Development of a Video-Based Tracking System for the Routine Clinical Evaluation of Motor Disorders

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Introduction

Current clinical protocols for the evaluation of disorder severity are subjective, and though reliable, are not well-suited to the detection of small differences from visit-to-visit. We propose that by implementing a relatively low cost video-based tracking system of hand movements, we will be able to better monitor and record the progression of certain neurodegenerative motor disorders in patients. Our goal is for the system to identify trends in patients that lead to the detection of such diseases and enable interventional therapies.

Methods

A Keyence VHX-600 Digital Microscope used to assess the detect slight motions at various magnification settings, resolutions and distances. Preliminary testing was conducted on human subjects by instructing them to move a spatula-mounted target back-and-forth within a rectangle a predefined number of times. Video data was then post-processed in MATLAB.

Once data on the ability of the lens to detect small movements had been collected, a new camera was mounted on a gear-driven tripod. LabVIEW software was written to allow for additional flexibility in the design of boundaries, as well as to provide real-time feedback to subjects. The boundaries flash red if the target centroid leaves it.

Initial testing was conducted using the Keyence system. Subjects were tested while standing, with both their dominant and non-dominant arms. They were instructed to keep their upper arm parallel to their torso and their forearm in line with the camera, and to move the target back-and-forth between the left- and right-endpoints. The target was mounted on a spatula for testing with the Keyence system, and mounted on the back of the hand when used in conjunction with our custom software. The motivation for a hand-mounted target was to negate the confounding effect that holding an object may have on assessing coordination.

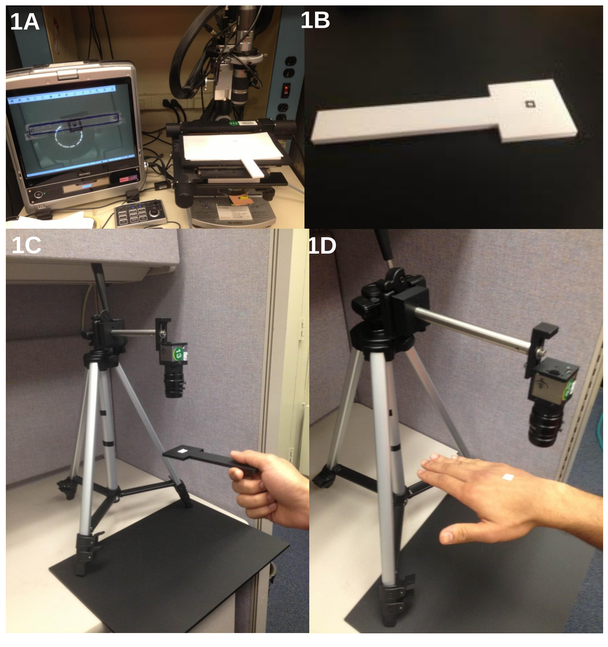

Figure 1. Images of system set-ups. (A, B) depict the hardware used during testing with the Keyence system. Subjects moved the target-laden spatula back-and-forth between the left and right endpoints. (C, D) depict the hardware used in conjunction with the custom software.

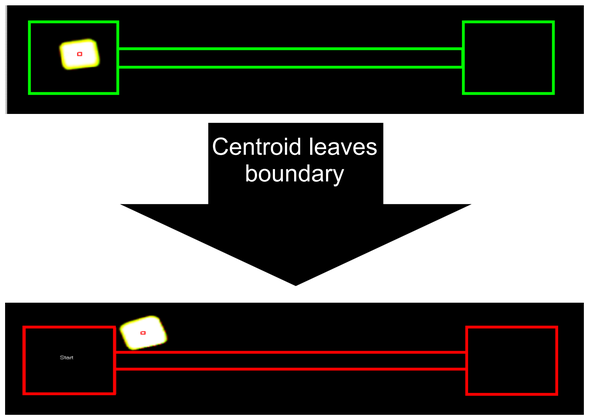

Figure 2. Demonstration of real-time feedback. As the subject moves the target around, if the target centroid leaves the outlined region, the boundary turns red to provide real-time feedback.

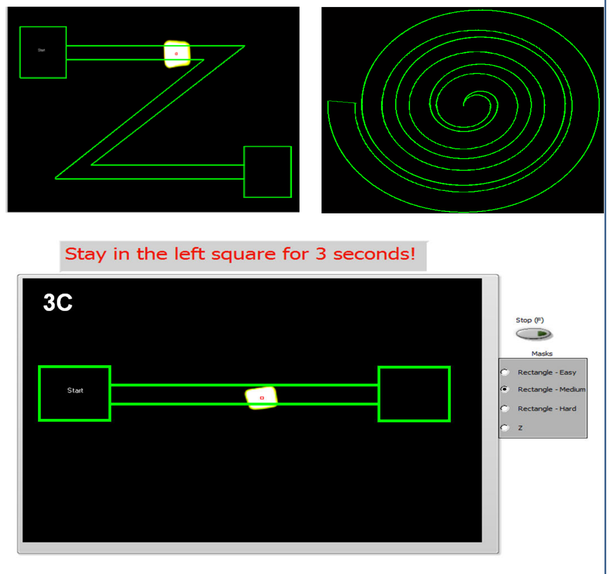

Figure 3. (A, B) Alternative boundaries that can be used in conjunction with the custom software system. Any closed-contour boundary can be drawn in Paint or a similar program, and loaded into the software for use in testing. (C) Screenshot of the custom software interface.

