Technical University of Denmark

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Automated Characterization and Recognition of 2D and 3D Brain structure in MRI for Diagnostic support.

Corpus Callosum morphometry

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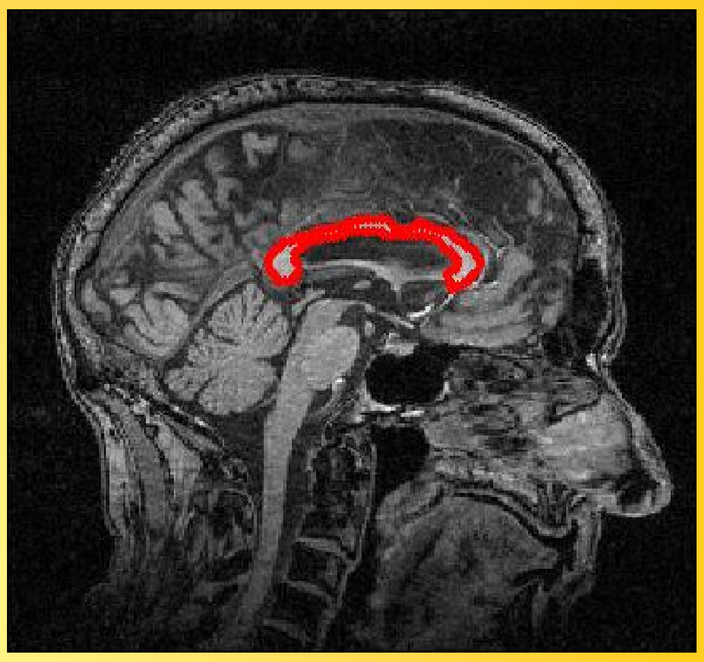
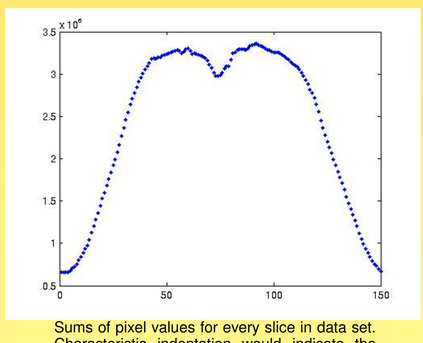
This project is concerned with accurate characterization and segmentation of brain structures in magnetic resonance imagery and relation of derived parameters to clinical and cognitive performance data. This is relevant for individual diagnosis of brain diseases such as dementia and epilepsy, surgical planning, and for population studies of the effect of particular drugs. The project is a collaboration between Informatics and Matematical Modelling DTU and the MR Department at Hvidovre University Hospital. Overall this project is part of a trend for image analysis at IMM to address vision system optimisation. The optimisation is made over imaging device, image processing, image analysis, and decision support system. Project is based on *Corpus callosum* morphometry. *Corpus callosum* (further reffered to as *CC*) is the nervous tissue that connects the two cerebral hemispheres of the human brain. Many neurological studies indicate that the size and shape of the corpus callosum are related to gender, age, neurodegenerative diseases et cetera. Obtaining manual tracings of the corpus callosum is both time-consuming, error-prone and operator dependent. Instead, this project aims at replacing this task with automated and efficient methods eliminating subjectivity.

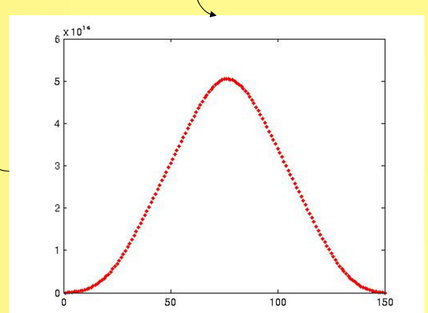
Ref: http://www.imm.dtu.dk/English/Research/Image_Analysis_and_Computer_Graphics/Research/Medical%20Image%20Analysis.aspx



Mid saggital plane with corpus callosum contour found in baseline data set.



Sums of pixel values for every slice in data set. Characteristic indentation would indicate the plane most resembling mid saggital plane - plane of our interest as it contains Corpus Callosum we are going to examine.



Symmetry search computed for every plane in MRI data set according to formula:

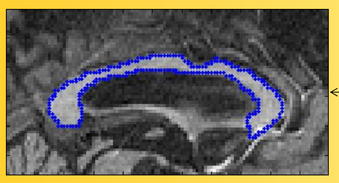
$$max_{S_0} \sum_{S \in [0,n]} f(S_0 - S) \times f(S_0 + S)$$

Where S's are respective sums of pixels for MRI images in the data set. Point of symmetry is indicated by a highest value on the plot.

Plane from MRI data set most resembling the mid saggital plane. Sufficient estimate for further CC examination.

