Multimodal Dialog Based Remote Assessment of Balance in Parkinson's Disease and Other Movement Disorders

Nikhil Sukhdev[1], Oliver Roesler[1], Michael Neumann[1], Sejal Desai[1], Ira Shoulson[1], Vikram Ramanarayanan[1,2]
[1]Modality.AI, Inc., [2]University of California, San Francisco
vikram.ramanarayanan@modality.ai

Background & Objective

- Postural instability and balance issues are major sources of falls in people suffering from neurological disorders such as **Parkinson's Diseases (PD)** [1]**.**
- Clinician administered balance assessments, such as the BESTest [2], are often infrequent and inconvenient because they require patients to travel to a clinic.
- To address these problems, we examine the feasibility to incorporate standard clinical balance assessments into our existing multimodal dialog platform.
- To the best of our knowledge, there have been no studies conducted in assessing balance remotely using a multimodal dialog platform

Objective: To demonstrate the feasibility of administering a balance assessment through a multimodal web-based dialog system for assessment of Parkinson's Disease and other movement disorders.

Methods

- A virtual guide named Tina guides participants through a series of exercises derived from the **Berg Balance Scale (BBS)** [3].
- The assessment incorporates both frontal and side views.
- MediaPipe Pose is used to extract landmarks; videos recorded with a resolution of 320x240 pixels and 15fps.
- Full body should be visible while sitting and standing (Fig. 1).
- **Six items** from BBS were adopted: **Sit-to-Stand; Standing Unsupported; Standing Unsupported with eyes closed; Standing on one leg right; Standing on one leg left; Stand-to-Sit; Sitting Unsupported.**
- Mandatory for a caregiver to be present while patients perform tasks.

Fig. 1: Frontal view sit-to-stand task.

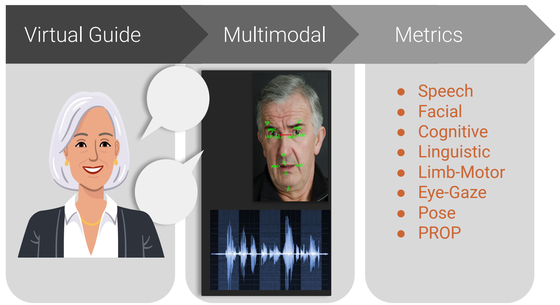

Fig. 2: Schematic diagram of the Modality.AI dialog platform.

- Prolific crowdsourcing: **51** assessments; **49** participants
- Internal Modality Testers: **11** assessments; **9** participants
- A pre-call survey was conducted to ensure participants are able to **stand on their own** and have a **solid chair without wheels and arms**

Feasibility Analysis

- **51** prolific sessions (**49** participants) included.
- **24** female, **25** male; mean age - **44 years**; range - **18 to 68 years**.
- 7 assessments ended after the pre-call survey as participants didn't have a suitable chair.
- **Compliance rate (tasks performed as per instructions): 86.8%**
- **63/477 (13.2%)** tasks showed non-compliance.
- Side view tasks showed higher compliance (77.8%): Learning Effect
- **Low Compliance on seating setup.**
- **Primary non-compliant behaviour**: Participants moving towards/away from the camera.
- **Sit-to-Stand** and **Stand-to-Sit tasks** showed highest non-compliance (Fig. 3).

Fig. 3: Non-compliance broken down by tasks.

Analytical Validation

- Evaluated the analytical validity of the **time taken from sit-to-stand (TSS)** metric.
- **22** assessments (crowdsourced and internal) included in which participants were visible from their heads to (at least) their knees.
- Mean Absolute Error (MAE): **224 ms;** Inter Annotator agreement: **202 ms.**
- Root Mean Square Error (RMSE): **267 ms**; Inter Annotator agreement: **285 ms.**
- Mean TSS (Ground Truth)**: 1.73 secs.**
- RMSE and MAE **< 16%** of Mean TSS.

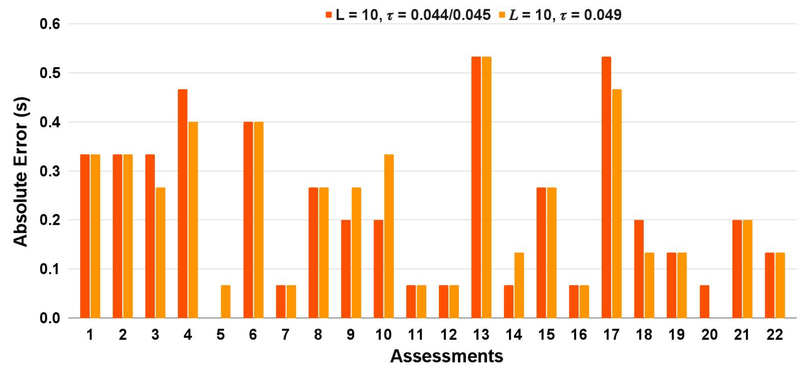

Fig.4 : Assessment-wise absolute errors for all optimal parameter combinations.

Conclusions

- We **investigated the feasibility** of **remote balance assessments**.
- The study shows it is **feasible** to conduct remote balance assessments through a multimodal dialog platform.
- The collected data can be used to extract **analytically valid balance metrics**.
- The utility of collected data depends strongly on **participants' compliance** to the instructions for the **task and seating setup**.

References

[1] Wood, B. H., Bilclough, J. A., Bowron, A., & Walker, R. (2002). Incidence and prediction of falls in Parkinson's disease: a prospective multidisciplinary study. Journal of Neurology, Neurosurgery & Psychiatry, 72(6), 721-725.
2] Horak FB, Wrisley DM, Frank J (2009) The balance evaluation systems test (bestest) to differentiate balance deficits. Physical therapy 89(5):484–498.
[3] Berg, K. (1992). Measuring balance in the elderly: Development and validation of an instrument.