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A Computerized Motor Function Monitoring System for Patients with Neurodegenerative Diseases

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Extended Abstract

Recent research has found that physical activity is critical for preventing chronic disease and premature death. Evidence shows that physical activity intensity is linearly and inversely related to mortality [1]. Theoretically, initiating treatment as early as possible during this stage could help delay or reduce the risk of progression to Alzheimer's disease or other forms of dementia for patients with mild cognitive impairment (MCI) [2][3]. If changes in motor functions occur in subjects with MCI, these changes could signify the transformation from mild memory problems into Alzheimer's disease. The advancement of computer vision has made it possible to develop remote monitoring systems for objective motor function assessment.

The aim of this study was to develop a computerized measurement system that can directly measure physical fitness and movement accuracy for the assessment of neuromuscular function for the assessment of general physical health. A depth camera (Intel® RealSense™ D435) was used to capture RGB and depth images (90fps) for movement analyses. By importing the RGB image, MediaPipe Framework (Google for Developers) was applied to obtain the XY coordinates of the specified joints in the image. The depth information (the distance from the joint to the lens) could be obtained through the reference from the registered XY coordinates to construct a global 3D coordinate system. By applying coordinate transformation and trigonometric (inverse) functions, the coordinates obtained from RGB and depth images could be mapped into the coordinates in the global system. Real-time movement analysis can be achieved by continuously computing the kinematic data such as the position of specified key points and the angles of joints. For reliability and validity tests, a fixed position of the right hip (60 degrees flexion), knee (45 degrees flexion), and ankle (90 degree in neutral position) joints was repeatedly captured in three camera positions (45 degrees from right, perpendicular, and 45 degrees from left). Sixty frames were captured in every camera position. One-way ANOVA was used to compare the means in different positions and found no significant difference across the three camera angles ($p=.65$, .56, and .87 in hip, knee, and ankle respectively). Compared with the real angles, all frames showed valid measures with a difference of less than 5% from the true angles (3.4% to 4.5%). This study concluded that by using a depth camera, the three-dimensional coordinates of specified joints can be located. The real-time location of joint angles can be utilized for kinematic analysis of the upper limbs, trunk, pelvis, and lower limbs, including overall functional performance, variability analysis, and symmetry analysis. Functional performance is measured by movement speed. Variability analysis is mainly about the variability of the same limb in different movement cycles. Symmetry is about the consistency between the left and right limbs.

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