Shoulder Joint Rotational Angle Estimation Using Tablet Devices and Pose Estimation AI

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INTRODUCTION: Shoulder joint motion analysis is an important element in sports medicine and rehabilitation [1]. Traditional angle measurements have been performed using a goniometer, but the complex motion of shoulder movement has made these measurements intricate [2]. Among them, the angle of rotation is difficult to measure from a direct-facing position. With the recent advancements in AI, various pose estimation models capable of human posture estimation using cameras only have been developed. In this study, we attempted to estimate the shoulder joint internal/external rotation angle (1st) using the combination of Mediapipe developed by Google Inc and machine learning model.

METHODS: Ten healthy volunteers were asked to stand at a position 2 m in front of a tablet device placed 150 cm above the ground. All participants were right-handed, and only the dominant side was evaluated. The upper arm was in contact with the trunk, the elbow joint was flexed to 90 degrees, and the forearm was in an external rotation position. Videos were taken while changing the external rotation angle from 0 to 50 degrees in 10-degree increments. Internal rotation was performed in the same manner. The actual shoulder joint internal and external rotation angles were measured using an angle measurement application on a smartphone. The recorded videos were processed into 15,886 image frames. The captured images were analyzed using the Pose module of Mediapipe. From the measured coordinates, the angles of the elbow and shoulder joints and the relative distance between the trunk and forearm were calculated as parameters for machine learning. Using these parameters, a machine learning model was created in Python using the measured values from the application as true values. We compared the performance of the machine learning model using both linear regression and Light GBM.

RESULTS SECTION: When the pose estimation AI was trained using linear regression, a correlation coefficient of 0.971 was achieved, with a Mean Absolute Error (MAE) of 5.778. When trained with Light GBM, the correlation coefficient was 0.999 and the MAE was 0.945.

DISCUSSION: The posture estimation AI and the actual shoulder joint internal/external rotation angle showed a high correlation. This method enables the estimation of internal and external rotation angles from a direct-facing position and does not require the introduction of special devices. It is easy to construct a measurement environment and is considered to be valuable for analyzing motor movements during sports and rehabilitation. In addition, measurement can be performed at a remote location as long as a device is available. If more complex movement analysis other than shoulder joint internal/external rotation movement becomes possible, it is expected to contribute to the efficiency of movement analysis and applications in rehabilitation and other fields.

SIGNIFICANCE: This method is a non-invasive, easily deployable approach with potential applications in sports analysis and rehabilitation.

REFERENCES:
[1] Carnevale A, et al. Wearable systems for shoulder kinematics assessment: a systematic review. BMC Musculoskelet Disord. 2019.
[2] Longo UG, et al. Optical Motion Capture Systems for 3D Kinematic Analysis in Patients with Shoulder Disorders. Int J Environ Res Public Health. 2022.

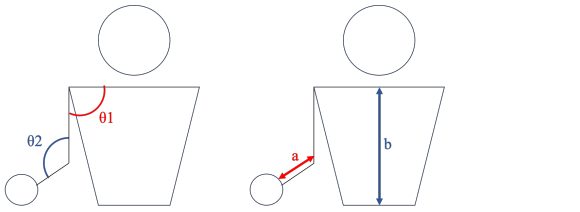

Figure 1: Parameters recognized by the camera.

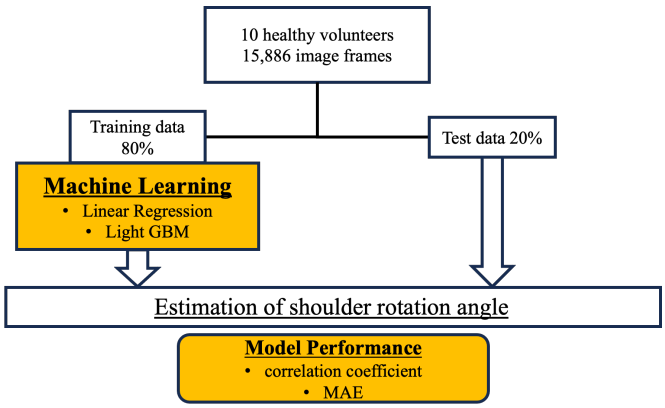

Figure 2: Workflow of data acquisition and machine learning.

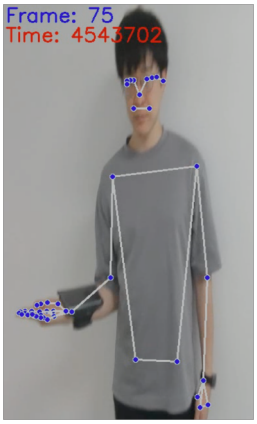

Figure 3: Estimating the rotation angle using Mediapipe.