

Estimation of Range of Movement of the Thumb Using Tablet Device and Mediapipe Integration

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Disclosures:

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INTRODUCTION:

The carpometacarpal(CM) joint is a saddle joint and the abduction of the thumb is a free-flying motion centered on the CM joint. The abduction angle of the thumb is defined as a combination of the palmar and radial abduction which is measured by using a goniometer. Recently, AI based pose estimation models enable to analyze real-time joint motion using video camera. In this study we used Mediapipe Hand to estimate the abduction motion of the thumb. We defined the abduction angle of the thumb based on the concept of the 3-D space model. [1,2] First CM joint was assigned as the coordinates origin, the second metacarpal bone was set as the base axis. The position of the interphalangeal(IP) joint of the thumb was described as rotational displacement coordinates(r,θ) based on the distance r from the base axis and the rotation angle θ from the palmar plane which is defined as 0 degrees. [Fig1.]

MATERIALS AND METHODS:

Ten healthy volunteers were seated 1 m in front of a tablet device placed 50 cm above the table, 1 m palm side, at 45° from the examiner. All participants were right-handed, and only the dominant hand side was evaluated. During measurements, the subject was seated at a table with the wrist in a neutral position. We capture participant's rotational displacement coordinates(r,θ) which is kept the distance (r) from the IP joint of the thumb to the metacarpophalangeal joint of the index finger constantly, and moved their thumb by changing θ from 0° to 90° in 10° increments using a goniometer-based device placed vertically on the base axis. [Fig2.] We construct machine learning model which calculate parameters such as distance, angle and so on from rotational displacement coordinates(r,θ) detected by the mediapipe hand and estimate the rotation angle of the thumb θ . [Fig3.] Using parameters, a machine learning model was created in Python using measured values from the application as true values. We compared the performance of the machine using liner regression and Light GBM.

RESULTS SECTION:

We processed movie as 4337 images. In the linear regression model the Mean Absolute Error (MAE) was 15.115 degrees and correlation coefficients was 0.734 ,and the LightGBM model the MAE was 1.987 and correlation coefficients was 0.993 of our measurements with the true value of the goniometer.

DISCUSSION:

The machine learning model created from the posture estimation AI showed a high correlation with the actual thumb motion angle. Using these methods, it was possible to estimate the working area of the thumb and the corresponding range of motion of the thumb. It is expected to contribute to the application of hand function evaluation in the future.

SIGNIFICANCE:

Dynamic analysis using tablet device and mediapipe integration can be a useful for estimation of range of movement of the thumb.

REFERENCES:

- [1] Li-Chieh K et al. A kinematic method to calculate the workspace of the trapeziometacarpal joint. Proc Inst Mech Eng H. 218(2): 143-149, 2004.
- [2] Li-Chieh K et al. A quantitative method to measure maximal workspace of the trapeziometacarpal joint -normal model development. J. Orthop. Res. 22: 600-606, 2004.

IMAGES AND TABLES:

Fig.1 The position of the IP joint of the thumb was described as rotational displacement coordinates(r,θ) based on the distance r (①) from the base axis and the rotation angle θ (②) from the palmar plane which is defined as 0 degrees.

Fig.2 The subjects were seated 1 m in front of a tablet device placed 50 cm above the table, 1 m palm side, at 45° from the examiner with the wrist in a neutral position using a goniometer-based device placed vertically on the base axis.

Fig3. We used the Mediapipe Hand to estimate the abduction motion of the thumb.

Fig.1

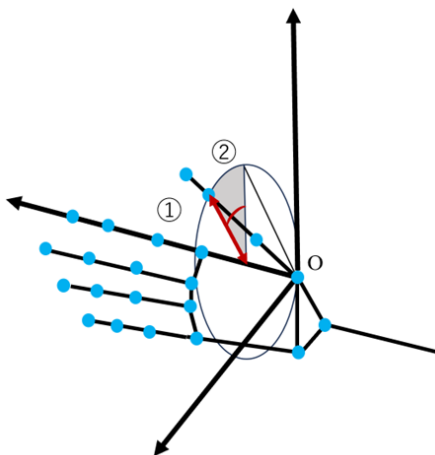


Fig.2



Fig.3

