Grid based Evaluation of a Liver Segmentation Method for Contrast Enhanced Abdominal MRI

Svenja Specovius, René Siewert, Juliane Doege, Dagmar Krefting
Institute of Medical Informatics

Dirk Schnapauff, Timm Denecke
Institute of Radiology
Charité - Universitätsmedizin Berlin, Germany

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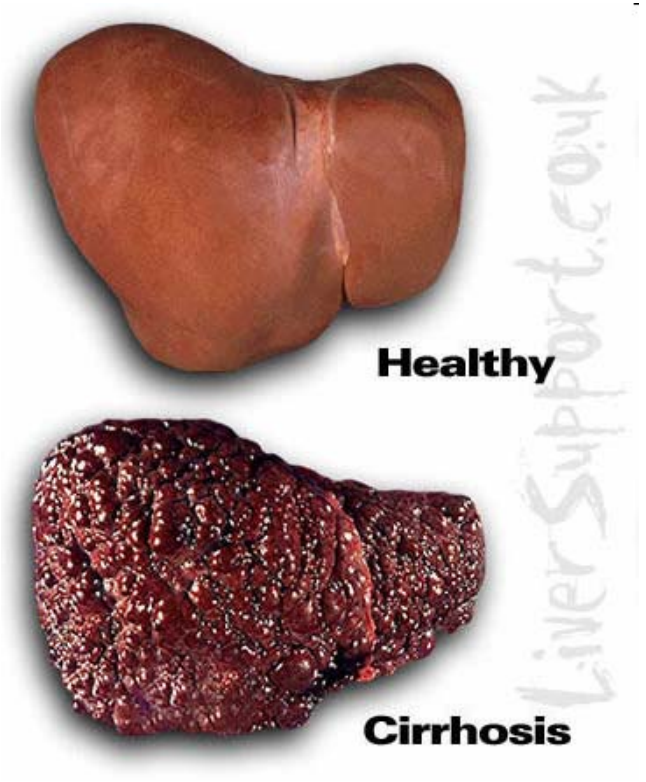
Motivation – Liver diseases and surgery

Liver diseases:

- Cirrhosis
- Liver Cancer

Liver surgery

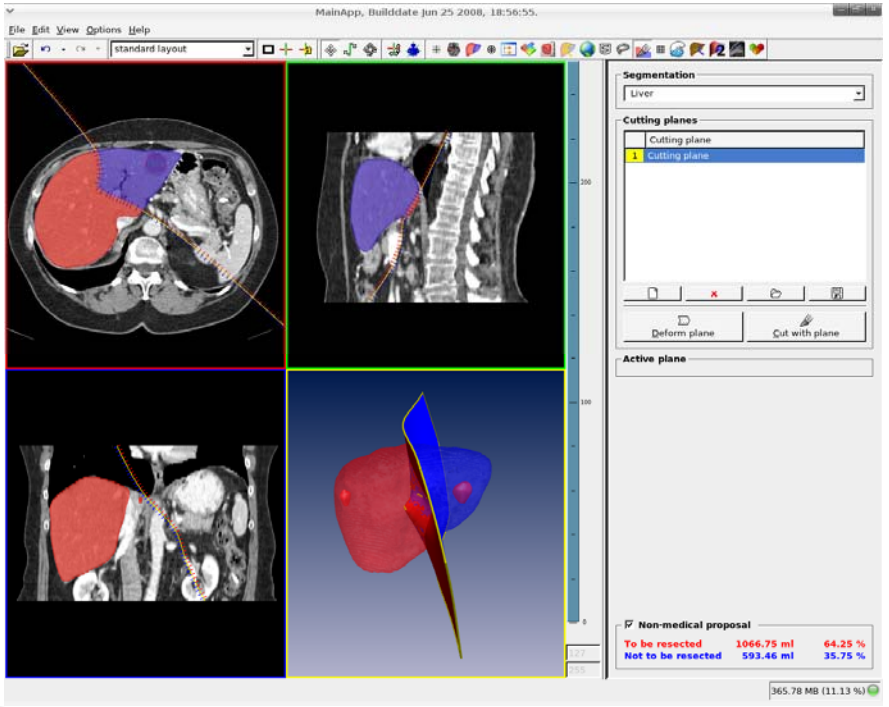
- Partial liver resection
- Living liver donation



