

Bolus Tracking in Colon MRI

Project Presentation

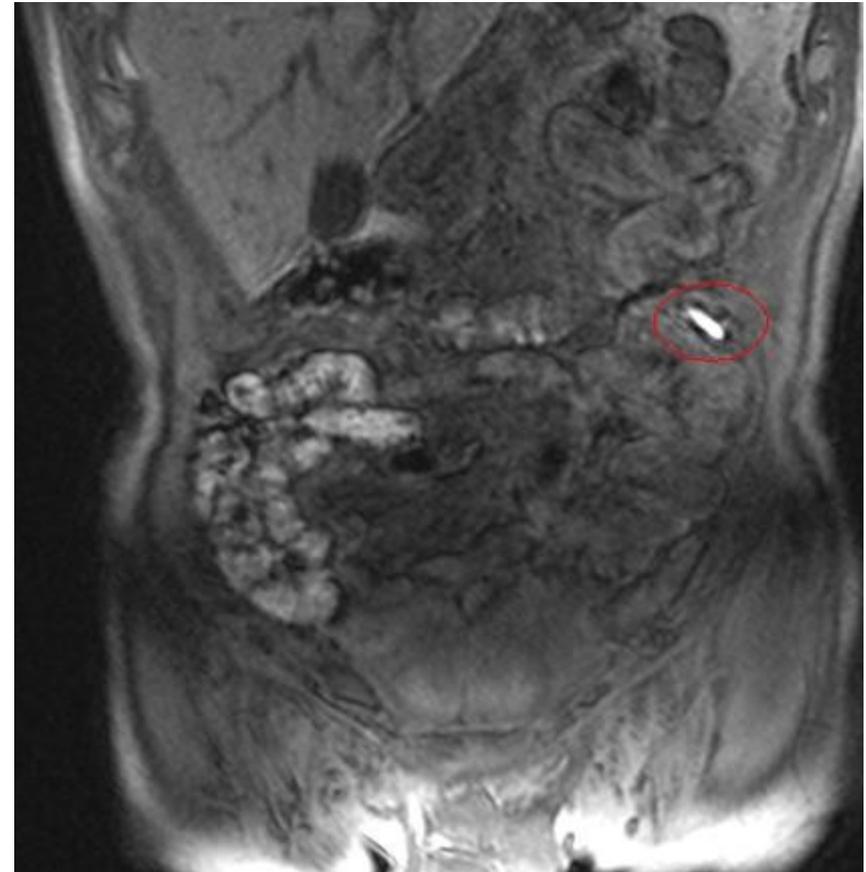
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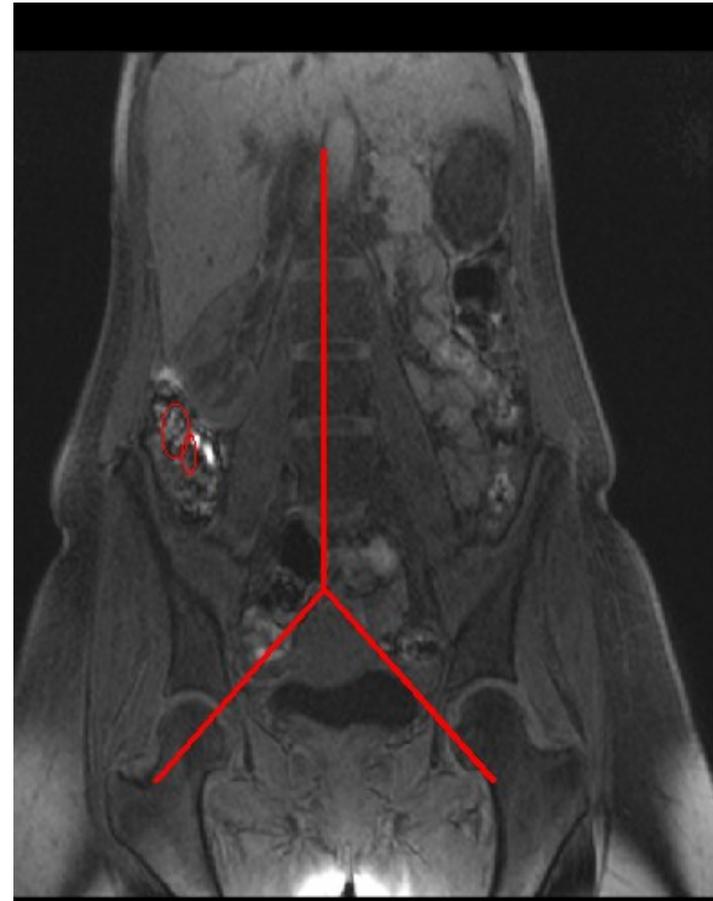
Detecting Colon Motility

