Image Processing Group: Research Activities in Medical Image Analysis

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Image Processing Group Members

- Marko Subašić, Assistant Professor
- Tomislav Petković, postdoctoral fellow
- Hrvoje Kalinić, doctoral student
- Vedrana Baličević, doctoral student
- Adam Heđi, former graduate student
- Hrvoje Bogunović, former graduate student
- Tomislav Devčić, former graduate student

IPG members sailing on Adriatic coast, 2006

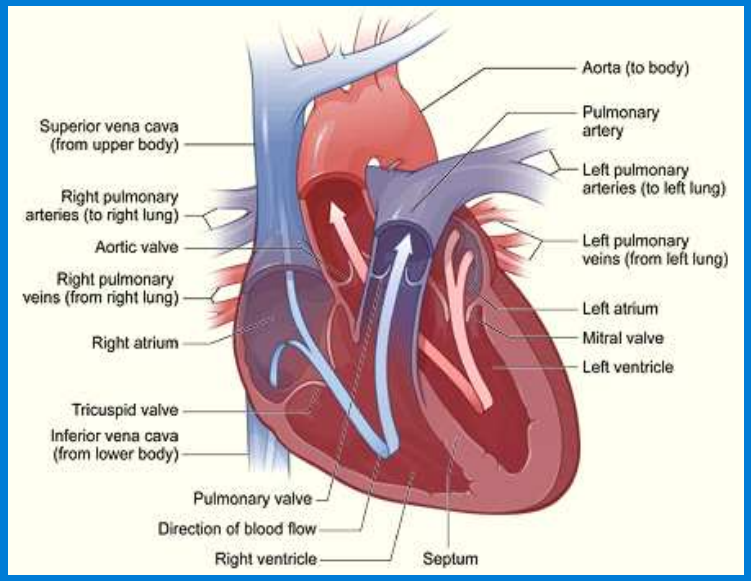
6th Int'l Symposium on Image and Signal Processing and Analysis
September 4-6, 2011, Dubrovnik, Croatia

Image Processing Group, Faculty of Electrical Engineering & Computing, Univ. of Zagreb

Medical image analysis projects

- Some example projects:
  - Aortic outflow velocity Doppler ultrasound image analysis
  - Detection and tracking of catheter for intravascular interventions
  - 3-D analysis of abdominal aortic aneurysm
  - 3-D analysis of intracerebral brain hemorrhage
  - Virtual endoscopy

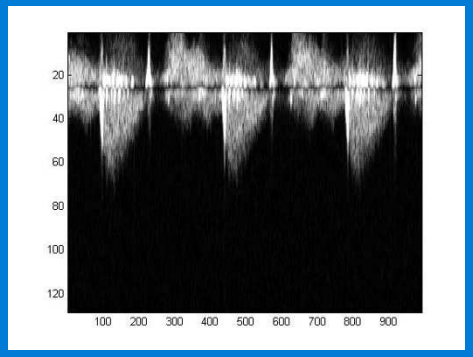
Aortic outflow velocity profile analysis

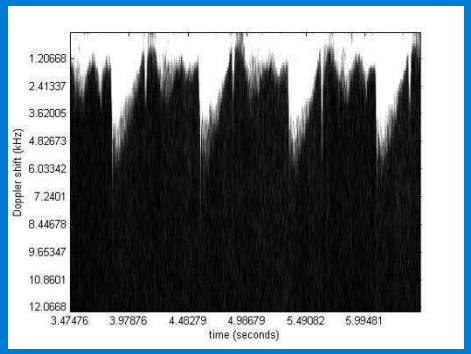


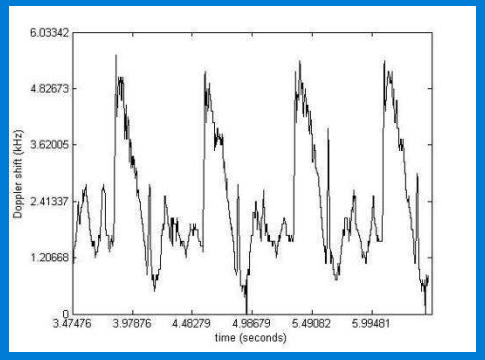
- Partners:
  - Hrvoje Kalinić, Sven Lončarić, FER
  - Maja Čikeš, Davor Miličić, University Hospital Rebro
  - Bart Bijnens, Pompeu Fabra University Barcelona

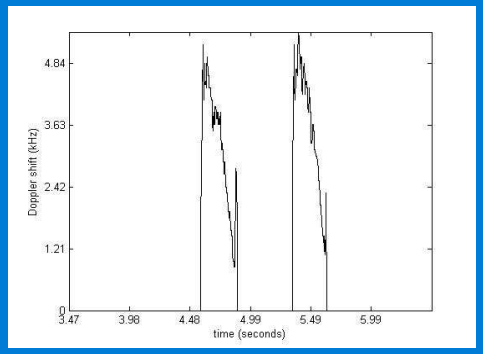
Aortic outflow velocity analysis method

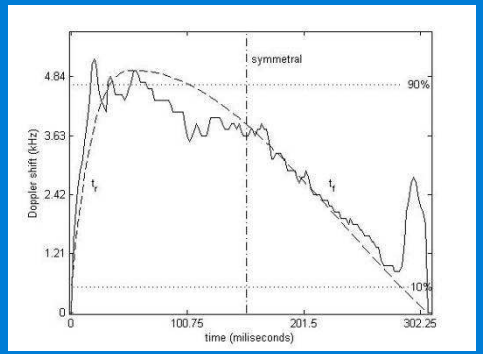
HDF image → Automatic signal extraction → Manual indication of ejection time → Signal modeling → Signal feature extraction → Signal interpretation →