Motivation - Liver surgery planning

- Liver is the only human organ that can recover partially
- Portion of remaining/implanted liver is crucial
- Topographic 3D Liver volumetry is required

CT based tools:
-high resolution
-established method
-high radiation exposure



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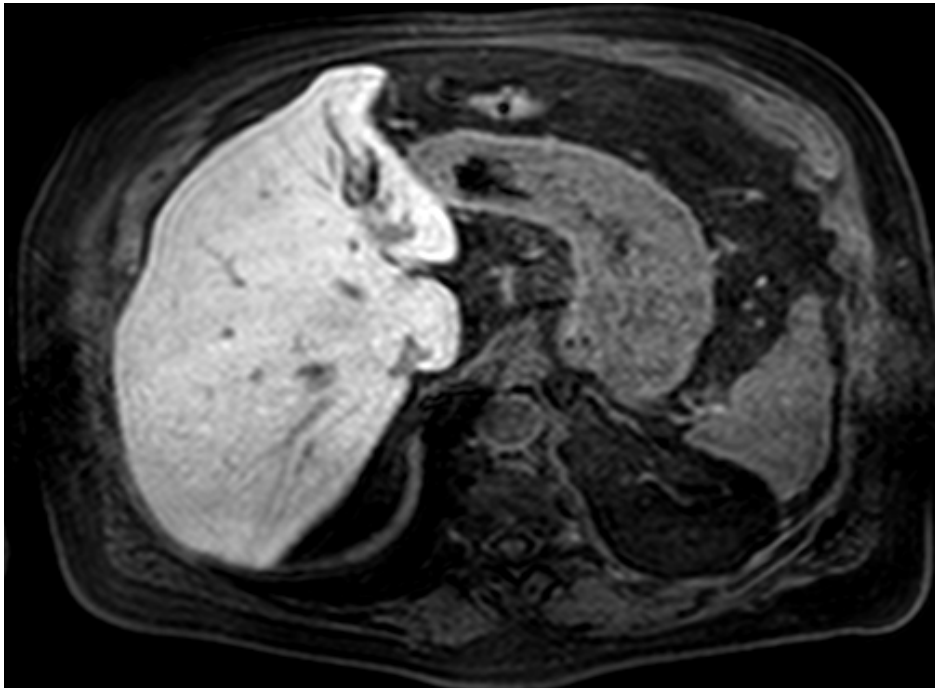
Perspective: MRI based volumetry

Recent developments

- 3D sequences
- Fast acquisition methods
- Organ specific contrast agents

  Liver: Gd-EOB



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Software requirements

Interactive virtual liver surgery tools are available

- Automated liver segmentation
- Semi-automatic vessel segmentation
- Volumetry on segmented liver
- Resection planning

Problem: Segmentation works only for CT

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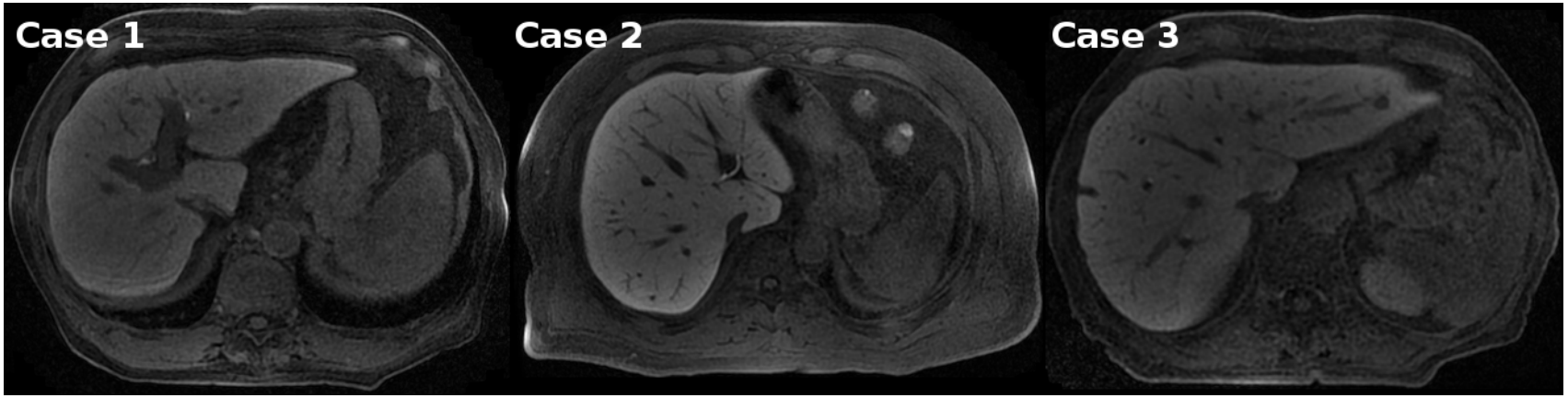
Liver segmentation algorithm

