Legends to the Video

Segment 1. Patient exhibits choreiform movements during the interview, which abruptly stop during performance of visual tasks. She can protrude her tongue for 10 seconds. Her difficulty with tandem gait is suggestive of astasia-abasia.

Author Roles: Fekete: Writing of the first draft and review and critique of manuscript and recording of initial video and editing. Jankovic: Review and critique of manuscript and editing.

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References


TremAn: A Tool for Measuring Tremor Frequency from Video Sequences

Simple visual estimation of tremor frequency by a physician is a part of routine clinical examination in a patient suffering from tremor, allowing a rough differentiation between slow and fast as well as between apparently regular and irregular periodic movements. A more precise measure of the tremor frequency is provided by accelerometers and electromyography, however, specialized equipment must be attached to the patient’s body. Although wearable devices have been recently introduced integrating accelerometers and gyroscopes to capture movement features, these methods can still be viewed as being cumbersome and impractical for routine clinical use. As an alternative, we propose a method of tremor frequency analysis based on video recordings of the patients—Tremor Analyzing Tool (TremAn).

TremAn measures the visible periodicity of the tremor. This approach measures the changes in the image intensity (sum RGB components) of a selected area in the video sequence hence capturing movement of a specific body part in front of a background. From a theoretical perspective, the 3D movement of an object does not necessarily correspond to changes in image intensity. Our practical experience tells us that changes in image intensity correspond well to tremor motion. The image intensity from the selected area, collected over time, forms a one-dimensional periodic signal. The frequency of this signal is measured based on its Fourier transform power spectrum computed with the use of the implementation by Ooura. Higher levels of precision are reached by collecting the signal at spatial points, which are regularly distributed within the area of interest. The movement of the body part is expected to be consistent; hence, the spectra of all the selected points are summed to produce one final spectrum. This approach eliminates accidental noise, however, if two dominant frequencies are present, two peaks can be seen in the resulting power spectrum, with the higher peak taken as the principal frequency.

TremAn allows for analysis of tremor recorded in most common video formats (.avi or .mpg). The assumptions made to ensure correct analysis are as follows: the tremor is visible in the video, the area of interest is stable (the video sequence was captured with a fixed camera, with no shifting, zooming or focusing of the shot and the body part captured was not moving markedly except for the tremor itself). The length of the analyzed video sequence should be at least 5 seconds and the sampling frequency should be at least 15 frames per second. To use the tool, users may simply open the video sequence in the application, select the area of interest (specific body part) with a single mouse click in the video sequence, and then initiate the analysis.

The output of the algorithm is the frequency of tremor for the selected body part. The progress of the frequency in time is also recorded and can be used to investigate whether the frequency was stable or changing. Several forms of visualization are offered: the signal progress, full frequency spectrum, or the frequency progress. These are all shown in graphs with the possibility to export the result as video, single image, or text file. Refer to Figure 1 for an example of the user interface.

Refer to Video 1 for examples of tremor analysis. The first segment shows a frequency measurement (3.22 ± 0.2 Hz) of the right hand rest tremor in a patient with Parkinson’s disease. In the second patient with clinically probable psychogenic tremor, the frequency of postural tremor of the left hand varies with time and decreases by more than 1 Hz in 25 seconds. The third example analyzes a recording of tremor...
taken from a previous publication in Movement Disorders Journal. In line with the results of electromyography mentioned in the original article, the patient’s head tremor frequency measured by TremAn is 5.3 Hz.

TremAn tool offers a convenient alternative to the common methods of tremor analysis. The patient does not need to wear any recording technology. The tool can be also used to analyze archived videos from various sources.

The results obtained by TremAn demonstrated a close correlation with tremor frequencies measured with accelerometers in the validation study with over 160 video sequences (manuscript in preparation, partly presented at the recent IEEE EMBC Conference). Also the analysis of the aforementioned archived video showed that the results correspond well to tremor frequencies measured with electromyography. However, care should be taken that the tremor is recorded in standardized positions. For example, here, video segment 1 probably does not show as nice a peak as the others, because the tremor of the hand is superimposed on the underlying leg tremor. Measuring other features, such as amplitude of the tremor might be feasible only under very strict conditions from calibrated videos and it is not practicable from ordinary video sequences.

