Computer Vision Of Smartphone Video Has Potential To Detect Functional Tremor

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Computer Vision Of Smartphone Video Has Potential To Detect Functional Tremor

Authors:

Dr Stefan Williams (Corresponding Author)
Leeds Institute of Health Science (LIHS), University of Leeds, Level 10, Worsley Building, Clarendon Way, Leeds LS2 9NL (UK)
stefanwilliams@doctors.org.uk

Professor Simon Shepherd
School of Engineering
University of Bradford
Bradford, UK

Dr Hui Fang
School of Computer Science
Liverpool John Moores University
Liverpool, UK

Dr Jane Alty
Department of Neurology
Leeds Teaching Hospitals NHS Trust
Leeds, UK

Paschal O'Gorman
School of Medicine
University of Leeds
Leeds, UK

Dr Christopher D Graham
Department of Psychology
Queen's University Belfast
David Keir Building
Belfast, Northern Ireland

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Dear Editor

Functional neurological disorders (FND) constitute more than 15% of referrals to neurology clinics [1], and functional tremor is the most common functional movement disorder [2]. Physical features of a functional tremor include: tremor present at rest, posture and action; variability in frequency and direction; and reduction or abolition of tremor with distraction [2]. Tremor judgement by eye is inherently subjective and imprecise [3], and a need for objective tests is recognised [4]. Although laboratory accelerometery can distinguish functional tremor from other tremors [4], it is a limited resource. Smartphone accelerometers can measure tremor frequency and discriminate tremor type [5], but a clinical test whereby patients hold a smartphone is not one that has entered routine practice. An alternative ubiquitous item of hardware that could be used to assess tremor is the camera (present in smartphones, personal computers, CCTV). Computer vision technology uses algorithms to detect and interpret the contents of camera images [6]. It is widely used commercially, e.g. facial recognition, but there are only a few reports of its application within neurology. Here we describe early results for computer vision of functional tremor.

We present results for two participants, with functional tremor (FT) and essential tremor (ET) respectively, diagnosed by a movement disorder specialist. The participant with FT had a history of a sudden onset tremor that waxed and waned, and on examination the tremor exhibited distractability and entrainment, as well as variability of amplitude, direction and frequency, together with increased severity on attention. Each participant was asked to extend their left arm, and a 30 s video of the hand was recorded with a smartphone on a tripod, from a lateral position, at 60 frames per second. From 15 s onwards, each participant was asked to tap in time with a 3 Hz metronome using the contralateral hand (outside the video frame). The magnitude of video pixel movement was amplified 25x using an Eulerian magnification algorithm [7]. After defining a bounding box around the hand region, the direction and amplitude of pixel movement was measured between pairs of video frames [8]. The magnitude of pixel movement in two directions perpendicular to the axis of the forearm was plotted over time. A spectrogram of the two traces was produced using Short Term Fourier Transform techniques, to reveal changes of spectral density with time, and a Matched Filter was then applied to each dataset [9].

Visual inspection of the two videos showed a very similar fine amplitude high frequency tremor of the hands, with little visual evidence of entrainment after metronome onset in either video. However, the computer vision method detects a change in the pattern of movement after metronome onset for the FT (Figure 1A,B), with spectral energy concentrated around 3 Hz for the second half of the dataset (i.e. 15-30 seconds), corresponding to entrainment with the metronome (Figure 1C). In Figure 1D, the ET, there is no evidence of a change in spectral energy concentration with the metronome. Furthermore, after matched filtration, in the functional patient video, the moving mean of the standard deviation crosses the binary discriminator (zero line) at the metronome onset, showing that the shift to 3 Hz is statistically significant (Fig 1 E,F).

In this early report, we demonstrate that entrainment, a highly specific feature of FT [5], can be detected by measurement of pixel movement in standard smartphone video. Existing objective methods such as accelerometry can aid distinction of different tremor types [4]. Our early results suggest the potential for a new, contactless, objective test to aid distinction of different tremor types, without a requirement for special equipment. To our knowledge, there is only one previous report that used simple video to assess tremor [10]. That involved a one-dimensional technique, sampling pixel colour oscillation at static points to give tremor frequency. Our technique tracks pixel movement in two dimensions, allowing the future possibility of a measure of direction and magnitude, and movement beyond simple oscillation.