Results

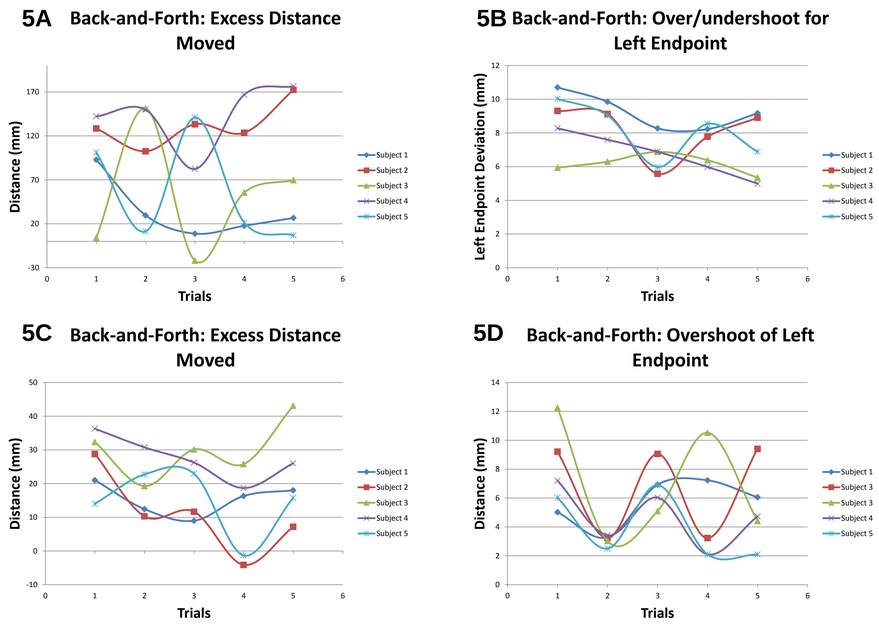

Figure 5. Overview of motor deviation data collected from both systems. (A, B) Using the non-feedback system: from a back-and-forth test, the excess distance was computed as the ideal straight-line path distance subtracted from the actual distance. Overshoots for the left endpoint were considered positive if the subject ended to the right of the endpoint, and negative to the left of the endpoint. (C, D) Using the feedback system, datasets similar to A and B were collected.

Factors Influencing Movement Measurements	Prototype 1	Prototype 2	Comments on Prototype Differences
Sitting or Standing?	Standing	Sitting.	Sitting minimizes the influence of postural sway on results.
Arm Position	Upper arm parallel to torso, forearm extended perpendicularly.	Upper arm partially extended, forearm perpendicular to torso.	Having the upper arm partially extended is not as precise an instruction, but is necessary for an appropriate range of motion. Could implement precise elbow or hand positioning.
Target Location	Mounted on a handheld spatula.	Mounted directly on the hand.	A spatula-mounted target is susceptible to small involuntary hand movements resulting in large target movements; hand-mounting diminishes this effect.

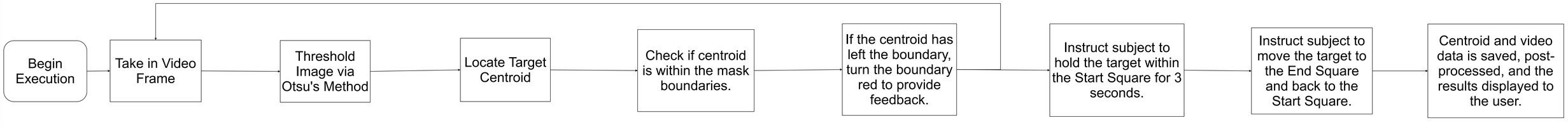

Figure 4. Flowchart of the software used to track target location and provide instructions.

References and Acknowledgements

1. Marini, F. Quantitative Evaluation Protocol for Upper Limb motor Coordination Analysis in Patients with Ataxia. (2010). Annual International Conference of the IEEE EMBS.
2. Swider, M. The application of video image processing to quantitative analysis of extremity tremor in humans. (1998). Journal of Neuroscience Methods..

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Conclusions

- The foundation for a video-based motion tracking system for evaluation of motor disorders has been established.
- Software system provides research clinicians the flexibility to define and evaluate various motion tests.
- Instrument provides real-time feedback to subject which appears to improve performance.
- Observed that subject performance varies over time with and without visual feedback, thus additional testing is required to refine testing procedure, complexity, and data analysis.

Future Directions

- Improved object tracking algorithms suitable for use under various lighting condition (i.e., clinic).
- Addition of a video-based frequency content extractor or integration of hardware accelerometers for tremor analysis.
- Develop a reliable and robust clinical procedure and instrument to quantify the severity of motor disorders.
- Evaluate system as a means to monitor progression and response to treatment, as well as utility in early disease detection.