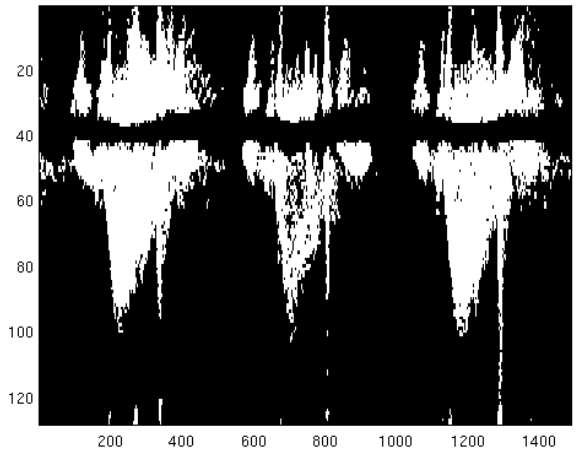


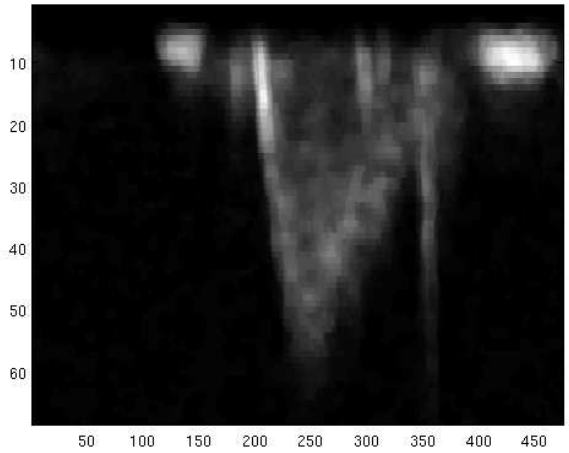


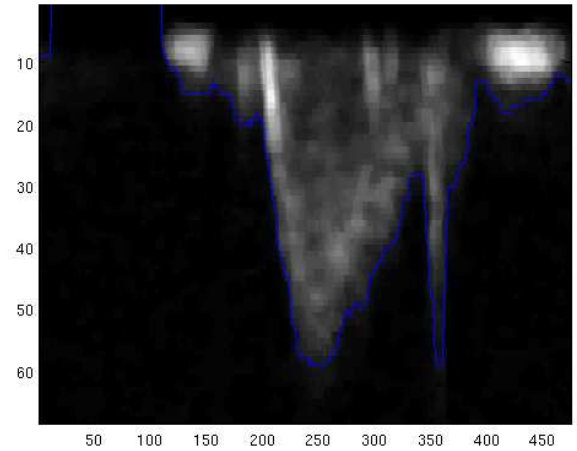


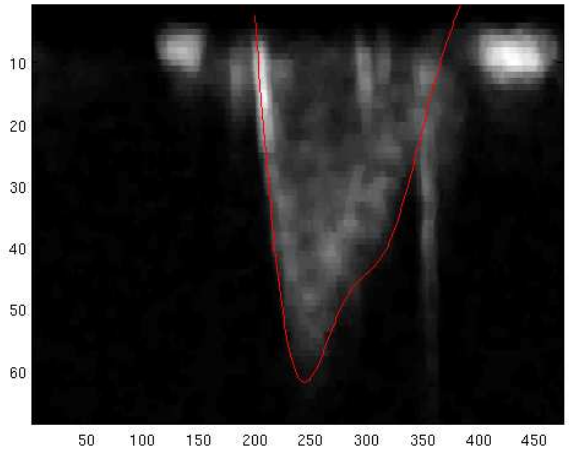


Aortic outflow velocity profile



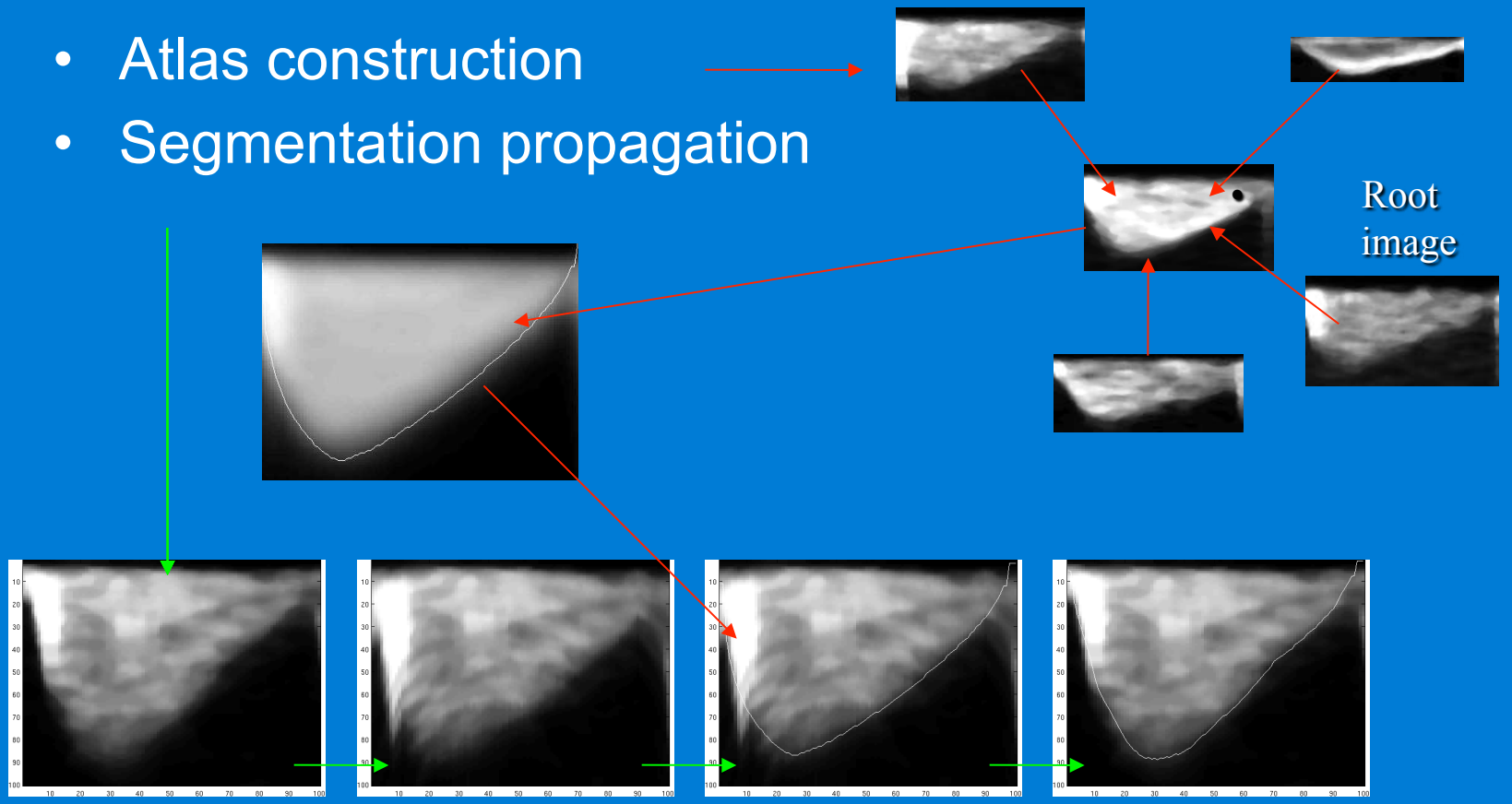






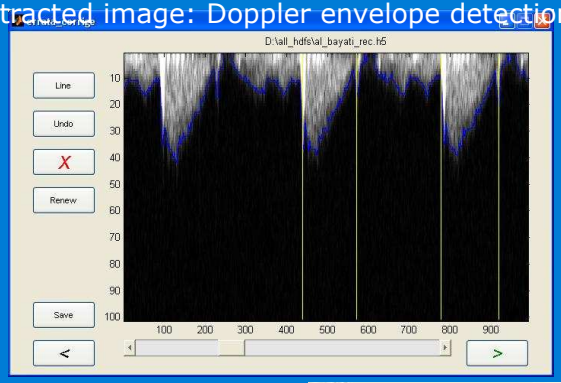
Atlas-based segmentation

- Atlas construction
- Segmentation propagation

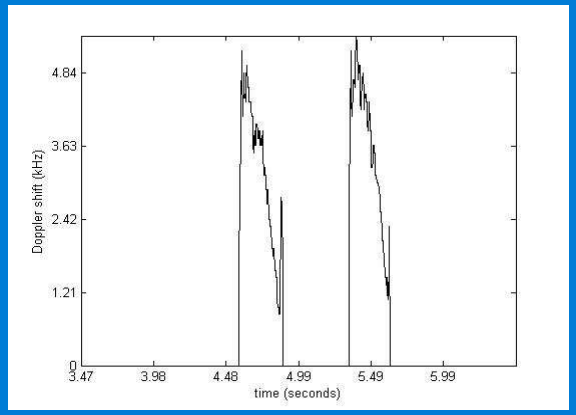


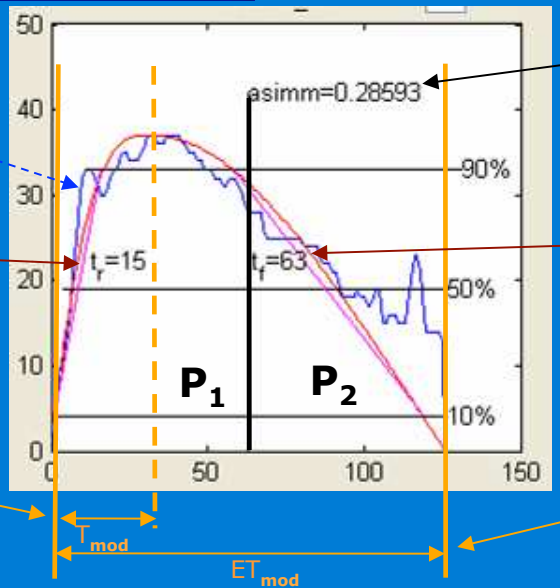
Atlas-based segmentation

Extracted image: Doppler envelope detection, ET selection



Signal modelling used for feature extraction





Original signal

asymmetry factor (asymm) = $(P_1-P_2)/P_{overall}$
the difference of area under the curve of left and right
half of the spectrum normalized by the overall area