- colon motility disorders (constipation, diarrhea) important issues in daily clinical work
- new non-invasive approach on detecting colon-transit-time
- ingestion of MR-visible markers
- acquire MR-images at different time intervals after ingestion



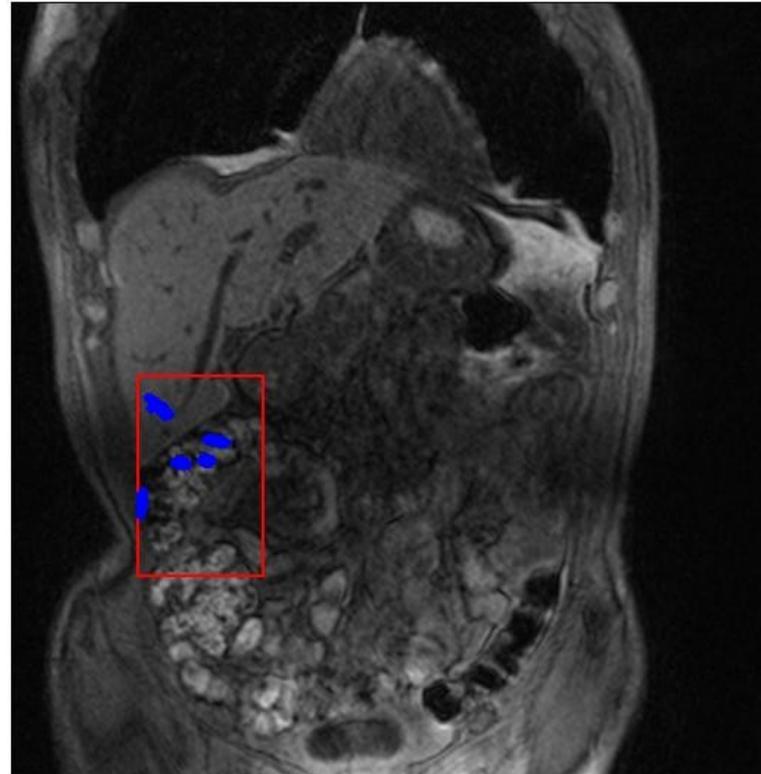
Tracking the Markers (current approach)

- draw three lines in each slice to partition the space
- scroll through slices
- segment markers manually
- time consuming, not very precise!



New Approach

- segment and track the capsules automatically
- time saving
- evaluation easier and more comfortable



