

Automated Target Location And Trajectory Selection For Stereotactic Planning In Deep Brain Stimulation

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Abstract. Image based target determination and trajectory planning are essential procedures for deep brain stimulation (DBS). Using techniques of digital image processing, we developed software prototypes for computer-supported DBS planning procedures. The prototypes detect automatically the anatomical landmarks AC and PC (anterior and posterior commissure of the third ventricle) in a sequence of T1-weighted magnetic resonance images (T1-MRI). For electrode implantation, they determine and assess a set of trajectories from an entry region to the target point. Image processing methods, which combine structural and morphological feature extraction, are described for determination of the mid-sagittal plane (MSP) and localization of AC and PC. Brain tissue is segmented in critical and non-critical matter and 3D cost functions are introduced for trajectory assessment. The prototypes were tested successfully with 39 T1-MRI data sets gained from different patients at various hospitals in Europe.

1 Introduction

Stereotactic deep brain stimulation (DBS) is an established treatment option for different kinds of neurological diseases, especially movement disorders, such as Parkinson's disease (PD), Dystonia or different kinds of tremors [1]. The Subthalamic Nucleus (STN) is considered to be the most promising target for DBS electrodes in the treatment of advanced PD. The STN is a small, almond-shaped structure, which is located in the midbrain, adjacent to the Substantia Nigra (SNR) and the Red Nucleus [2]. Different methods exist for the identification of the anatomical position of neural areas for DBS targeting. The STN and its boundaries are directly visible in T2-weighted magnetic resonance images (T2-MRI). However, T2-MRI can bear significant geometric inhomogeneities. Therefore, an indirect targeting method based on detection of the anatomical landmarks AC and PC (anterior and posterior commissure of the third ventricle), which can surely be recognized in T1-weighted MRI (T1-MRI), seems to be more exact. The topographical relation between ACPC-midpoint and the target STN is well known from the literature [3,4,5,6].

The preoperative planning procedure for stereotactic DBS is practically dominated by two steps: target localization and trajectory planning. First, the target position for the placement of the stimulating electrodes has to be decided. Second, a secure trajectory has to be chosen for inserting the electrode from the burr hole to the target point without intersecting critical brain tissue. Currently, this task is performed by the neurosurgeon. It requires high experience and it is also time consuming.

The aim of our study was the development of automatic methods for the DBS planning procedure. First, our system detects anatomical landmarks AC and PC and the mid-sagittal plane in a sequence of T1-MRI and calculates the target position for the DBS electrodes. In a next step, cerebral structures are analyzed in T1-MRI and classified into critical and non-critical tissue. Based on this, suitable and safe trajectories between a specified entry area and the target are calculated. The trajectories are valued by means of their risk of penetrating critical cerebral tissue and the best valued trajectories are proposed for DBS. Both methods support optimized results in a standardized manner, but the neurosurgeon must make the final decision.