics of Medical Imaging*. Upper Saddle River, N.J.: Pearson Education/Prentice Hall, 2003