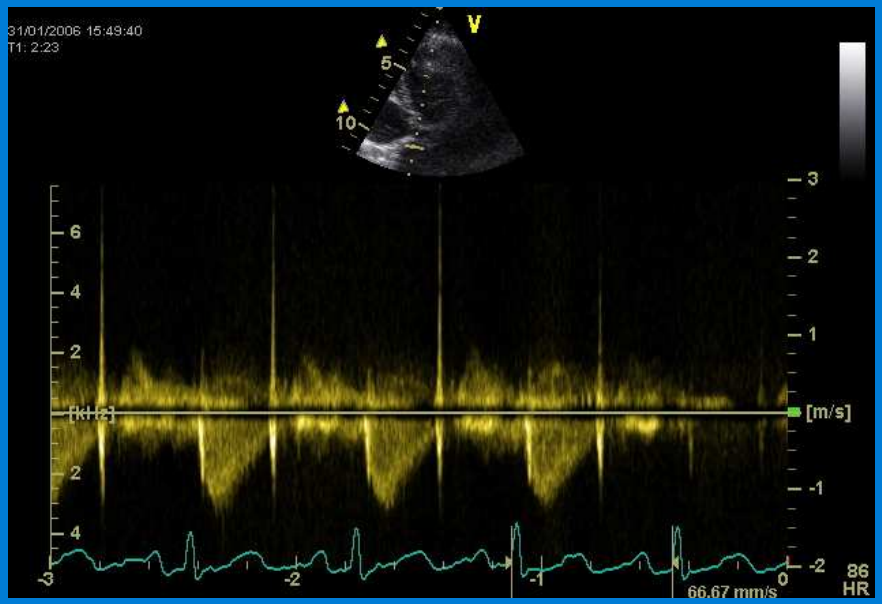
rise time (t_{rise})
time from 10% to 90%
of ascending trace value

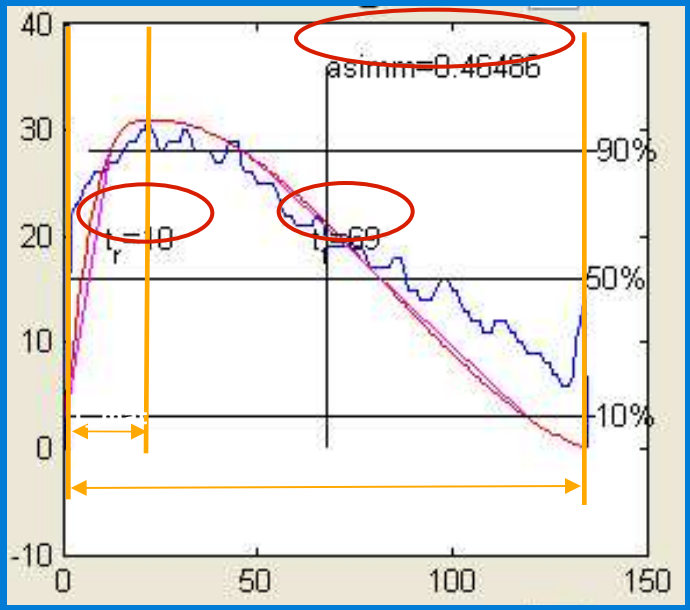
fall time (t_{fall})
time from 90% to 10%
of descending trace value

Time from onset to peak aortic flow (T_{mod})

Ejection time (ET_{mod})

CAD negative





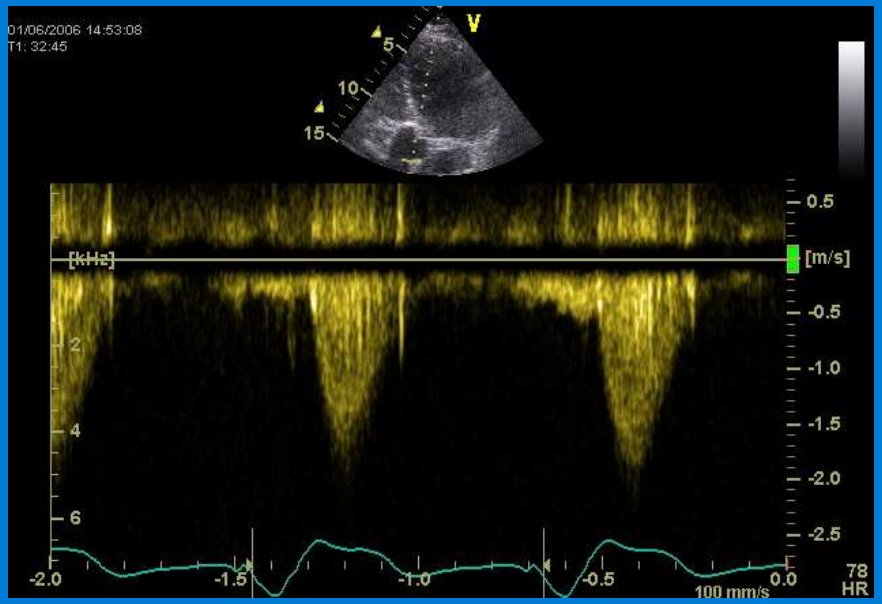
Typical normal trace, triangular in shape, with the peak ocurring early

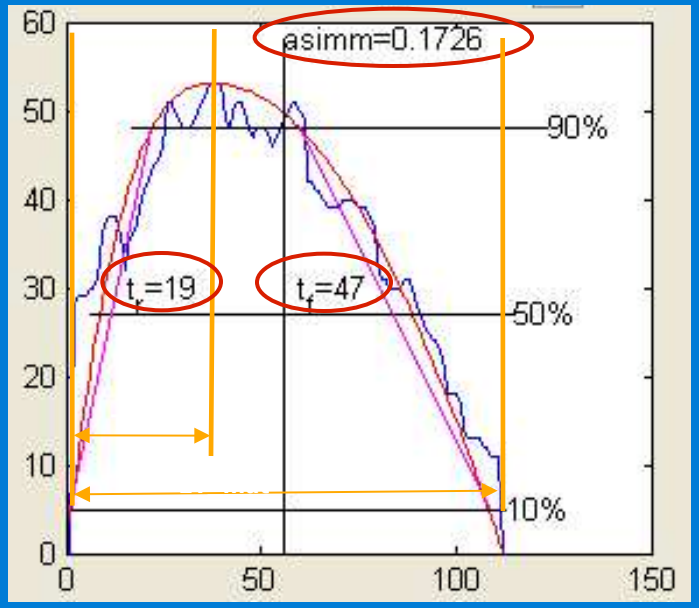
↓

No evidence of CAD, negative DSE

- Shortened T_{mod}/ET_{mod}
- Prolonged t_{fall}
- Asymmetric curve

Severe CAD





Typical broadening with a much more rounded shape and later peak

↓

Severe CAD, positive DSE

- Prolonged T_{mod}/ET_{mod}
- Prolonged t_{rise}
- Shortened t_{fall}
- Symmetric curve

Real-Time Guidewire Tracking

- Project team:
  - Sven Lončarić, Tomislav Petković, Tomislav Devčić, University of Zagreb
  - Draženko Babić, Robert Homan, Philips Healthcare

