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INVESTIGATION OF AN IMAGE-BASED TOOL FOR PLANNING SAFE TRAJECTORIES IN DEEP BRAIN STIMULATION

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OBJECTIVE:

Deep brain stimulation (DBS) is a usefull option for treating patients with movement-disorders [1]. Planning of trajectories for DBS is nowadays based on MRI-data and adapted to the individual anatomy. By using MRI for planning the safety of this operation is significantly improved [2]. In some cases planning is very easy to perform, while in others it can be very complicated and time-consuming. The surgeon has to identify a safe trajectory, never knowing whether there is a better one, which he was not able to identify. Aim of this study is to fasten the procedure of planning by giving the surgeon computer-generated coordinates for potential safe trajectories.

MATERIAL AND METHODS:

The process can be devided into two steps: At first T1-weighted MRI datasets acquired for DBS-procedure were supplied with the target- and entry-point of the clinical DBS-procedure, based on AC-PC coordinates (Fig. 1). Multiple trajectories were virtually created by the algorithm (Fig. 2), based on methods of aortic-segmentation [3]. In the second step (Fig. 3) all trajectories were analysed by grayscale-values along each trajectory, using a 5mm safety-radius. Values excessingor underrunning a specified range were defined as unsafe and trajectories were sorted. Trajectories determined as safest in each dataset were selected (B) and reimported to Framelink5-platform. An evaluation was performed by a neurosurgeon experienced in DBS, comparing them with the surgical-trajectory.

RESULTS:

The process was realized in C++ inside the MeVisLab-platform [5]. The automatic calculation and sorting of trajectories in our implementation took less then 3 seconds (measured on an Intel Core i5-750 CPU) Ranking of the trajectories showed that in all evaluated datasets the clinical trajectory was among the first seven software-generated trajectories in ranking. Evaluation of the safest trajectories generated by software led to a different "optimal" trajectory in 7 of 10 cases compared with former surgery. All of the best at least 5 potential trajectories generated and evaluated by the algorithm were identified as safe alternative by the surgeon. Results of ten evaluated trajectories are listed in table 1.

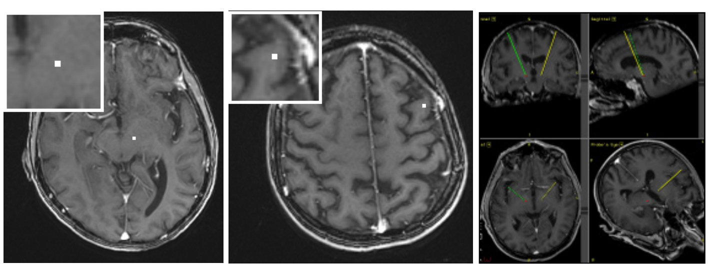

Fig. 1: Target-point at the STN (left), entry-point located at the brain-surface (middle) and visualisation of trajectories in framelink5 after image-fusion with T2-weighted MRI (right).

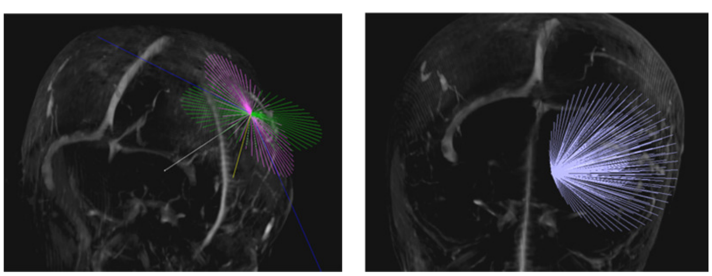

Fig. 2: Left: Initial trajectory (white) radial rays in x-y-plane (DICOM-coordinate-system) at the entry-point (green), directional vectors of the initial trajectory-plane (blue). Rotation slope between x-y-plane and "trajectory-plane" (yellow), radial rays rotated into "trajectory-plane" (pink).
Right: Trajectories for different entry-points sampled along the rays (light blue).

Case	AC/PC coordinates (mm)		number of trajectories	sorted list (pos)
	target-point	Entry-point		
1	-13.86/-6.39/0.0	-57.36/19.18/58.61	31	1
2	13.86/-6.3/0.0	63.28/27.72/57.44	31	7
3	-12/-4/-4	-46.27/30.75/60.58	41	2
4	12.01/-3.98/-3.96	31.13/33.46/72.44	101	2
5	-9.92/-4/-4	-37.57/76.32/43.29	61	8
6	10.49/-4.88/-3.35	44.6/62.29/48.05	51	5
7	-13.96/-5.5/-1.5	-42.05/27.16/69.1	31	7
8	12.58/-5.76/-4.1	41.64/21.16/74.76	31	5
9	-10.37/-3.69/-3.65	-46.27/30.75/60.58	31	1
10	10.37/4.52/-4.26	35.16/54.13/58.69	51	1
$\mu \pm \sigma$	-	-	46.00 ± 22.24	3.9 ± 2.81

Table 1: Listing of the evaluated trajectories. AC-PC coordinates with entry-point and target-point of the surgical trajectory. Number of the initially generated trajectories, which have been evaluated and sorted corresponding to their grayscale-value-aberrations, descending for „safety-aspect". Positioning of the initial trajectory in the ranking of all constructed and evaluated trajectories.

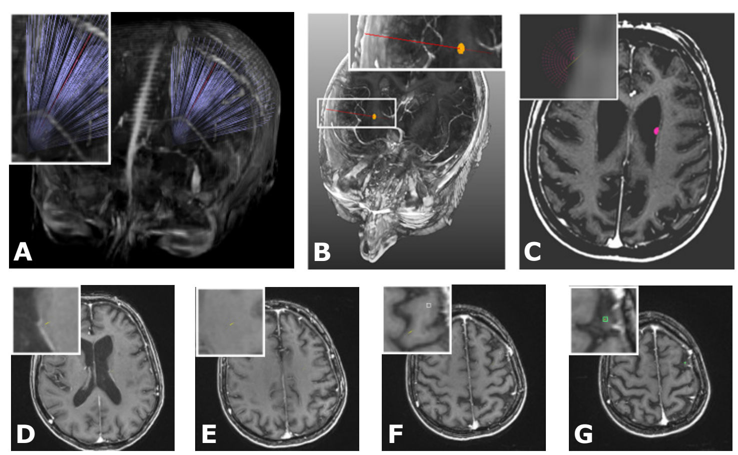

Fig. 3: A: Initial trajectories (light blue). B: Selection of a single trajectory (red) with safety-radius (yellow). C: Detection of a high grayscale-aberration near the ventricle. D-G: Visualisation of a tested trajectory in axial 2D-slices (yellow). F: Entry-point of clinical DBS-procedure (white)

CONCLUSION:

We present a tool for helping surgeons planning trajectories for deep brain stimulation. For this the target-point and an approximate entry-point have to be defined. A preselection of possible trajectories is then generated by the computer, based on grayscale-aberrations in T1-weighted MRI-datasets. Computer-generated trajectories created by our algorithm seem to be safe and planning time can be impressingly decreased. As a next step safety-aspects of the constructed trajectories should be visualized colorcoded at the brain-surface in a newly generated dataset for direct visualisation during DBS-planning.

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