New Approach

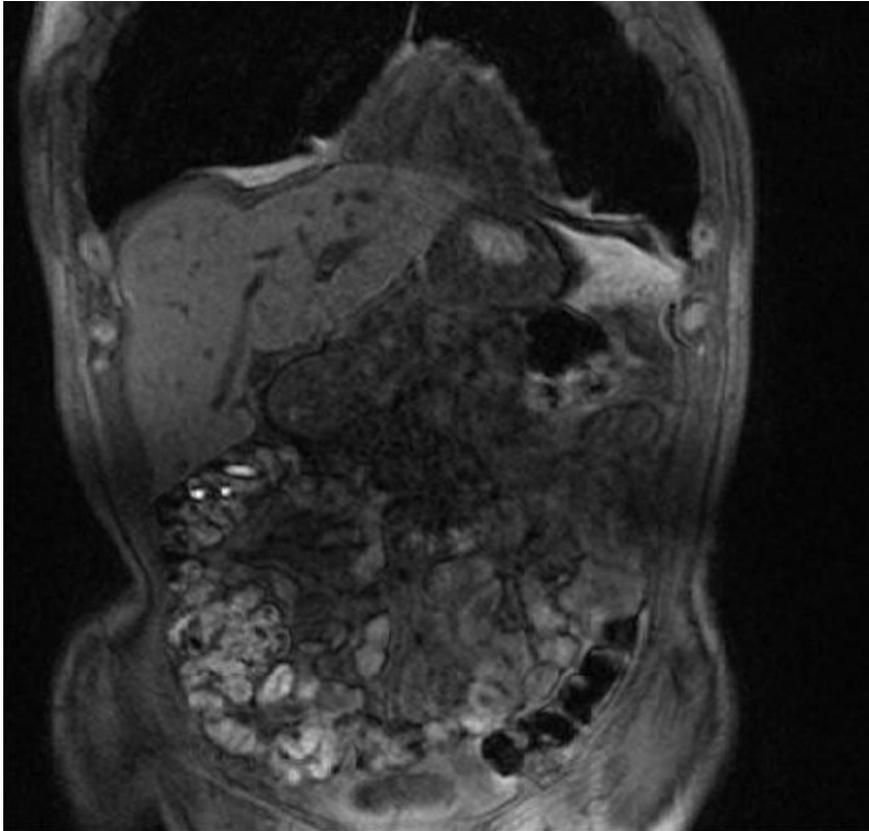
- development of an interactive GUI-based software-tool
- necessary: Criteria for classification, taking into account
 - Intensity
 - Size (volume)
 - Shape
- combination of criteria in order to get good results

Intensity Thresholding

- capsules appear at high intensity
 - perform intensity thresholding as first step

- Problem: doctors experimented with different concentrations of contrast medium
 - selection of suitable value for threshold difficult
 - manual evaluation of sample datasets
 - pick value that performed best

Intensity Thresholding (Example)



Intensity Thresholding (Evaluation)

Benefits:

- ✓ most capsules segmented correctly
- ✓ Fast and easy to apply

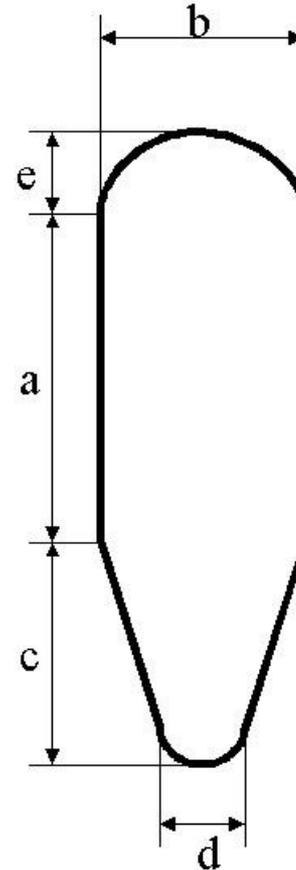
Drawbacks:

- x Much too crude as single step
 - x Many artifacts of similar intensity
- ➔ Additional more sophisticated methods necessary!

Object Volume (idea)

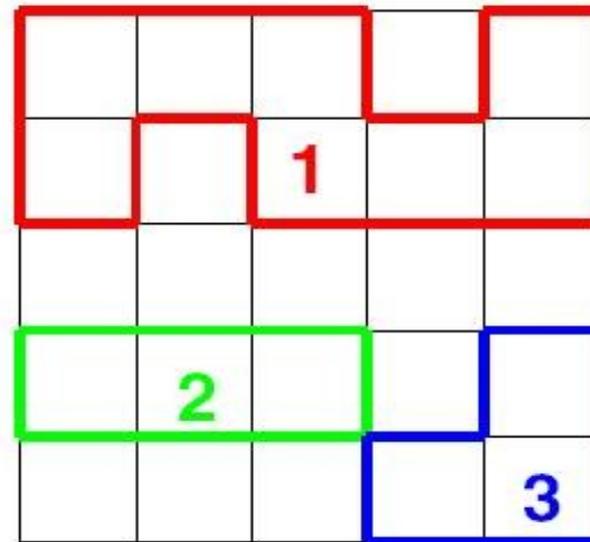
- Measurements of capsules are known
- Use basic geometry to calculate reference volume
- Compare estimated volume of segmented objects to reference volume