PHILIPS

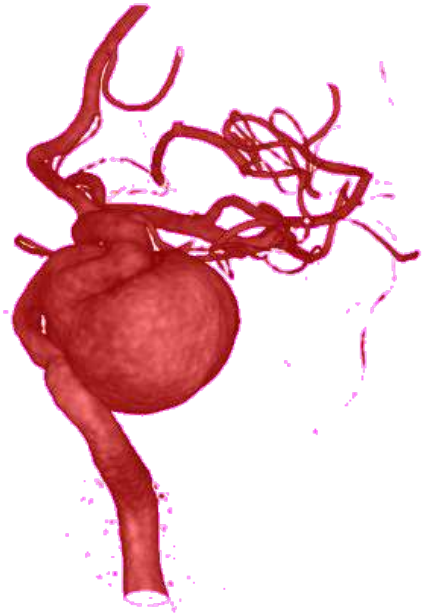
Problem statement

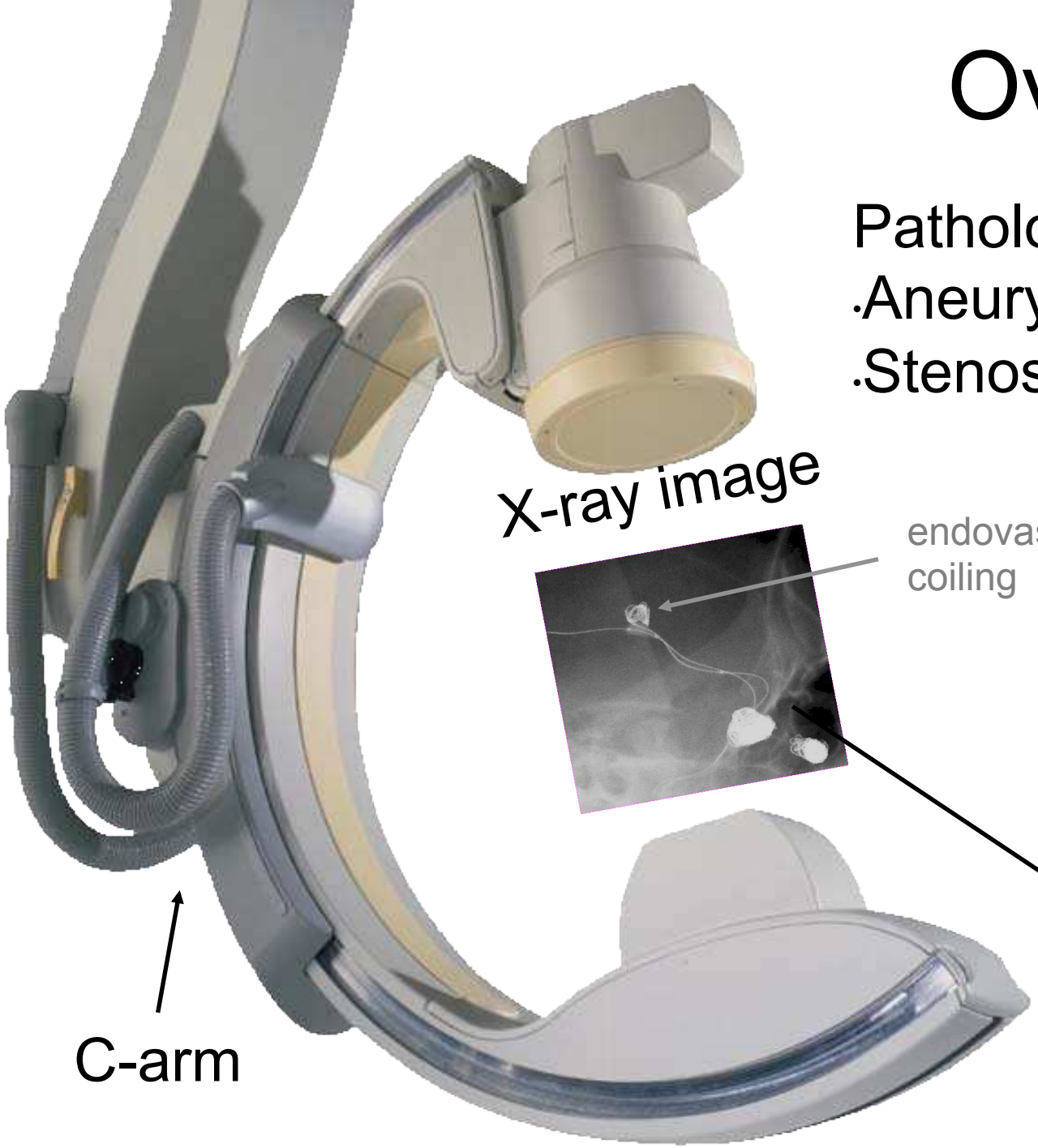
- Automated guidewire tracking system should provide the surgeon with the information about *3D guidewire position* in *real-time* during the intravascular intervention.
- If possible the simplest monoplane X-ray imaging device should be used.
- Develop *smart software* to extend usability of existing *expensive hardware*

Overview

Pathology:

- Aneurysim
- Stenosis





X-ray image

endovascular coiling

guidewire

C-arm

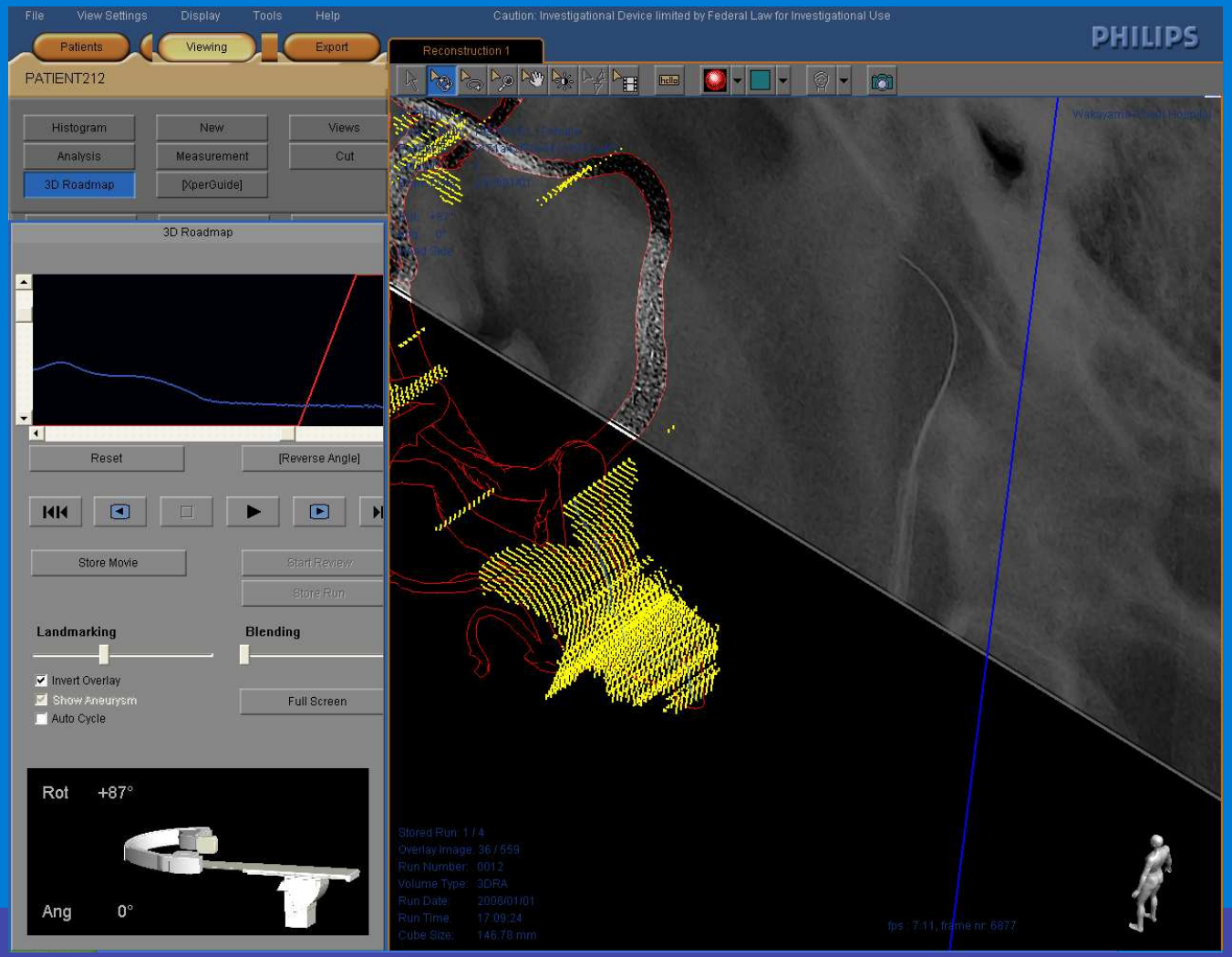
Achieved results

- A prototype system was developed
- Processing time is about 100 ms per image of 1024x1024 with 16 bits resolution
- Reconstruction from single image is possible, but yields *many ambiguous solutions*
- Reconstruction from two views (biplane) is *also ambiguous*