Challenges:

- High form variability of healthy, cancerous and resected livers
- Imhomogeneous and non-normalized voxel intensities
- Artifacts



Context based approach

Define rules for liver detection and discrimination from other tissue

- „liver tissue belongs to the brigthest tissue“
- „is the largest object“
- „is always below the lung“...

Implement as subsequent voxel classification

- Background, body, liver-border, certainly liver, presumably liver,...

Example liver segmentation

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The role of parameters

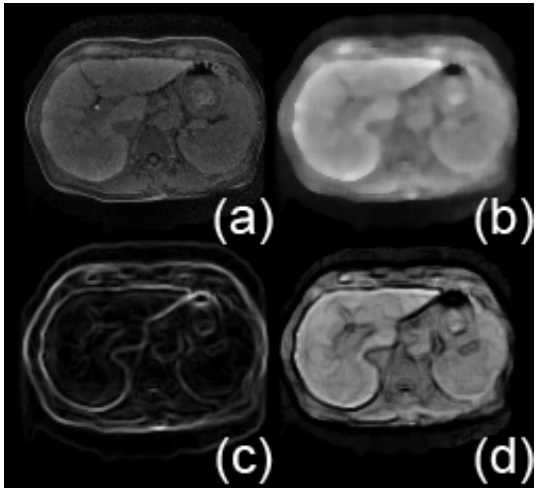
The final code contained a total of 18 parameters

- Kernel sizes (filter, local shape evaluation, Morphological operations)
- Coefficients (Thresholds, Stop criteria)

How to find the best parameter set for each dataset?

Parameter categorization:

