Continuous neurodegenerative care through a computer vision home-based rehab tool

Author
Alba Barnés, Jessica Ortiz, Alejandro Izquierdo, Rubén Campuzano, Germán Gallego – AiMA Empathic AI

Citation
Barnés, A., Ortiz, J., Izquierdo, A., Campuzano, R., Gallego, G. Continuous neurodegenerative care through a computer vision home-based rehab tool.

Introduction

Non-communicable diseases are the leading cause of global mortality, accounting for approximately 71% of deaths worldwide [1]. Within this broader context, neurological disorders, including stroke, are emerging as a significant public health challenge [2].

By 2050, it is projected that there will be 21.43 million incident stroke cases and overall, 224.86 million disability-adjusted life years attributable to stroke globally. As a consequence, the number of individuals living with post-stroke impairments will increase rapidly, leading to persistent functional limitations, reduced quality of life, and a growing burden on caregivers. These conditions require ongoing management, with exercise and rehabilitation playing essential roles across three stages of prevention: primary (risk reduction), secondary (disease modification), and tertiary (symptom management).

As healthcare systems already face significant pressure to provide sustained care, the increasing demand for rehabilitation services and tertiary

prevention further exacerbates this burden. This growing demand highlights a misalignment between continuous disease progression and intermittent clinical evaluations. As a result, the delivery of timely, data-driven, and individualized care is hindered. Furthermore, access to rehabilitation services is often limited by structural barriers, such as shortages of specialized professionals and restricted clinical services, particularly in isolated areas.

Addressing this gap raises key questions: Can home-based systems provide continuous monitoring of functional performance? Can biomechanical metrics derived from markerless motion capture reliably detect changes in functional performance over time in home-based settings? Additionally, can continuous monitoring enable earlier therapeutic adjustments and more proactive care? Could it improve outcomes while reducing clinical and socioeconomic burdens?

Methods

This study focuses on upper-limb rehabilitation in chronic post-stroke patients, using stroke as a model for secondary neurodegeneration. Exercises are based on the Fugl-Meyer Assessment for Upper Extremity, targeting movements such as joint flexion, extension, and hand-to-face actions [5]. Thereby, evaluating motor domains, including range of motion, coordination, and control.

Exercise selection is limited by tracking reliability, excluding movements with inconsistent landmark detection. Table 1 (participant characteristics) is not included, as the clinical protocol will begin in May 2026 pending ethical approval. Patient eligibility, however, will consider mobility, paralysis, and cognitive status.

A standard RGB camera is used for markerless motion capture, enabling the collection of objective kinematic data without wearable sensors. The system estimates full-body and hand key points in real time using MediaPipe [3], [4] while reconstructing the user's pose and computing biomechanical metrics such as joint angles, position, and alignment. It currently monitors exercise performance alongside self-reported pain.

The platform is web-based, built with Vue.js for the frontend and Node.js for the backend, and is accessible on any device with a camera. Data is stored and processed in Google BigQuery, supporting large-scale and longitudinal analysis.

Exercise performance is evaluated using a rule-based validation system in which each repetition is assessed against predefined spatial and angular conditions between anatomical landmarks (e.g., close/far, left/right, above/below). These rules adapt to each exercise and body segment, allowing classification of movements as correct or incorrect. Importantly, incorrect repetitions are categorized (e.g., insufficient range of motion), providing detailed feedback on performance.

To support adherence, the system provides real-time feedback and tracks engagement metrics such as session completion, repetitions, and execution time. Clinicians receive periodic summaries (daily or weekly), enabling remote monitoring and data-driven therapy adjustments.