System overview (monoplane reconstruction)

- 3D position reconstruction is desirable
- *Ambiguous solutions exist* due to the projective nature of imaging device
- All viable solutions are found and *most probable one is selected* as reconstruction result
- Fast minimization algorithms are required due to real-time constraints

Software demonstration



Abdominal Aortic Aneurysm (AAA)

- Project on AAA segmentation from CT images

- Partners:
  - Marko Subašić, Sven Lončarić, University of Zagreb
  - Erich Sorantin, Medical University Graz, Austria

Abdominal Aortic Aneurysm (AAA)

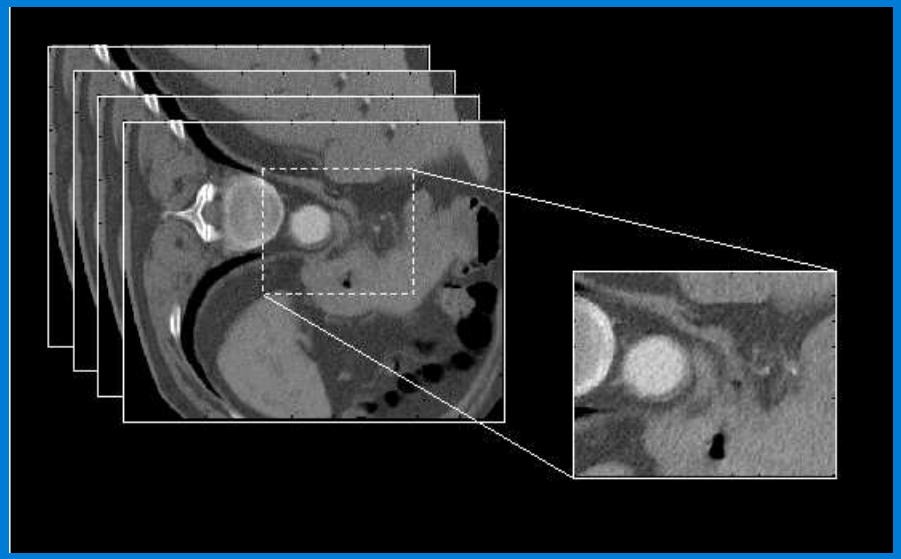
- Enlargement of abdominal aorta due to weakened aortic wall
- Enlargement of aorta can lead to aortic wall rapture
- Imaging of AAA is very important in condition assessment

Abdominal aorta

With aneurysm

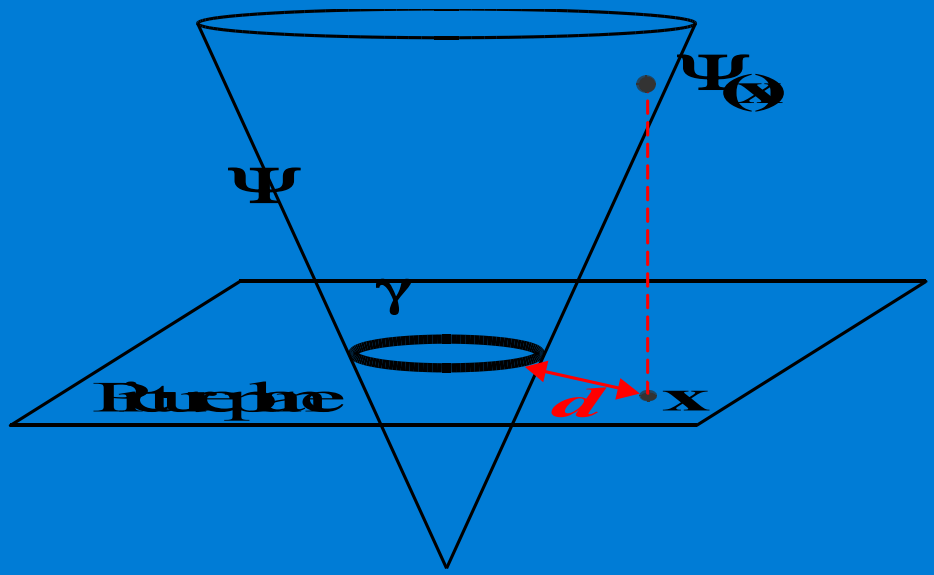
AAA segmentation method

- Abdominal volume CT input data
- Manual segmentation??



Geometric deformable model

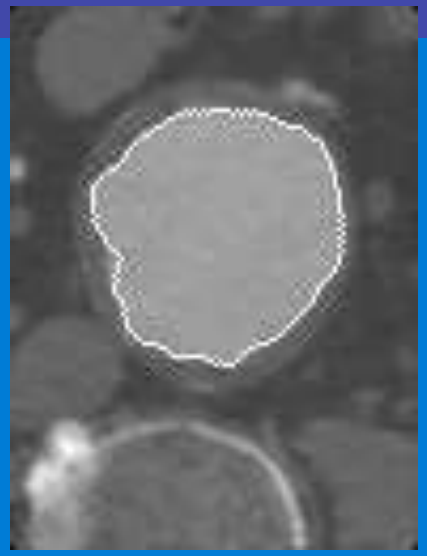
- Ability to change topology: break and merge
- Easy to build numerical approximation of equations of motion
- Straightforward expansion to higher dimensions 3-D, 4-D ...
- Level-set algorithm

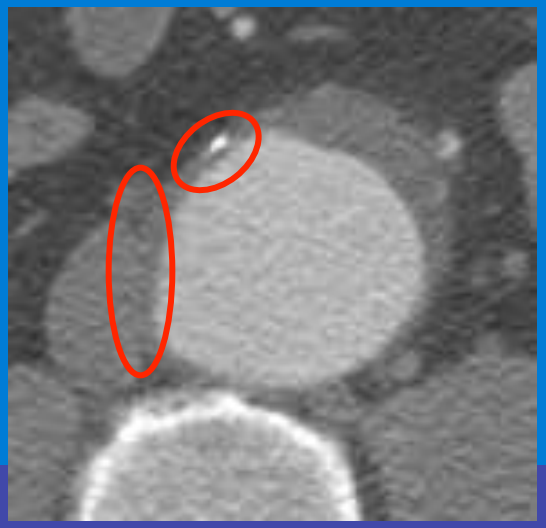


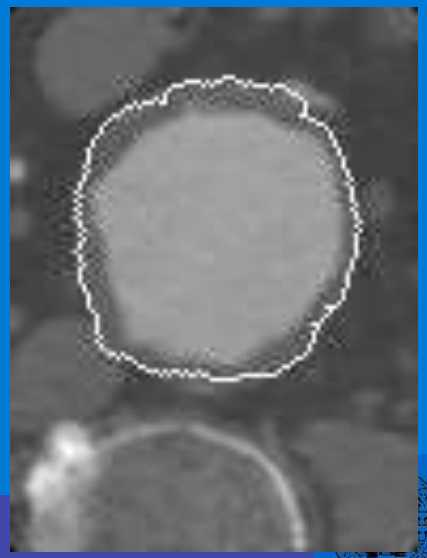
The problem

- Two regions of interest:

1. Aortic interior
   - Good image conditions – not a difficult task
2. Aortic wall
   - Poor image conditions on outer aortic border – a more difficult task
   - Calcification: a sediment of calcium inside aortic wall
   - Barely visible outer aortic border

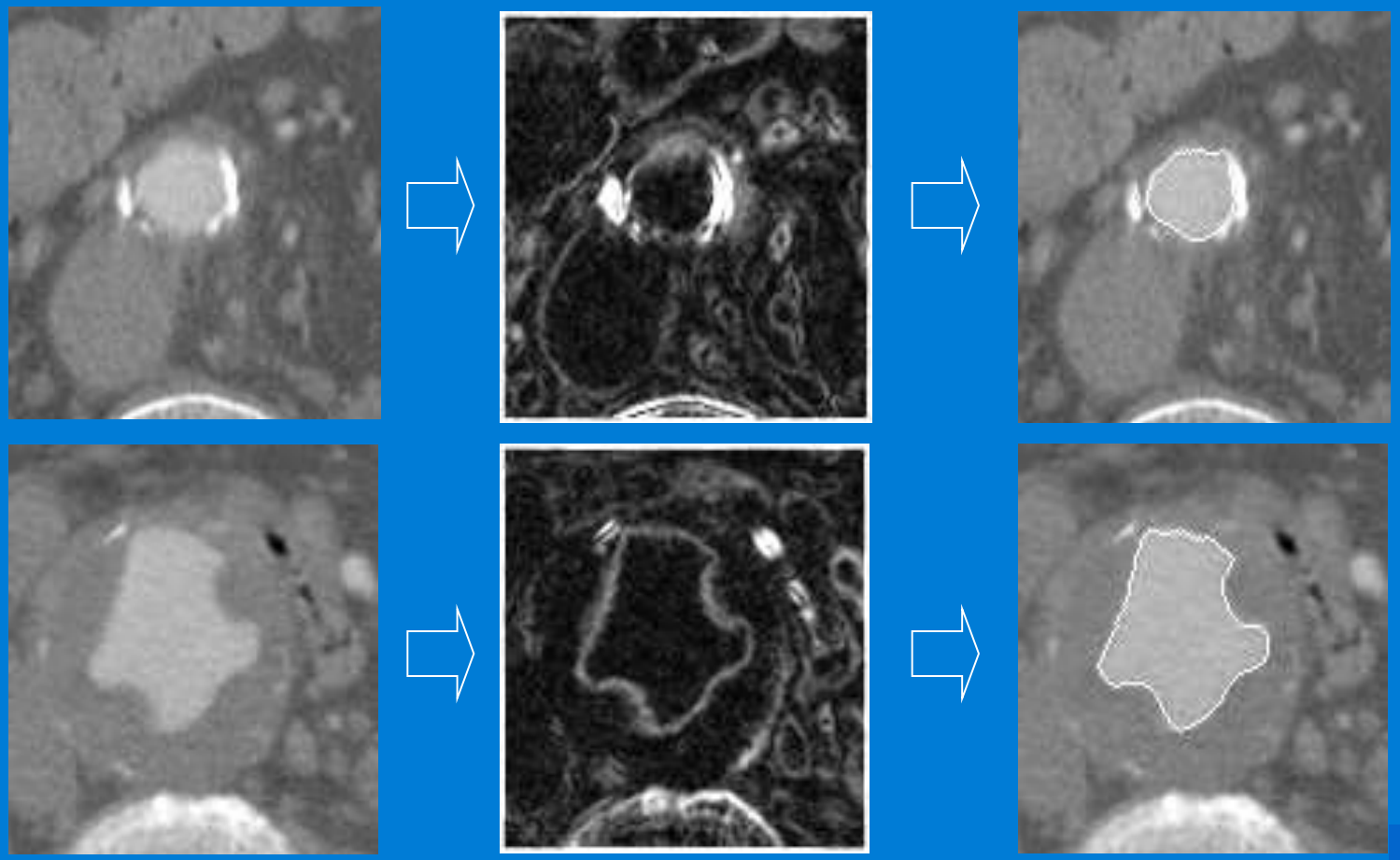




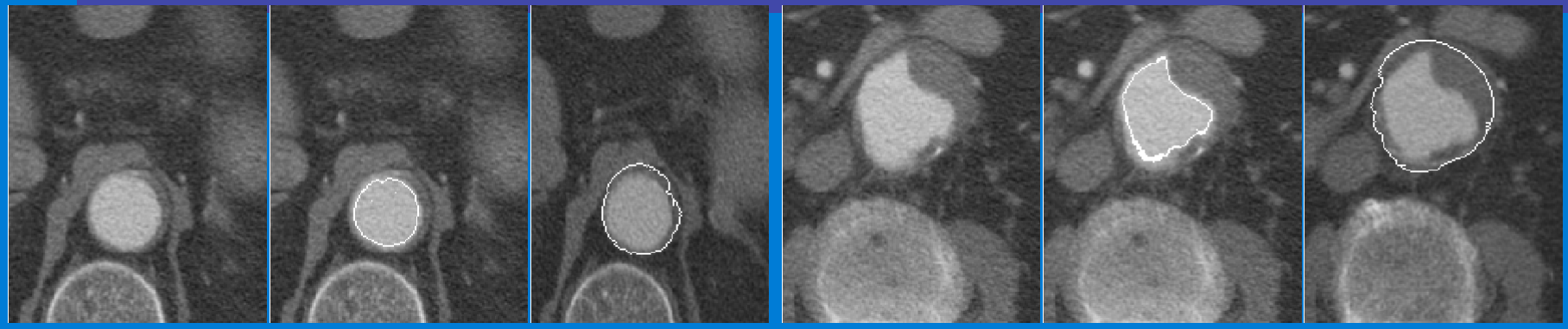


Deformable model for AAA

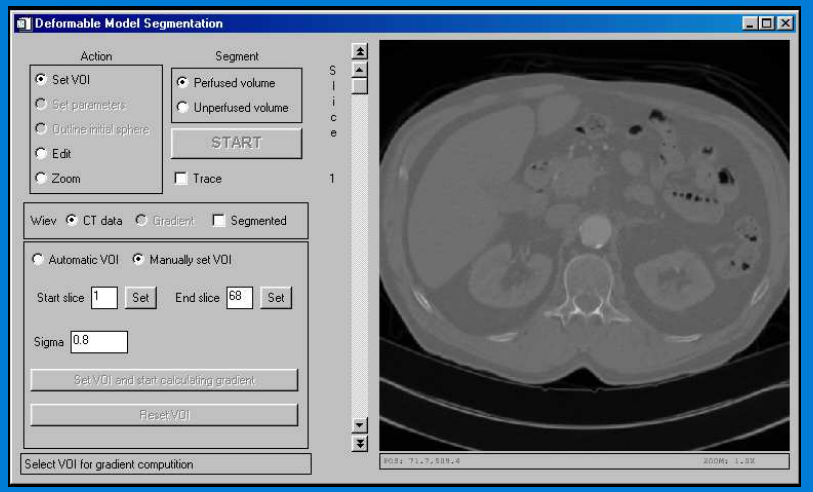
Input:
spiral
CT



Results



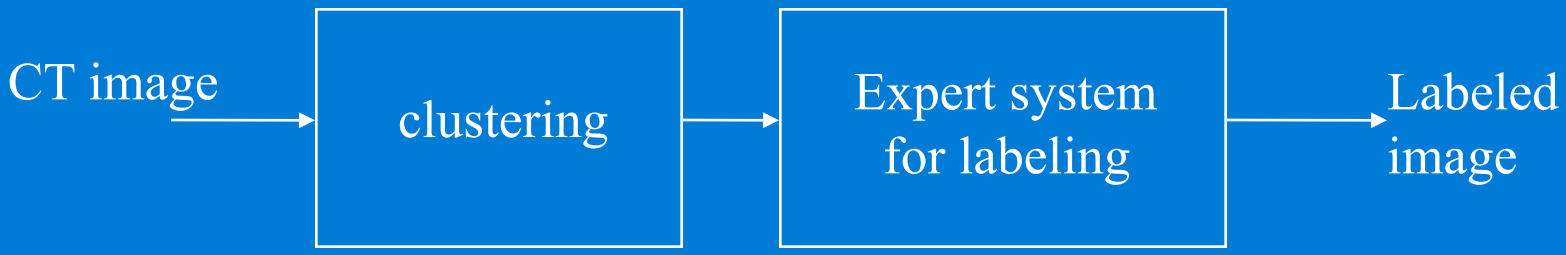
	relative error [%]	standard deviation [%]
automatic level-set (corrected automatic segmentation results)	14.71	8.17
automatic level-set (corrected semi-automatic segmentation)	19.75	13.28