Given *corpus callosum* contour found in baseline data set we are interested in finding and analysing corpus callosum in the follow up MRI data set created during subject examination after 3 years. Shape of specific parts of Corpus callosum is thought to be mirroring particular subjects abilities (e.g. walking speed, verbal fluency, etc.). Analysing changes in CC shape for one subject during a period of time combined with medical examination and tests performed would give more accurate information on which part of CC is responsible for particular abilities and how does it change with time and how does it vary between male and female subjects.

Extracting region of interest (ROI) containing CC contour from a baseline image, we are interested in respective ROI in the follow up image. Thus an algorithm that would ensure choice of proper follow-up ROI is run on estimated mid saggital plane found in follow-up data set. This operation might be treated as rigid registration as in fact the template matching including rotation is employed. Proper choice of follow-up ROI is ensured by a image differences check (the smallest difference between the images would indicate choice of most accurate fit).



Baseline ROI with CC contour.

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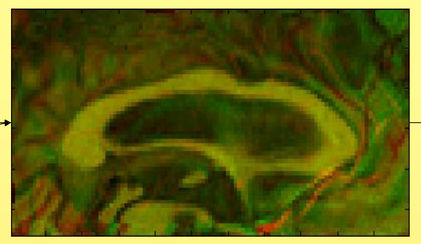
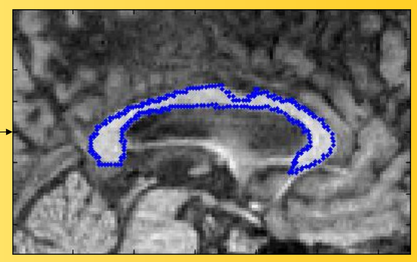


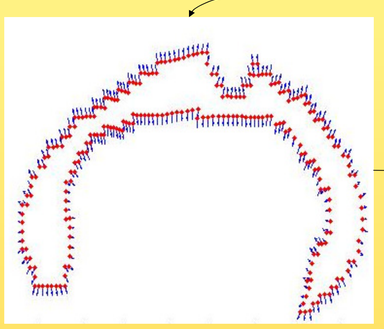
Follow-up ROI (green channel) registered to Baseline ROI (red channel)



CC contour on the Follow-up image found on the basis of original CC contour points projection on the Follow-up image with use of transformation net.

Intermediate step while follow-up ROI search.

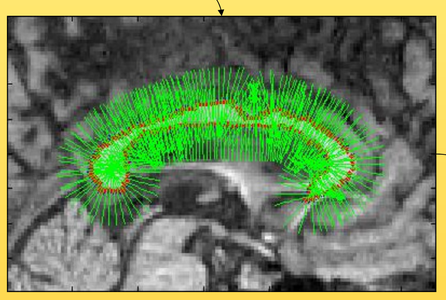
Full registration of Follow-up ROI image to Baseline ROI image would give transformation net from which it is possible to extract CC contours after registration on the Follow up ROI image. Full registration means use B-splines plus warping. The algorithm used for registration is Gauss-Newton algorithm.



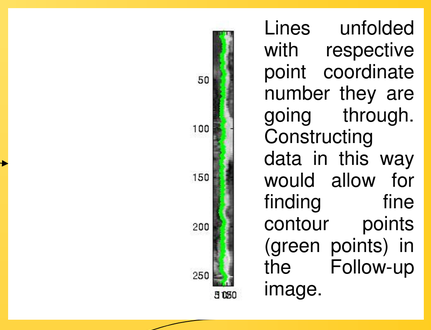
Set of unit vectors pointing outwards CC and fixed on estimated contour points is computed.

Contour found in this manner is however not accurate enough for the project purposes. Thus this new set of points serves as a base for exact contour search. Set of contour points serve as base for construction of new coordinate system that would allow for fine contour tuning. Dynamic programming algorithm was chosen for this purpose.

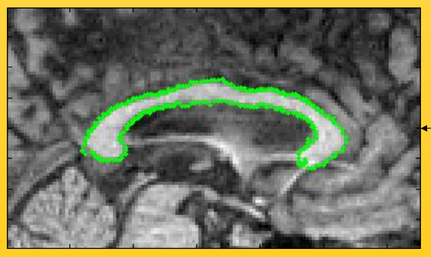
Follow-up ROI



Lines going through the estimated contour points and parallel to vectors are constructed. These lines form the new coordinate system for the dynamic programming purposes.

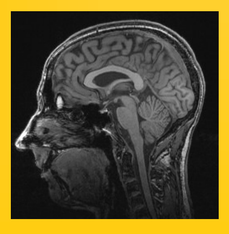


Lines unfolded with respective point coordinate number they are going through. Constructing data in this way would allow for finding fine contour points (green points) in the Follow-up image.



Contour of the CC from the Follow-up image calculated with use of dynamic programming.

At this stage still statistical analysis needs to be done in order to reveal correspondences between ageing, gender, personal abilities and the corpus callosum shape. Contour found with use of algorithms employed so far needs to be further divided into parts thought to have connections with particular subject's abilities and compared with respective parts of the same subject's corpus callosum shape from the baseline set. Then these shapes would be compared with the outcomes of medical examination and tests to reveal correlation between all these relations.



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