

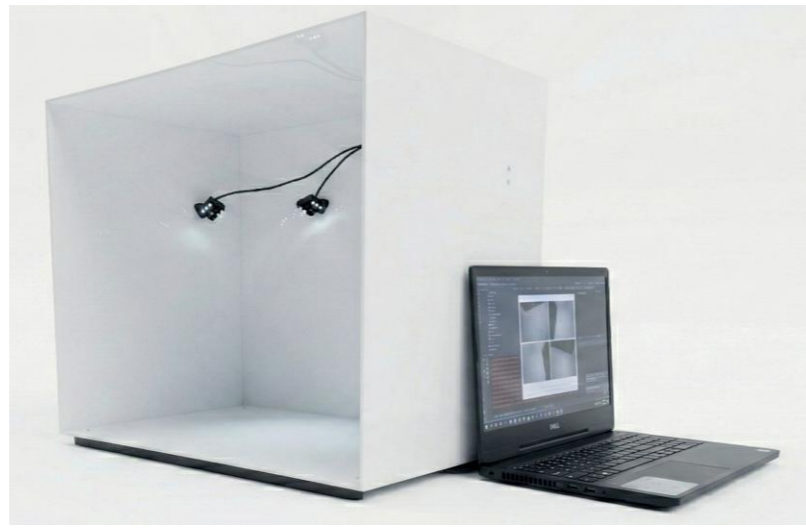
VALIDITY AND RELIABILITY OF THE HANDCUBE: A NOVEL MULTI-CAMERA COMPUTER VISION SYSTEM FOR AUTOMATED, OBJECTIVE ASSESSMENT OF FINGER KINEMATICS IN REHABILITATION

Kim-Ming Tsoi, King-Pong YU*, Chi-Chau Chan, Hei Ho, Ka-Leung Chan, Wai-Ling Ma

Community Rehabilitation Service Support Center (CRSSC), Hong Kong Hospital Authority

*Corresponding author. Tel.: +852 2462 4228; email: ykp587@ha.org.hk

INTRODUCTION & AIM



Quantitative assessment of hand and finger kinematics is essential for diagnosis, treatment planning, and monitoring rehabilitation outcomes but conventional tools, including manual goniometry and observational scales, are labour-intensive, examiner-dependent, and limited in their ability to capture complex, dynamic three-dimensional (3D) motion of individual digits. There is therefore a clear need for an objective, affordable, and easy-to-use system capable of providing detailed, repeatable 3D kinematic data during functional hand movements.

METHOD

The HandCube is a markerless system using a four normal webcam setup for multi-view to reconstruct 3D hand. During evaluation, a patient is required to perform different gestures within the cube (eg. hand open, fist, oppositions and pinches). Based on computer vision and machine learning algorithm, prominent joint landmarks in 3D space are automatically output as kinematic report as well as interdigital web space range.



To verify the system's reliability, a calibrated robotic hand (OHand, OYMotion) was used in this study to perform the series of hand motion, the actual angles of joints (measured by goniometer) had been matched and compared to angles provided by hand cube system. The HandCube recorded each gesture five times while the robotic hand was rotated through 360 degrees to simulate different orientations.

KEY FEATURES

Multi-Mode Recording

- Standard Gestures
- Static Deviation Measure
- Free Recording
- Thumb Motion Capture

Real-time Hand

Providing #21 3D landmarks per hand

Automated Calculation

- Joint Angles
- Web Angles
- Deviation Angles

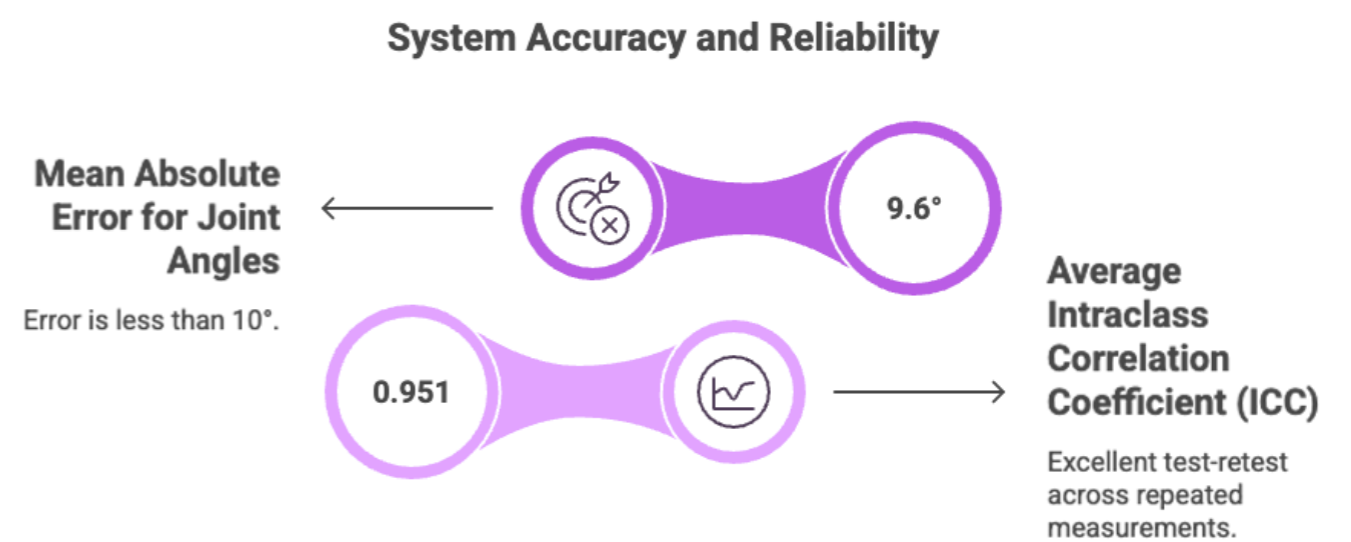
Integrated Analysis UI

Profile Manage

- Review recordings alongside synchronized scrolling plots of joint/web angle statistics.
- SQLite-backed patient/subject database for organized data collection.

RESULTS & DISCUSSION

The system demonstrated strong agreement with researchers using a goniometer. The mean absolute error for joint angles was 9.6°, which is less than 10°. The system also provides 0.951 in average Intraclass Correlation Coefficient (ICC) among all movable finger joints of the robotic hand, which showed excellent test-retest across repeated measurements.



CONCLUSION

The HandCube represents a significant advancement in rehabilitative assessment technology addressing the limitations of subjective manual methods. This innovation has the potential to standardize hand assessment, enable manageable progress tracking, and support data-driven clinical decision-making.