corrected automatic segmentation (corrected semi-automatic segmentation)	12.35	13.92



ICH segmentation from CT images

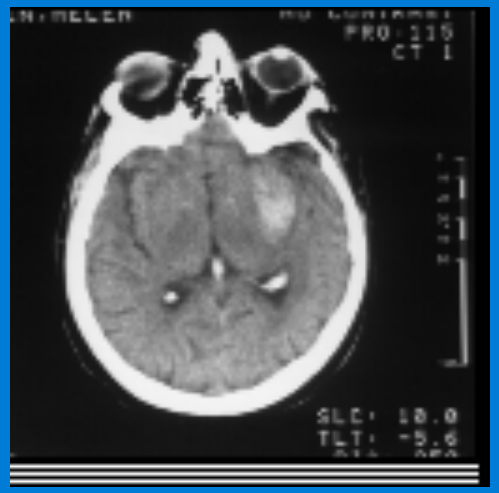
- Project: Segmentation of intracerebral brain hemorrhage from CT images
- Goal: quantitative analysis of hematoma and edema
- Partners:
  - University of Cincinnati Medical Center, USA
  - University of Zagreb

Expert system segmentation



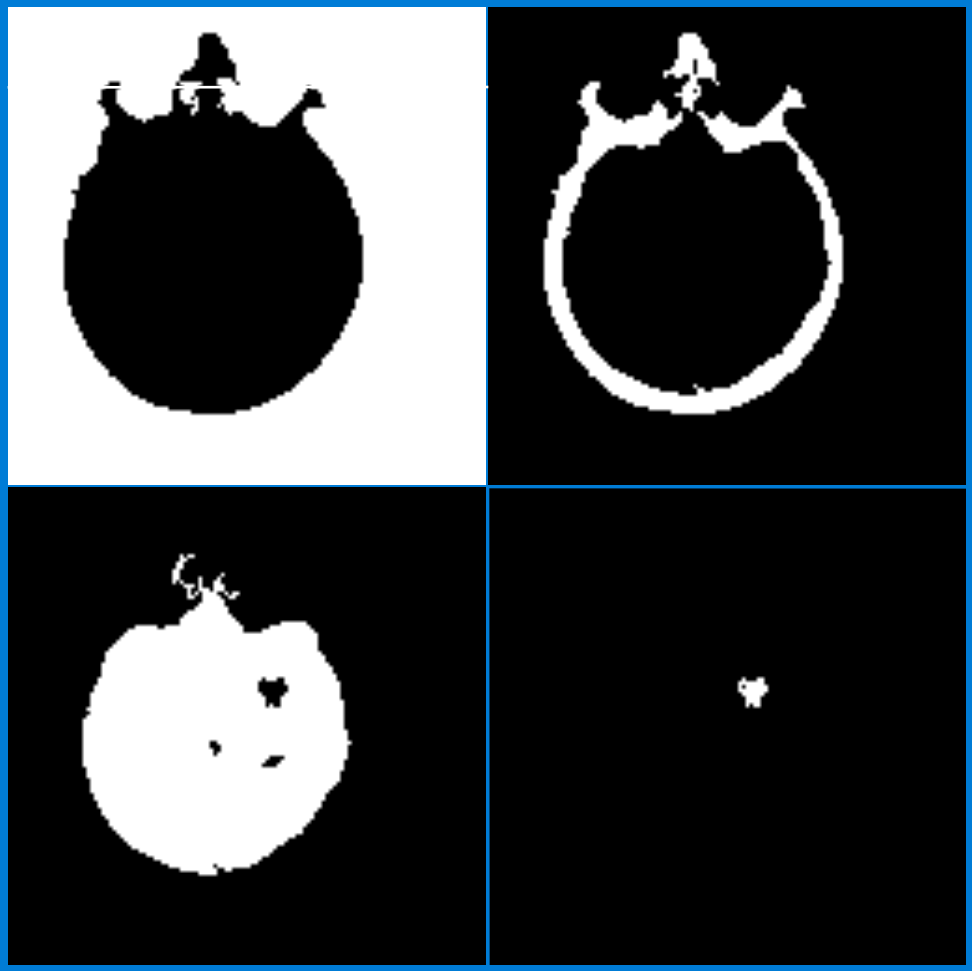
- Segmentation by clustering breaks image into small regions
- Expert system has knowledge about size, shape and neighborhood relations between regions and uses this knowledge for region labeling
- Labels: hematoma, edema, brain, skull, background