→ Classification criterium



Object Volume (Connected Components)

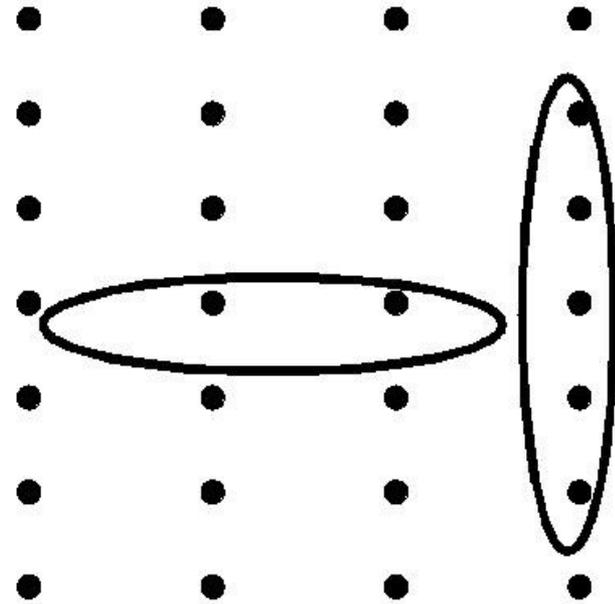
- use connected Components Algorithm (CCA) to identify and label distinctive objects
- calculate volume per pixel from dataset's resolution
- calculate object's volume by its number of voxels
- compare to reference volume



➔ Accept / Reject

Object Volume (Problems)

- Inhomogeneous resolution in all available datasets (less than half of x- and y- resolution in z-direction)
 - thus number of pixels per object varying strongly
- only possible to set a certain range of volumes



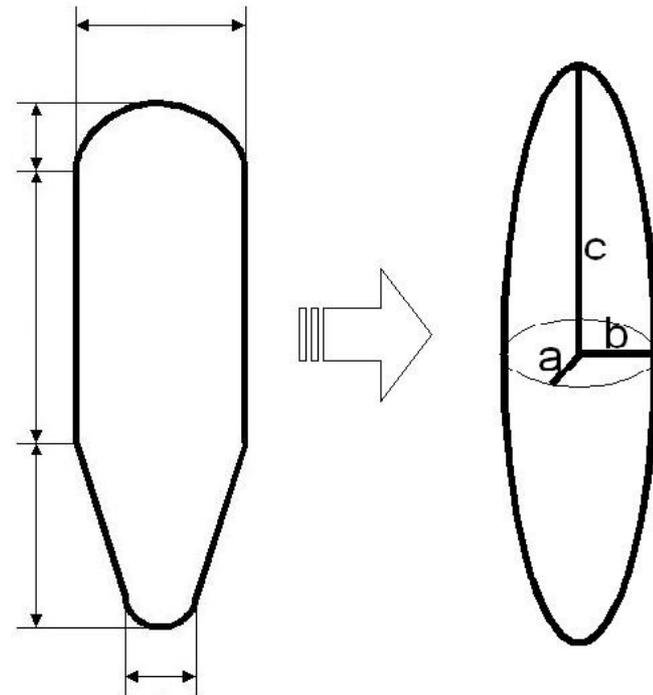
Object Shape

- take into account shape of capsules as additional criterium
- consider capsules as ellipsoid shapes (simplification)
- calculate main axes of pointcloud using the PCA algorithm
- compare calculated values to reference value

➔ Accept / Reject object

Object Shape (simplification)

- Left: real shape
- Right: estimated ellipsoid shape with main axes a , b and c



Object Shape: Principal Components (PCA)

□ pointset:
$$X = \begin{pmatrix} x_1 & x_2 & x_3 & \dots \\ y_1 & y_2 & y_3 & \dots \\ z_1 & z_2 & z_3 & \dots \end{pmatrix}$$

□ demean pointset:
$$X \rightarrow X' : \forall i: x_i' := x_i - \bar{x}; y_i' := y_i - \bar{y}; z_i' := z_i - \bar{z}$$