- robust
- optimizable
- sensitive



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Parameter scans

Exploration of a multidimensional parameter space

Target function supposed to be nonlinear

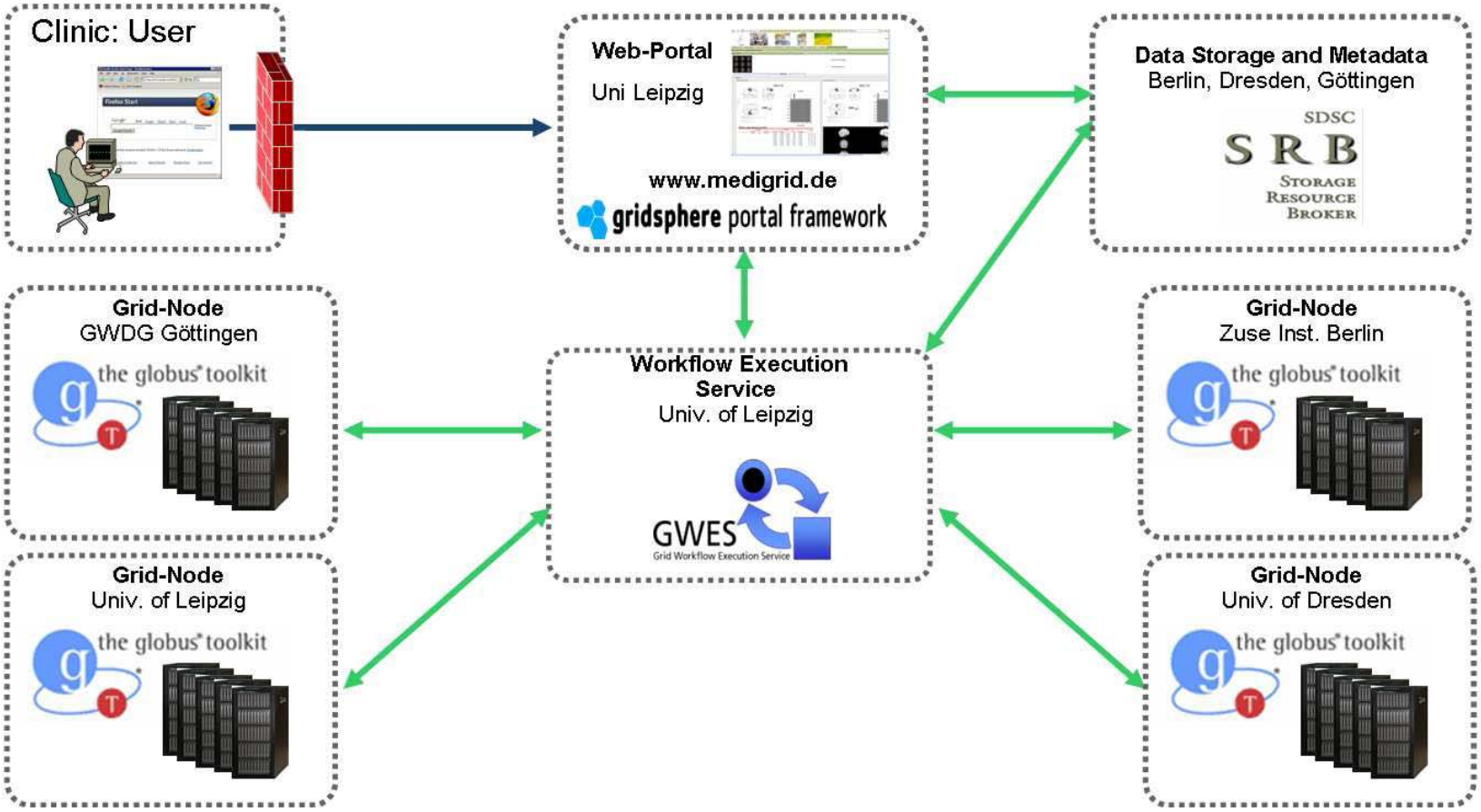
Parameter boundaries can be guessed (normalization)

Sensitivity on parameter changes is difficult to guess (sampling of the parameter space)

Basic parameter scan: 18 x 10 x 16 = 2880

Estimated runtime: 24 days

Implementation



Results – Implementation

Basic implementation was simple and quick

Problems with stability and scalability of the system:

- Data transfer
- Failure of single runs

Solution:

- Data storage onsite, single cluster for one dataset
- Explicit error handling on workflow level

