Application Fields and Innovative Technologies

The Application of AI-enabled Automatic Swallowing Movement Recognition in Ultrasound as Measurement for Mendelsohn Maneuver Training P.T.C. Shek, W.Y.S. Lam, E. Kwong, E.T.C. Wong, Y.P. Zheng. *Gerontechnology* 25(s)

Purpose Mendelsohn maneuver has been a long-standing swallowing maneuver for dysphagia rehabilitation that manipulates volitional swallow by requiring the patient to hold the swallow for a prolonged period of time. Ultrasound has been used as biofeedback in the training [1], yet the reliability of human evaluation of the movement has been questioned. The current research aims to create an AI-empowered recognition model to identify the timestamps of swallowing movements, thereby facilitating accurate feedback in Mendelsohn maneuver training. **Method** A total of 160 trials of ultrasound images of Mendelsohn maneuver in post-treatment tests from 16 healthy young adults were utilized. The study was divided into several phases: in Phase 1, human judgment of success or failure of the trial and the timestamps of the trials were identified. Judgment was blindly done by two trained research personnel who were engaged in the data collection process. The timestamp annotation was done by an experienced speech pathologist. The annotated time frames included: the onset, maximum, secondary holding, offset, and relaxation frames of (a) hyoid bone displacement, (b) thyroid bone displacement, (c) tongue base retraction. Timestamp-calculated accuracy was based on whether all three target movements of interest, from maximum to offset time, lasted for at least two seconds. The inter-rater and intra-rater reliability between raters and timestamp-calculated accuracies were calculated. In Phase 2, the deep learning model SiamFC from Feng's study, which was previously trained on hyoid bone tracking on healthy adult swallows, was used in the tracking of the process of Mendelsohn maneuver. A post-processing script was used to derive the success or failure of the trials. The performance of the model was evaluated by the percentage of judgment accuracy. **Results** In Phase 1, human judgment demonstrated moderate inter-rater reliability 0.489 and substantial intra-rater reliability (0.622 and 0.657). Inter-rater reliability between human judgment and human timestamp annotation was only at 0.504 at moderate agreement. In phase 2, the deep learning model SiamFC from the Feng's study [2] had been applied onto all trials. The model achieved 56.88% successful rate in tracking the hyoid bone throughout the swallowing process. Among the successfully tracked trials ($n = 91$), the model achieved 79.12% agreement with human expert judgment. **Discussion** Human judgment and annotation data demonstrated the need for timestamping in facilitating accurate judgment of the accuracy of the maneuver in ultrasound. The current model demonstrated potential in employing AI in automated judgment for biofeedback in the accuracy of the maneuver in ultrasound. Integrating AI for automated timestamping and judgment not only relieves the labour-intensive work in timestamping but also provides an efficient way to provide accurate feedback in the acquisition of swallowing maneuvers. The current data with young adults will provide clear data for the model in future generalization to older or dysphagic populations. Further research can investigate the possibility of utilizing semi-automated timestamping data for qualitative analysis of success and errors in the process of swallowing maneuver acquisition.

References
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