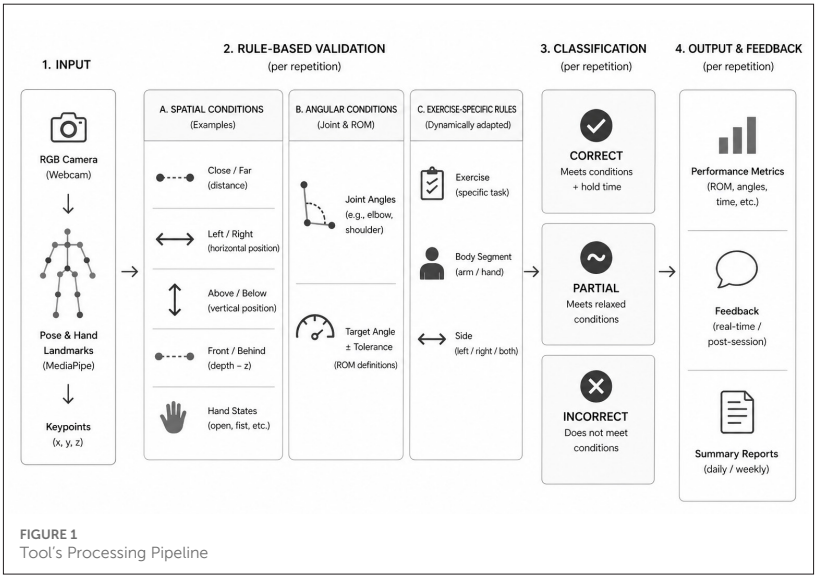

FIGURE 1
Tool's Processing Pipeline

Preliminary Results

At the time of writing, formal clinical outcomes are not available, as the study is currently awaiting the hospital's ethics committee approval. Therefore, this section reports preliminary findings based on in-house evaluations conducted with 10 participants outside the target clinical population, including healthy individuals and users with unrelated conditions.

It is observed that the system enables time-efficient and scalable home-based rehabilitation, with session duration emerging as a key indicator of usability and adaptation. Initial sessions were longer and more variable (overall mean of 21.4 minutes), reflecting onboarding processes such as system familiarization and setup. In contrast, repeated sessions stabilized between 10 and 15 minutes, indicating rapid user adaptation and reduced cognitive and operational demands.

Usability, assessed using the System Usability Scale (SUS), yielded a mean score of 40.25/50 (80.5/100), indicating good overall usability and strong learnability. Participants reported high confidence, low perceived complexity, and minimal need for technical support, with many expressing willingness to use the system regularly. However, variability in responses and qualitative feedback highlighted limitations, particularly in motion tracking accuracy, especially for hand movements, as well as environmental and device-related constraints. Overall, these findings support the system's feasibility while identifying key areas for improvement prior to clinical validation.

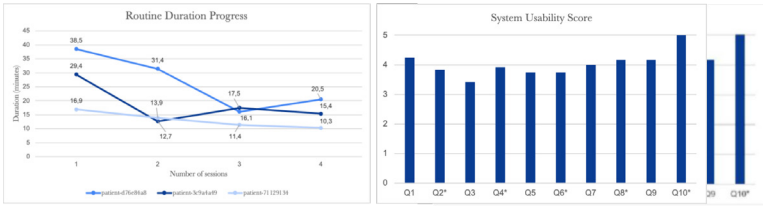

FIGURE 2
Routine Progression of 3 Users and Overall System Usability Results

Preliminary Conclusion

Preliminary internal findings indicate that the proposed system is feasible for home-based rehabilitation and monitoring of functional performance. The reduction in session duration and a SUS score of 80.5/100 suggest it is user-friendly and can support sustained engagement in non-clinical settings. Moreover, the system can generate objective, longitudinal biomechanical data, offering a deeper understanding of motor performance compared to traditional assessments, potentially facilitating earlier identification of functional changes.

Despite these promising results, current findings must be interpreted with caution. Evaluations were conducted in a non-target population, and key limitations, particularly in motion tracking accuracy (notably for hand movements), environmental constraints, and device variability, may affect reliability in real-world conditions. These factors highlight the need for further technical refinement and validation.

While impacts on outcomes and costs remain to be confirmed, the system shows potential to reduce clinical and socioeconomic burdens, particularly within OECD healthcare models focused on prevention and data-driven care [6]. Building on these initial findings, additional pilots are underway in Spain, expanding the evaluation to adults over 65 to validate implementation strategies and assess the tool's scalability within the target population.

References

[1] "NCDs at a Glance 2025 NCDs surveillance and monitoring: Noncommunicable disease mortality and risk factor prevalence in the Americas," Washington, D.C., 2025.

[2] V. L. Feigin *et al.*, "Global, regional, and national burden of neurological disorders, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016," *Lancet Neurol.*, vol. 18, no. 5, pp. 459–480, May 2019, doi: 10.1016/S1474-4422(18)30499-X.

[3] V. Bazarevsky, I. Grishchenko, K. Raveendran, T. Zhu, F. Zhang, and M. Grundmann, "BlazePose: On-device Real-time Body Pose tracking," Jun. 2020, [Online]. Available: http://arxiv.org/abs/2006.10204

[4] F. Zhang *et al.*, "MediaPipe Hands: On-device Real-time Hand Tracking," Jun. 2020, [Online]. Available: http://arxiv.org/abs/2006.10214

[5] L. Jaasko, I. Leyman, S. Olsson, and S. Steglind, "FUGL-MEYER ASSESSMENT UPPER EXTREMITY (FMA-UE). Assessment of sensorimotor function."

[6] *Health at a Glance 2025*. in Health at a Glance. OECD Publishing, 2025. doi: 10.1787/8f9e3f98-en.