UNIVERSITY of HOUSTON | ENGINEERING

Department of Biomedical Engineering

Ph.D. Dissertation Defense

Investigation of Spatio-Spectral Dynamics of Local Field Potentials in Parkinson's Disease

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ABSTRACT:

Parkinson's disease (PD) is characterized by the progressive loss of dopaminergic nigral neurons resulting in serious motor and non-motor deficits. Deep brain stimulation (DBS) of the subthalamic nucleus (STN) has emerged as an effective neurosurgical treatment for the patients with PD where their motor symptoms cannot be controlled with medications. Accurate localization of STN is an important factor defining the efficacy of DBS. The most common targeting method in DBS surgery is the microelectrode single unit activity recording which is performed by listening to bursting firing patterns of individual neurons to identify the basal ganglia (BG) structures. However, it requires significant expertise and is fraught by potential technical difficulties. On the other hand, local field potentials (LFPs), owing to their oscillatory and robust nature, can overcome these technical issues. In this regard, we recorded LFPs from multitrack *microelectrodes and macroelectrode* in PD patients who underwent DBS surgery. We demonstrated for the first time that combination of different subband features derived from beta and high frequency oscillations (HFOs) of LFPs can be used to estimate the optimal track for DBS implantation and to identify the dorsal STN border with high accuracy. These results

establish the initial evidence that LFPs can be strategically fused with computational intelligence in the operating room to increase the chance of optimal placement of the DBS electrode within the motor sub-territory of the STN, without an appreciable downside.

We also investigated the spatio-spectral patterns of LFPs in the most commonly accepted subtypes of PD-tremor dominant (TD) and postural instability and gait difficulty (PIGD). Studies have shown that patients with TD-PD have a relatively slow disease progression and the annual increase in symptom severity in PIGD is larger. In particular, severe cognitive dysfunction is consistently seen in PD patients with late-onset or in PIGD patients while TD-PD patients or those with young-onset show either no cognitive impairment or less. Despite the differences between these phenotypes shown by different modalities, as of today, no underlying neural correlates have been identified. Here we show that activity in the subbands of LFPs recorded with *microelectrodes* from sub-territories of the STN provide distinguishing neurophysiological information about these phenotypes.