□ compute covariance matrix
$$C := X' \cdot (X')^T$$

□ Compute Singular Value Decomposition (SVD) of C

Object Shape (PCA Application)

- SVD yields matrices $C = U \cdot D \cdot U^T$

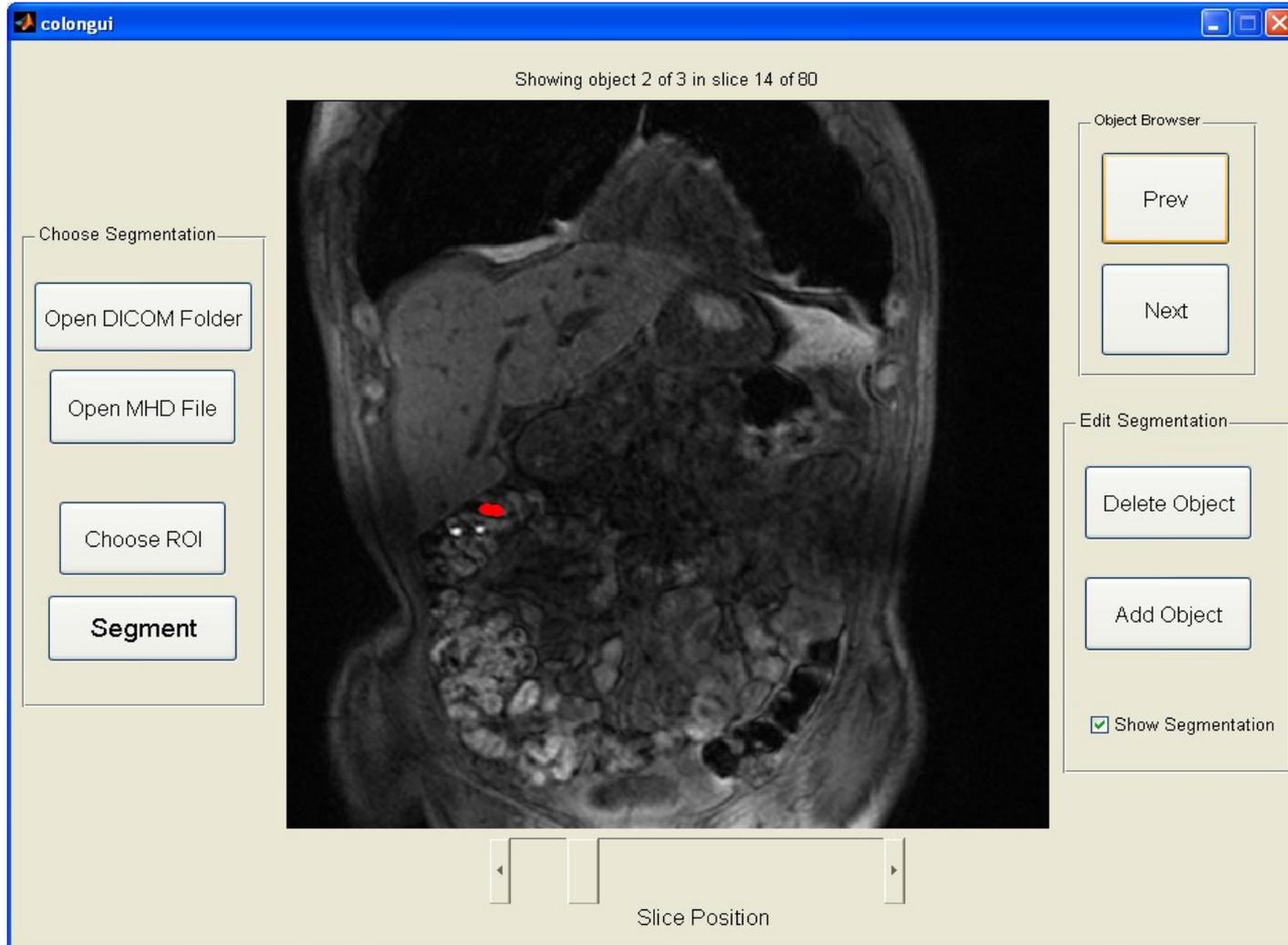
- D is a diagonal matrix with $D = \begin{pmatrix} c & & \\ & a & \\ & & b \end{pmatrix}$

