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Individual Characterization of Drawing Pattern in a Pattern Lock Application of the Smartphone

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***Abstract*— Individual characterization of the finger movement can be applied in a variety of areas, such as security in E-commerce or early detection of neurodegenerative diseases. However, the way of characterizing finger movement has been understudied. The finger movement is a sophisticated motor task, highly variable by multiple factors like posture and joint position. Therefore, it is important to identify the best way to obtain reliable data for characterization. In this paper, we tested the use of a smartphone pattern lock application to identify the best posture to characterize and distinguish the finger movement patterns between individuals.**

***Clinical Relevance*—The individual characterization of finger movement can be used as a potential biomarker.**

I. INTRODUCTION

Simple finger movements such as E-signature, smartphone pattern lock, and symbol drawing have been used in a variety of areas, such as security, authentication, and early detection of neurodegenerative diseases [1]-[3]. However, in spite of the importance of consistency and rigor in getting those finger movement patterns, the postures at which such finger movement should be performed have not been well investigated.

In this study, we tested the use of a pattern lock app on smartphones to characterize the finger movement pattern for each individual. We collected data from subjects' drawings and rated the separation between each subject's movement pattern based on kinematic parameters. Specifically, we compared among three postures regarding the positions of elbow and wrist joints, because the finger movements heavily depend on those proximal joints.

II. METHODS

We designed a pattern lock app which can be used on both iOS and Android platforms to collect data of user drawings. Eight subjects, with an average age of 28.5, consisting of two females and six males, participated in the experiment. All subjects were instructed to complete a specific unlock pattern in their smartphones with three different arm postures regarding elbow and wrist joints. Three postures consist of: 1) both elbow and wrist are free in the air, 2) both elbow and wrist are fixed on the desk, and 3) elbow is fixed on the desk and wrist is free in the air. The pattern was a rectangular spiral on a 4×4 grid, to include multidirectional movements. The app collected the trajectory of the user drawing at a constant sample rate and saved the data to a cloud storage. We used the raw data to extract features of speed and deviation from the standard grid of each subject in each trial, and used the normalized features as an input to Principal Component Analysis (PCA) algorithm to further reduce the dimensionality to two for visualization.

III. RESULTS

Based on the distribution consistency algorithm [4], we evaluated the cluster separation: the higher score means the better separation of the clusters. The scores for the three postures are: 77.9 for both elbow and wrist up in the air, 73.3 for both elbow and wrist fixed on the desk, and 84.2 for elbow fixed on desk and wrist up in the air. Based on the scores and plots of the feature separation, we determined that the best individual characterization was obtained when elbow is fixed on the desk and wrist is up in the air.

IV. DISCUSSION & CONCLUSION

Three postures regarding the positions of wrist and elbow joints were compared in terms of the individual characterization of the subjects' finger movement for pattern lock application. When elbow was fixed on the desk and wrist was up in the air, the clusters for each subject in PCA space were separated with the best score. We expect it is because this is the most common posture that people select to use their smartphones with their fingers. Finger movement is limited in its degree of freedom when both elbow and wrist joints are fixed on the desk, and the finger is mainly moved with the whole arm when both elbow and wrist are up in the air. The selected posture will play an important role in the follow-up experiment with a large number of subjects, to characterize the individual finger movement pattern.

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