The Design of Visual Recognition Software to Analyze Deep Brain Stimulation Video

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INTRODUCTION

Deep Brain Stimulation (DBS) is a surgical procedure in which an electrode is placed in the basal ganglia of the brain in order to treat involuntary movement disorders such as dystonia, Tourette syndrome, essential tremor, and Parkinson's disease. The procedure involves observing a patient's passive movements, intraoperative neurophysiological monitoring, and electric stimulation run through different regions of the brain in order to determine an optimal location to place the electrode. Taking video of this procedure is beneficial, since the patient's movement and reactions to electrical stimulation are often re-examined depending on how well they respond post-surgery. However, the video recorded often has many useless parts, since important events do not occur continuously during surgery. This makes it much more difficult to review video from surgery. The size of the video files can also become problematic since there is a finite amount of space in the designated hard drive, and, once the hard drive is full, no more video can be recorded. Using Python and the libraries OpenCV and FFmpeg, visual recognition software is developed to automatically split up video clips and shorten them. The software is based on an algorithm utilizing frame-by-frame pixel analysis, HSV (hue, saturation, value) skin masks, and metadata modifications to determine and indicate visual cues from various parts of the surgery.

BACKGROUND AND SIGNIFICANCE

How Deep Brain Stimulation (DBS) Works

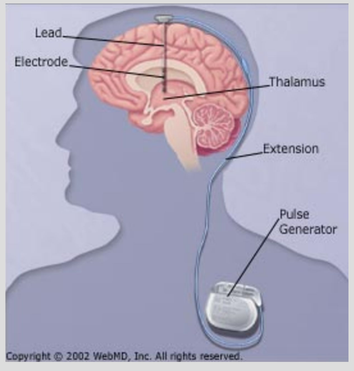

Figure 1. A diagram depicting what is implanted in a patient in Deep Brain Stimulation. The DBS lead has an electrode at the end and is inserted into the brain at a certain depth. A pulse generator embedded near the patient's chest runs a current through the electrode to alleviate involuntary movement disorders stemming from that region of the brain.

In Deep Brain Stimulation, a hole is drilled in a patient's skull and a needle-like metal rod with an electrode at the end is moved to various depths. As the electrode is moved to different depths, the patient's passive movements are observed. A current may be run through the electrode — this is called stimulation — and the patient's passive movements are observed again. Depending on how the patient reacts to stimulation for certain depths, the electrode is given a permanent location.

Deep Brain Stimulation is able to alleviate involuntary movement disorders by preventing neurons in the brain from having a refractory period. By running a current through certain neurons, the neurons are put into a state of constant disruption and can never undergo a refractory period, preventing them from firing.

METHODOLOGIES

Approach to Designing Algorithm

Save:	Delete:
1. When patient is being electrically stimulated 2. When surgeon indicates that he wants part of surgery to be saved 3. When the patient makes significant movement	1. When electrode is being moved to a different depth 2. Any other time that does not fit the criteria to be saved

Figure 2. Parts of video intended to be saved versus parts of video designated to be deleted.

Figure 3. A sample of the four-screen DBS video used for analysis. On the upper left quadrant the patient's vitals are displayed, on the lower right quadrant the Neuromonitor interface, and on the lower left and upper right quadrants the patient's body is displayed.

1. Neuromonitor

- Buttons on neuromonitor can be used to determine when the patient is being electrically stimulated, when the surgeon indicates that he wants a certain part of surgery to be saved, and when the electrode is being moved to a different depth.
- Buttons on the top of the neuromonitor turn red to indicate the occurrence of certain things. The number of pixels within a certain BGR range are counted to tell if a button is red or not.

2. Patient Movement

- An HSV skin mask is created to approximate the patient's skin to detect when the patient moves and disregard extraneous movements
- If skin mask movement exceeds a threshold for 3 consecutive frames, it is likely that significant patient movement is occurring.

3. Various Adjustments to Video Parsing

- Adjusted for skin activity spike every 15 frames (video rendering)
- Prevented output videos from being less than 3 seconds long

After these steps, the original video is split into smaller video clips which are either designated to be saved or deleted.

RESULTS/ANALYSIS

Output Results

DBS Clip	Original Clip Data (in MB)	Shortened Clips Data (in MB)	Shortened File Size Divided by Original File Size
DBS Surgery 1: Clip 1	502.2	57.9	0.115
DBS Surgery 1: Clip 2	1530	850.3	0.556
DBS Surgery 1: Clip 3	1220	432.3	0.354
DBS Surgery 1: Clip 4	258.6	0	0
DBS Surgery 1: Total	3510	1340.5	0.382

Figure 4. The reduction in file size from running the footage from a particular DBS case through the program. The original footage was originally comprised of four separate clips. In total, the program produced 93 smaller clips (45 designate to be saved and 48 designated to be deleted) from the original video, leading to a 61.8% reduction in file size.

Steps Moving Forward

1. Improve consistency of algorithm for analyzing various types of DBS cases

- Conditions from DBS cases vary frequently:
  - Thresholds for patient activity may need to be adjusted for each surgery
  - Optimizing skin mask for each patient
  - Need to account for possible changes in the location of buttons on the neuromonitor

2. Create interface which allows user to edit the output video

- Program is still in early stages
- This would allow for possible mistakes that are found by the user to accounted for and fixed

3. Develop organized way for output clips to be sorted, labeled

- Allow program to sort the output clips into separate folders
- Use metadata to provide extra information about output clip designation

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