Automated Deep Brain Stimulation Programming Using Motion Sensors

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Introduction

Deep brain stimulation (DBS) is a well-established treatment for Parkinson's disease (PD). Optimizing DBS settings quickly and in a way that minimizes costs and patient travel burden are important factors for follow-up care, but can be a significant challenge due to the number of variables that must be considered (i.e., severity of multiple symptoms, side effects, and battery life). The goal of this study is to determine if automated and objective assessment of DBS response could improve therapeutic benefit and battery life compared to clinician settings.

Methods

- 9 PD subjects with average OFF medication tremor and/or bradykinesia UPDRS scores ≥ 2 were recruited prior to or just after DBS implant surgery at the University of Minnesota
- Subjects visited the clinic for programming sessions at approximately 1, 2, and 4 months post-surgery, withholding anti-parkinsonian medication overnight
- Subjects wore a motion sensor (Fig 1) on the most distal portion of the first finger of the more affected hand during motor tasks to provide objective measures of tremor and bradykinesia
- Stimulation settings were assessed at various monopolar settings and subjects performed four standardized motor tasks from the UPDRS (Fig 2) following each change in stimulation
- Algorithms were developed offline to select the optimal stimulation contact and voltage combination

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<th>Table 1: Subject Demographics</th>
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<td>Age</td>
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<td>Gender</td>
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<td>DBS Target</td>
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Rest Tremor | Postural Tremor | Finger taps | Pronation-Supination

Figure 2. Motor tasks completed at each DBS setting

Figure 3. Tuning maps based on objective motion sensor ratings of rest tremor, postural tremor, and bradykinesia for a single subject. The black box indicates the final DBS settings the clinician selected. The white box indicates the presence of stimulation-induced side effects.

- Total motor score, or the sum of the eight symptom severity scores, was utilized as a measure of therapeutic benefit
- Algorithms were developed to:
  1. Maximize therapeutic benefit by identifying the contact and amplitude at which the therapeutic benefit was maximized
  2. Minimize voltage while maintaining at least the therapeutic benefit achieved by the clinician settings

Figure 4. Summary of automated algorithms for selecting DBS settings.

Figure 5. Block diagram of search algorithm

- Developed a prototype system to actively guide a monopolar review of the DBS programming space
- Leverages motion sensor algorithms for motor symptom assessment and allows clinician to manually enter side effects
- Once the functional map is complete, the system identifies stimulation settings which maximize symptomatic improvements while minimizing battery usage and side effects

Conclusions

- Results support the value of automated objective assessment in DBS programming
- Current work is evaluating online automated guidance of DBS programming
- An automated system designed for use by a general practitioner without years of experience in DBS programming could potentially expand the accessibility of DBS for patients not located near specialized centers and increase the efficacy and efficiency of post-operative DBS management

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