Legends to The Video

**Segment 1.** Patient with Parkinson’s disease rest tremor of right hand. The area of measurement is highlighted in green. In the bottom of the video frame, the current time and measured frequency is displayed. Graphs 1–3 demonstrate the progress of the signal, the full frequency spectrum and the progress of the measured frequency, as mentioned in the text and shown in Figure 1. At the end of the processed sequence the example of the image output with the principal frequency is shown.

**Segment 2.** Patient with probable psychogenic tremor. Same features of video analysis as in Video segment 1.

**Segment 3.** Patient with Parkinson’s disease, with no-no head tremor (patient 5, segment 4, downloaded from Roze et al.). Same features of video analysis as in previous segments.

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A 29-year-old woman, with a history of depression at the age of 18, and an abortion (fetal malformation) at age 24, was seen for acute onset of wave-like movements of the tongue with concomitant cervical torsion (Video, Segment 1). 2 hours after she had taken 75 mg of venlafaxine prescribed by her general physician due to complaints of sadness and anxiety. After a single 5-mg dose of biperiden, these movements subsided. In the following week, these symptoms occurred for three times and again remitted with 5 mg of biperiden. She remained asymptomatic for 1 year. At this time, her general physician prescribed her 50 mg of sertraline for depressive symptoms. 2 hours after the first intake, an exuberant, irregular, arrhythmic, large-amplitude chin tremor developed (Video, Segment 2). This tremor persisted for several hours and was highly variable and responsive to both suggestion and placebo administration, the patient being remarkably indifferent to its occurrence. Both coactivation and entrainment signs could be elicited. Brain MRI, EEG, and a thorough lab work-up were normal. Electromyography of masseter muscles fulfilled Milanov proposed criteria for psychogenic tremor. The diagnosis of psychogenic tremor could then be confidently made. Psychiatric evaluation elicited a conversion disorder. She is currently taking no medication. The frequency of the chin tremor episodes has diminished. The last occurred during child delivery and ceased spontaneously.

In the first episode, the movement disorder phenomenology, its clear-cut relation to drug administration, and its prompt response to anticholinergic medication strongly suggest a venlafaxine-induced dystonia, similar to those previously reported to occur with this antidepressant. In contrast, several features led us to label the second movement disorder as psychogenic. As previously described, the chin tremor of our patient was highly variable and both distractibility and emotional indifference were remarkable. In addition, two of the most specific signs in psychogenic tremor, coactivation and entrainment, were found. Further supporting the diagnosis were symptom persistence after drug withdrawal and the physiologic incongruent electromyographic pattern.

Of relevance is that citalopram-induced jaw tremor and several cases of bruxism due to SSRI drugs are well known, but with complete symptomatic relief after drug withdrawal. Furthermore, we could not find any report of such a tremor induced by sertraline use.

In our patient, the development of a psychogenic movement disorder after an iatrogenic one is particularly noticeable, as if she had learned how it could arise. This is supported by data showing that, in conversive patients, subsequent symptoms are rather similar to those of a past neurological disease, and as that kind of learning process appears to occur. Treatment of conversion disorder is rather complex. However, making an accurate diagnosis and allowing the acceptance of its psychogenic nature is essential for the treatment to be successful and to avoid unnecessary investigations and drug prescriptions.

Additional Supporting Information may be found in the online version of this article.

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LEGENDS TO THE VIDEO

Segment 1. The patient was seen in the emergency room (ER) 2 hours after she has taken 75 mg of venlafaxine. As the video shows, she presented wave-like movements of the tongue and cervical torsion. These movements subsided with 5 mg of biperiden and she was discharged home.

Segment 2. The patient presented to the ER with an exuberant, atypical, and long-lasting chin tremor 2 hours after she has taken 50 mg of sertraline. The unusual clinical picture demanded the admin-