Experimental results



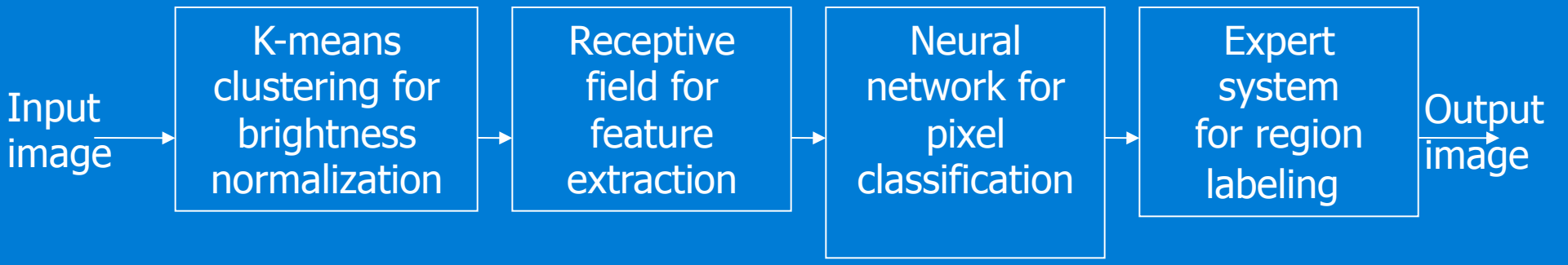
CT brain image

Segmented regions: background, skull, brain, hematoma



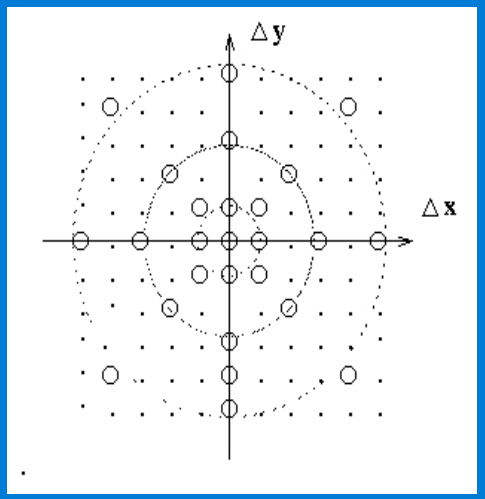
Artificial neural networks

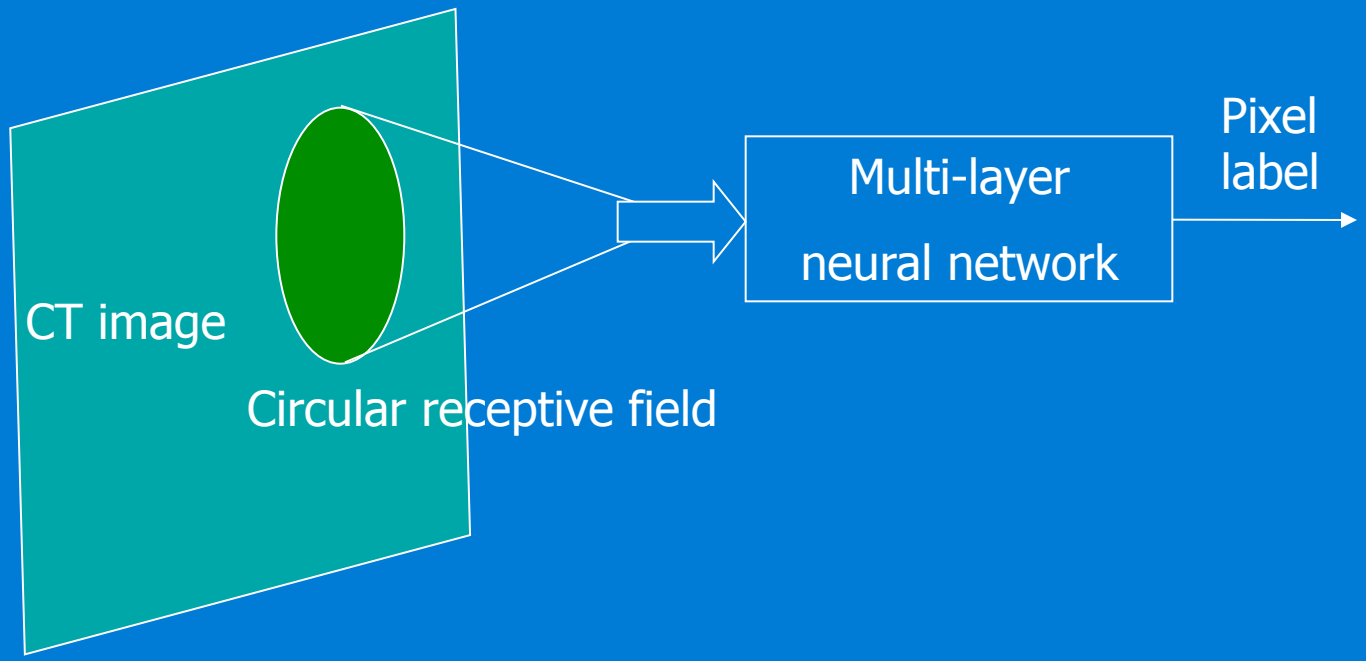
- Can be used for analysis of biomedical images
- Block diagram shows alternative methods for ICH image analysis



Artificial neural networks

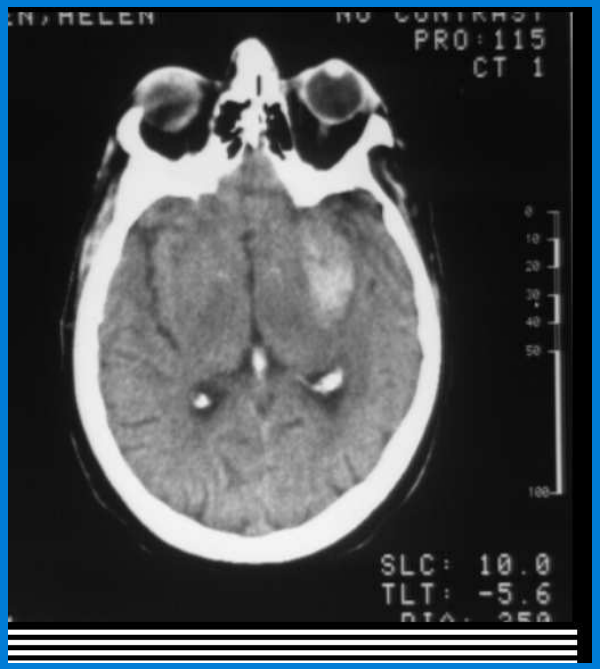
- ANNs can be used as classifiers
- Receptive field



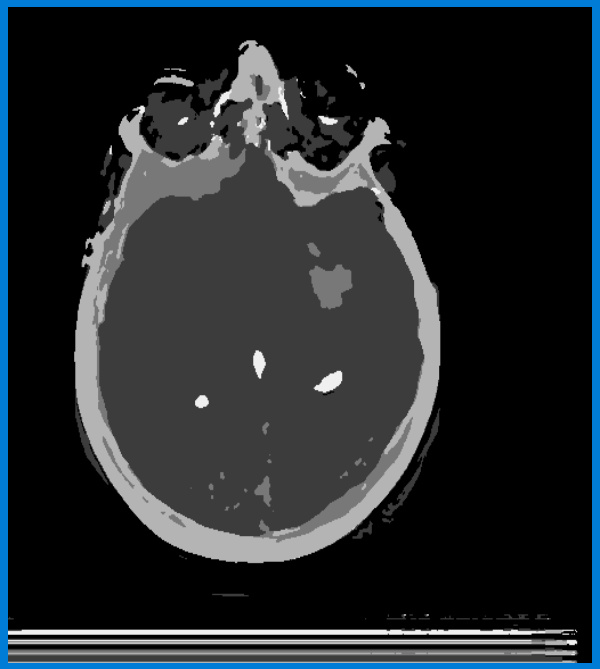


Results

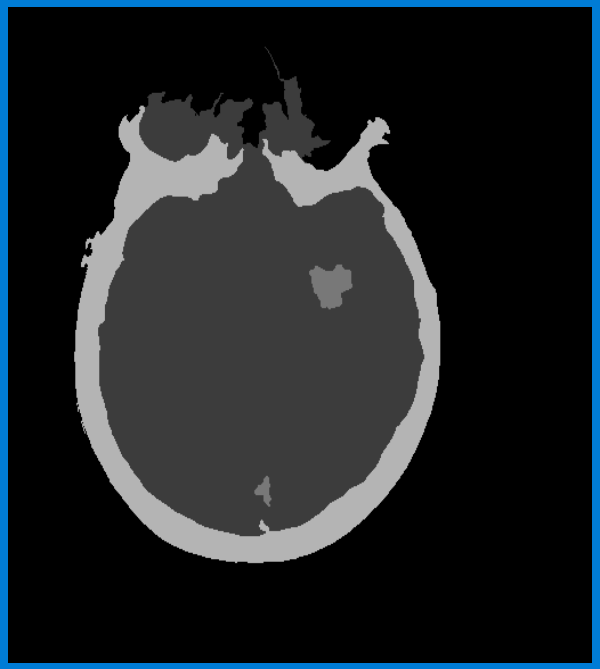
input image



segmented regions



labeled regions



Virtual endoscopy

- Virtualna endoskopija provodi se:
  - 3-D imaging of human body (CT, MR)
  - image analysis to determine organ position
  - patient-specific 3-D model for interactive exploration
- Advantages of virtual endoscopy:
  - less invasive then classical endoscopy
  - Unlimited moving and positioning of virtual endoscope
  - fly-through and interactive 3-D visualizations
- Examples: virtual colonoscopy, virtual bronchoscopy, colon “unwrapping”

Virtual bronchoscopy

- 3D modeling of organs
- Fly-through simulations

Conclusion

- Computerized medical imaging and image processing can aid clinical research, diagnostics, and intervention
- Interdisciplinary projects require interdisciplinary teams: doctors and engineers
- Computer: A tool for quantitative measurements of organ morphology and function

Thank you for your attention

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