Spiral Acquisition on the iPad for the Assessment of Motor Dysfunction

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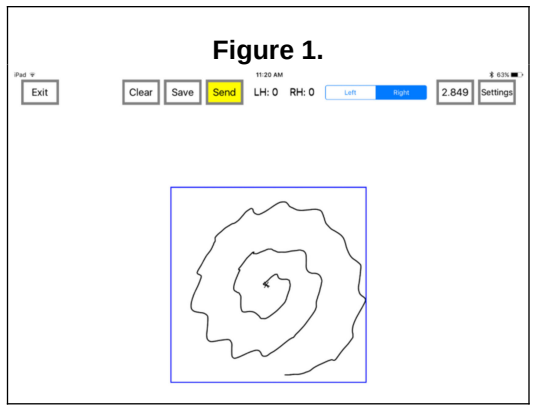
Introduction

Computerized spiral analysis (CSA) has been in use for many years as a clinical tool to evaluate movement disorders including Parkinson's disease, essential tremor, dystonia, and cerebellar tremor (Pullman, 1998; Saunders-Pullman et al., 2008). CSA analyzes patient-produced spirals digitally, precisely capturing objective measurements that provide deeper insight into these diseases and allow clinicians to evaluate their severity and progression (Van Gemmert & Teulings, 2006). Currently, spiral collection software is run on a computer connected to a Wacom drawing tablet [Intuos 4] (Pullman, 1998). While this method has provided robust data for years, it must be connected to a computer running software that is not widely available or distributed, thus limiting its accessibility to patients outside of a clinical setting. A portable touchscreen device such as the Apple iPad Pro is capable of both recording data and conducting analysis without any additional external hardware. We propose that the Apple iPad Pro and Apple Pencil have the potential to be a more practical alternative to the Wacom Tablet.

Experimental Methods

Our iPad Pro application displays a 10x10 cm square with a target in the center designed to mimic the paper template that is used for the Wacom Tablet version of CSA. Input is received from a finger, capacitive stylus, or the Apple Pencil (Figure 1). The software keeps a counter of the number of spirals obtained for each hand for a particular subject. Position, pressure, and time data are recorded and converted into metrics, which the application uses to calculate various indices of importance. After each spiral, the modified Degree of Severity is immediately displayed.

Figure 1.



Results

The analysis software processes individually collected spirals and creates visual representations of measured indices along with relevant numerical data displayed underneath each graph (Figure 2). Spiral data points are recorded in a table for each drawing (Table 1). The software then computes and aggregates a summary of numerical information averaged across all spirals for each trial of 10 spirals per hand for every patient, comparing these to database-derived, age -controlled normal values (Table 2).

Table 1.

Last name: xxxx
First name: xxxx
Age: xx
Gender: M
Handedness: R

Date:
Time:
Hand:

n	x(mm)	y(mm)	p(μn)	t(ms)
1	101.80	88.60	5242	0
2	101.65	88.50	5242	3
3	101.28	88.43	5242	8
4	101.00	88.20	7081	12
5	100.82	88.12	8001	16
6	100.68	87.97	8461	20
7	100.60	88.00	8920	24
…				
1640	75.20	50.20	0	6829

Figure 2.

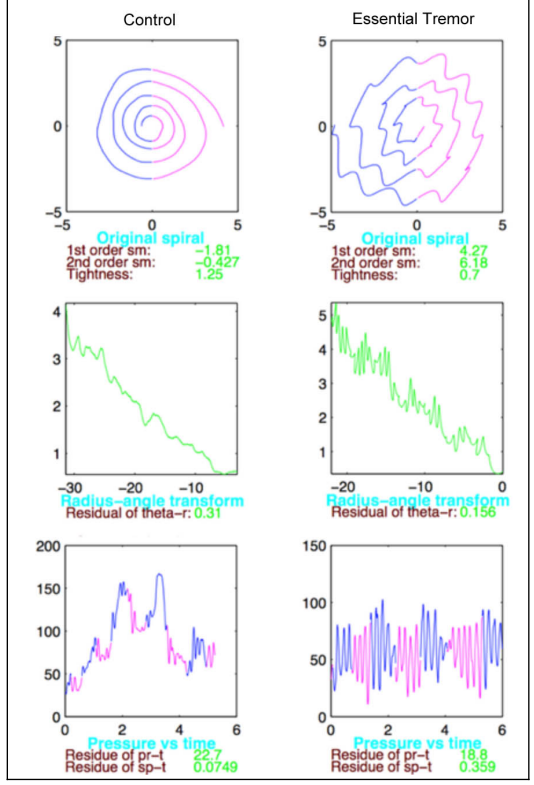


Table 2.

	Dominant		Non-dominant	
	Patient	Normal	Patient	Normal
Degree of Severity	3.625 ± 0.158	0.508 ± 0.310	3.431 ± 0.232	0.729 ± 0.346
Tremor:				
Trials with Tremor	10/10		8/10	
Frequency	4.836 ± 0.174		3.791 ± 0.404	
Amplitude (cm)	0.138 ± 0.043		8.494 ± 1.681	
Tightness	0.646 ± 0.088	1.082 ± 0.299	0.705 ± 0.058	0.911 ± 0.200
Slope Ratio	1.104 ± 1.483	0.403 ± 0.336	- 0.020 ± 0.618	0.314 ± 0.261
Width Variation	0.396 ± 0.023	0.240 ± 0.055	0.368 ± 0.070	0.261 ± 0.054
Average Speed (cm/s)	17.269 ± 2.363	23.788 ± 8.931	14.402 ± 1.042	22.091 ± 8.312
First Order Zero Crossing	8.439 ± 0.488	6.827 ± 2.328	9.707 ± 1.088	6.266 ± 1.883

Discussion

The application presented here would enhance the ability to monitor the onset and progression of a myriad of motor disorders by providing patients with a streamlined digital kinematic data collection method that could be used easily in the outpatient setting. The ability for patients to easily record and upload spiral data from their own home could contribute to more convenient acquisition of longitudinal data. This has the potential to create enormous amounts of patient-derived movement data that clinicians would be able to track, following day-to-day fluctuations of new treatment regimens and detecting any new abnormalities before they present in the clinic. In addition to the benefits this method provides patients at home, the iPad Pro application could also be used intra-operatively to measure changes in DOS during a deep brain stimulation operation and give the surgeon immediate feedback to help optimize electrode placement. Finally, the iPad Pro could be used to amass and analyze collected information to create newer, more accurate models of movement disorders, which may facilitate our understanding of movement disorders as a disease process and help guide clinical decision-making during the treatment of these conditions.

References

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