Recover-on-Track: A LiDAR and Video-based Tool for Stroke Telerehabilitation

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***Abstract*—With the rapid expansion of the elderly population and an ongoing increase in life expectancy, innovative strategies for managing geriatric conditions such as stroke have become indispensable. Here, we introduce 'Recover-on-Track', a telerehabilitation platform that leverages LiDAR sensors and human pose estimation (HPE) algorithms to provide detailed insights into home-based exercises of stroke patients. We integrated 2D HPE with LiDAR depth data to track motion, achieving results comparable to those of existing wearables-based systems. The preliminary analysis shows promising potential to distinguish between impairment levels. Recover-on-Track lays the groundwork for future exploration in telemedicine research, offering potential avenues for personalizing and enhancing stroke rehabilitation.**

I. Introduction

With projections indicating a threefold increase in the elderly population in the next thirty years, the healthcare system is confronted with escalating demands, particularly attributed to geriatric conditions like stroke [1], [2]. Current rehabilitation modalities are constrained by factors such as exorbitant costs, insurance constraints, and limited clinician time. This combination of challenges reduces consistency and adherence to long-term therapeutic regimens. Against this backdrop, the emergent domain of telerehabilitation becomes a promising avenue. Herein, we introduce 'Recover-on-Track', a telerehabilitation platform tailored for stroke patients. By fusing 2D HPE and LiDAR data, this tool introduces a markerless mechanism for monitoring in-home exercises using tablets. It aims to facilitate automated assessment of impairment levels and progress, allowing clinicians to create individualized and effective rehabilitation programs.

II. Material and Method

Fig. 1 illustrates the workflow. Video recordings and LiDAR data were concurrently collected using an iPad Pro (Apple Inc., Cupertino, CA), while accelerometer and gyroscope validation data were obtained through 11 wearable sensors (MVN Awinda, Movella Inc., Henderson, NV). Gathering data from stroke patients is resource-intensive due to ethical considerations, regulatory compliance, and variability in impairment levels. To establish a foundation for robust system development and testing, we gathered data from two research clinicians who performed standard exercises simulating mild to moderate impairment levels using the Fugl-Meyer Assessment (FMA), with scores ranging from 29-66. Utilizing MediaPipe Pose, we employed the upper limb of BlazePose's landmark topology to extract 2D joint coordinates [3]. The third coordinate was inferred from the depth map. Data features, designed in collaboration with therapists, are derived from the 3D trajectories; they capture movement characteristics, such as velocity, smoothness, affected shoulder displacement, and elbow flexion angle.

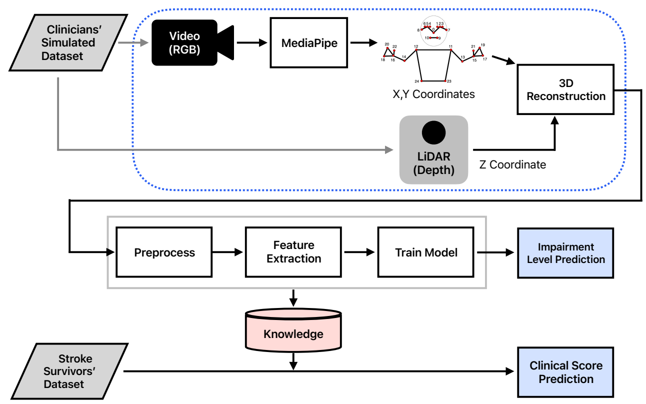

Fig. 1. Recover-on-Track Workflow

III. Result and Discussion

Our initial dataset validates our motion-tracking and analysis pipeline. Our proposed system achieves 3D tracking accuracy comparable to that of wearable-based systems. Moreover, the preliminary analysis and projection of the extracted data features suggest their efficacy in effectively discerning between different levels of impairment. Future developments involve gathering a comprehensive simulated dataset from clinicians to train deep learning models for predicting impairment levels. Employing transfer learning techniques, we intend to integrate these models with data from stroke survivors, to achieve accurate predictions of clinical scores like the FMA.

References

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