The use of a camera to assess tremor has several limitations. Firstly, it involves assessment of three dimensional motion from two dimensional images. This may potentially miss crucial features, especially if the tremor involves rotatory motions. Secondly, the social or emotional context of the tremor would be picked up by an experienced clinician but could potentially confound ‘automated’ classification, e.g. physiological tremor in an anxious patient. Thirdly, even the existing gold-standard for objective tremor measurement, accelerometry, is itself limited in sensitivity and specificity, particularly when individual tests are performed rather than a battery of tests [4]. This suggests that any future objective measure of tremor risks misinterpretation if relied upon solely for diagnosis. Clinicians are continuously gathering information during consultation and formulating their diagnosis. This level of clinical acumen is unlikely to be surpassed by objective ‘snapshot’ assessments. However, our method suggests the potential to develop a clinically useful, contactless tool that could support tremor assessment. Future work will compare signals obtained from this technique across groups of participants with different tremor disorders (hands resting and in posture), for sensitivity and specificity of diagnosis category as well as comparison with accelerometry data.

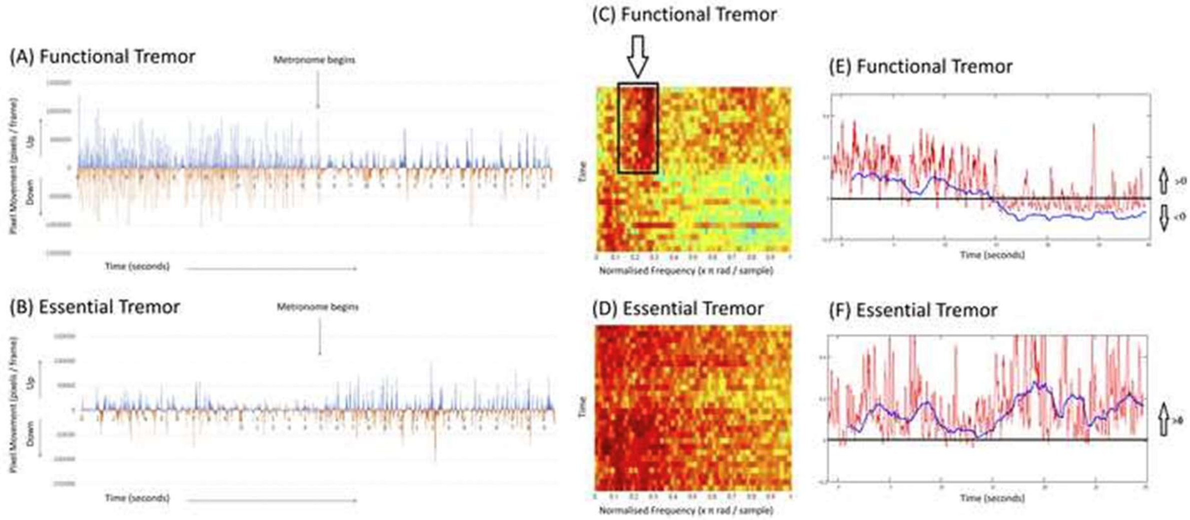

Fig. 1. (A) and (B) show pixel movement between pairs of video frames over two 30 second videos of outstretched left hand, filmed from a lateral position. Positive (blue) bars, show the number of pixels moving upwards between video frames (i.e. hand movement upwards). Negative (orange) bars show pixel (hand) movement downwards. There is a change in the pattern of pixel movement from metronome onset at 15s for a functional tremor participant (A) but not for an essential tremor participant (B). (C) and (D) show Short Term Fourier Transform applied to the time series, to show changes of spectral density with time. For the functional tremor (C), the second (metronome) half of the data shows the main energy concentrated at a frequency of 1/0.33 = 3Hz, corresponding to entrainment with the 3Hz metronome (arrowed box). For the essential tremor (D), there is no clear change with metronome, and energy tends towards 8-12 Hz. (E) and (F) show matched filtration residual series containing the characteristic anomalies of the data. The blue line shows the moving mean of the standard deviation, which switches to below zero after the metronome onset at 15s for the functional tremor only (a significant shift with the metronome).

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STATEMENTS

Ethical standards

This work was approved by the UK Health Research Authority (IRAS no. 224848).

Conflicts of Interests

On behalf of all authors, the corresponding author states that there is no conflict of interest.