- a, b, c are lengths of main axes of assumed ellipsoid shape

- use error measure $E = \left| \frac{a}{b} - 1 \right| + \left| \frac{c}{a} - \frac{24}{6} \right|$

→ Accept / Reject object

Implementation (MatLab GUI)

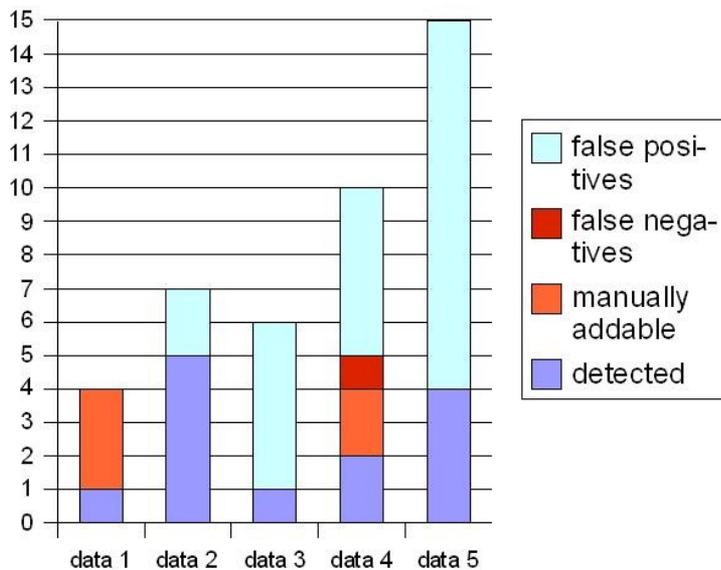


Test Results

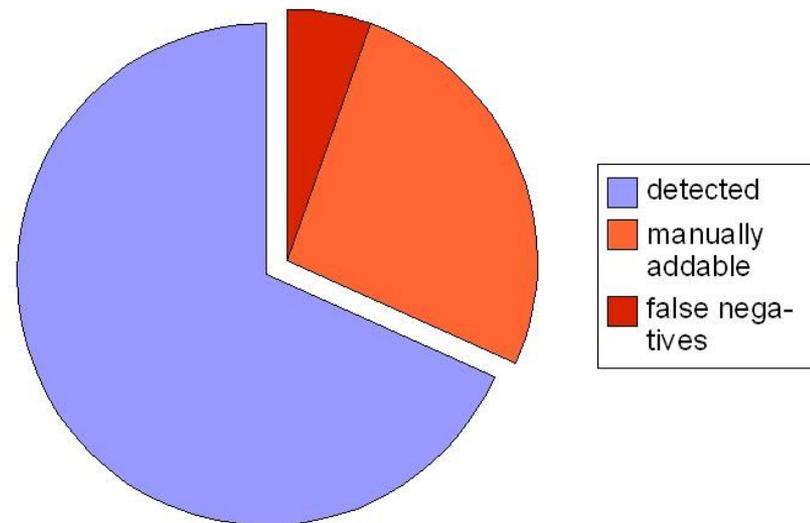
Benefits:

- comfortable to use
- high percentage of capsules is found

Search Results



Results of 10 datasets



Test Results

Drawbacks:

- Inhomogeneous resolution of available datasets (up to now)
- Different concentrations of contrast medium inside capsules

make it hard to give precise thresholds / narrow ranges for accepting/rejecting possible objects

➔ High number of false positives if number of false negatives is to be minimized

Conclusion / Improvements

- comfortable tool, easy to use
- time saving evaluation
- Combination of different criteria in order to get stable results

Outlook:

- homogeneous resolution of datasets
- Set more precise thresholds / narrower ranges for error
- Better results / less false positives?

Questions?

- Literature:
 - Buhmann, S., Kirchhoff, C., Wielage, C., Mussack, T., Reiser, M.F., Lienemann, A. :
A new method for the measurement of colonic transit time using MRI – a feasibility study