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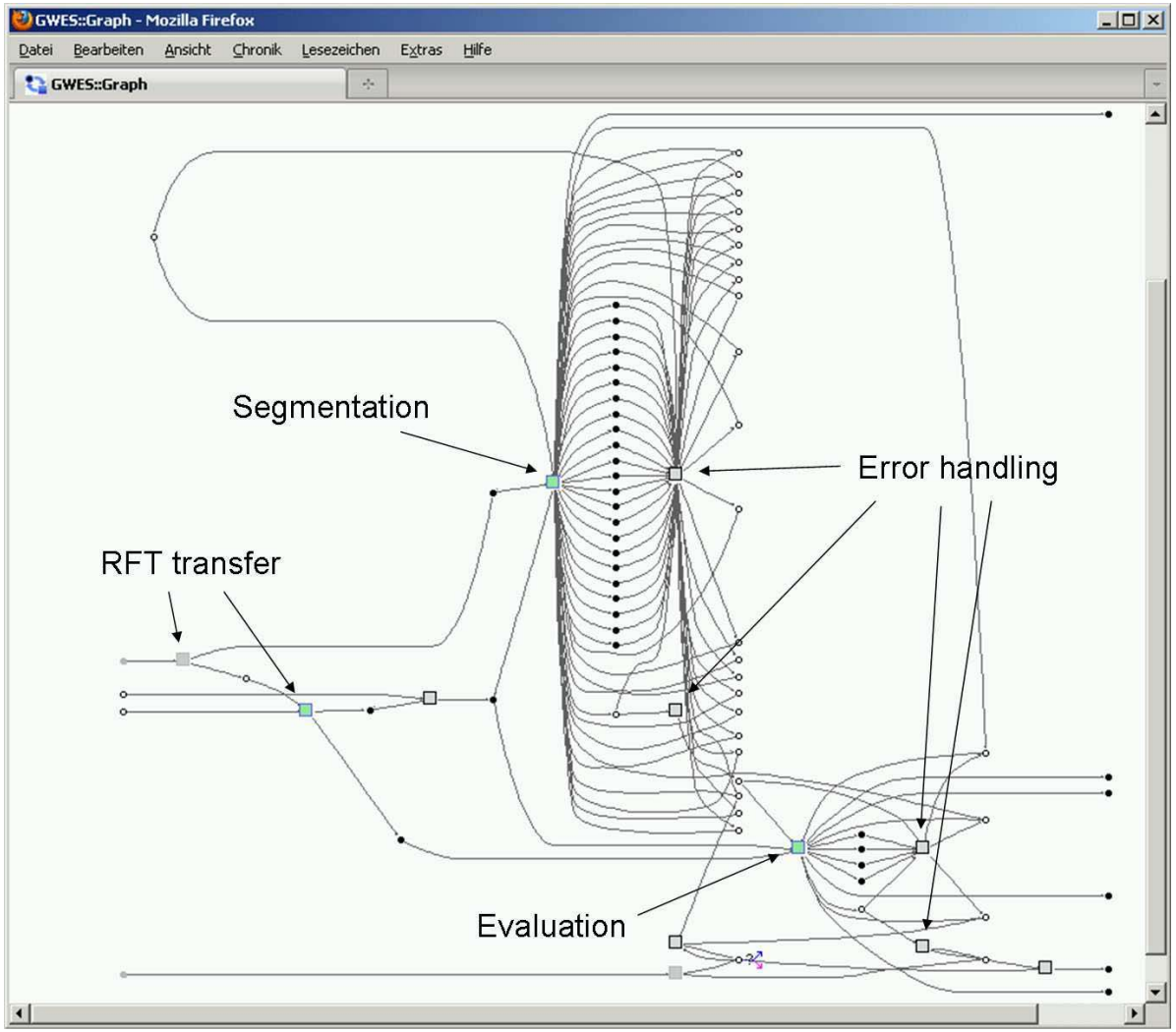
Results



Results – Runtime and Parameter

Runtimes:

- 1 - 5 hrs for each dataset (à 180 runs)
- Total timespan = 24.5 hrs

Parameters:

- 8 robust parameters
- Threshold related parameters still sensitive
- Shape criteria show irregular behavior

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Was it worth using the Grid for this task?

Yes, because

- Grid implementation time + runtime was much shorter than expected execution time on local resource
- System is now set up for further parameter scans
- Results have led to a redesign of the algorithm
- Results have revealed insufficiency of the ruleset

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This is far from being a „killer application“

Not solved years of computing power in a day

No big science

Grid has become a daily tool for us

- Basic implementation time less than a day –
  - Common implementation scheme
- Realized even by batchelor students
- Current failure handling sufficient
- Today: about 10 applications from neuroscience, radiology, cardiology,...

Future plans

Application related

- Advanced parameter space exploration
- Advanced gridbased evaluation
- Grid-enabled registration of dynamic imaging

General grid issues

- Failure handle strategies based on error messages
- Data management
- Portlet development (graphical user interfaces)

Thanks to

Site administrators: Stefan Freitag, Marcus Hilbrich, Dietmar Sommerfeld, Ralph Müller-Pfefferkorn,...

Workflow developer: Andreas Hoheisel

PneumoGrid-Project: Diagnostics and clinical trials in COPD

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