Politecnico di Torino

COMPUTER AND CONTROL ENGINEERING

Assessment Tasks and Virtual Exergames for Rehabilitation and Remote Monitoring of Parkinson's Disease

Funded By	Dipartimento DAUIN
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Context of the research activity	Motor impairments are among the most disabling symptoms of Parkinson's disease that adversely affect quality of life, resulting in limited autonomy, independence, and safety. Recent studies have demonstrated the benefits of physiotherapy and rehabilitation programs specifically targeted to the needs of Parkinsonian patients in supporting drug treatments and improving motor control and coordination and motor-cognitive integration. However, due to the expected increase in patients in the coming years, traditional rehabilitation pathways in healthcare facilities could become unsustainable. New strategies are needed, in which technologies play a key role in enabling more frequent, comprehensive, and out-of-hospital follow-up.
	This proposal regards a vision-based solution using instrumentation such as the Azure Kinect DK sensor to implement an integrated approach for remote assessment, monitoring, and rehabilitation of Parkinsonian patients. This will exploit non-invasive 3D tracking of body movements to objectively and automatically characterize both standard evaluative motor tasks and virtual exergames. The final objective is to develop a system that can be used by the patients at home, and that provides both individually tailored rehabilitation exercises, and data to monitor the disease evolution. The main innovation relies in the integration of evaluative and rehabilitative aspects, which will be used as a closed loop to design new protocols for remote management of patients tailored to their actual conditions. In this context, the candidate activity will address: - Body tracking techniques based on non-invasive single and multi-camera systems (2D and 3D RGB-Depth cameras), possibly combined with wearable inertial measurement units. - Kinematic analysis of the body movements of neurological subjects performing clinical tests and rehabilitation exercises. - Feature selection algorithms to evaluate the disease progression via proper clinical assessments scales - Ai algorithms for motion analysis and body tracking based on multidimensional data streams.

Objectives	- Adaptive exergame implementation. The system will be experimented by patients with the cooperation of the CNR-IEIIT, the “Dipartimento di Neuroscienze Rita Levi Montalcini”(DNLM) , Università di Torino, and the “Ospedale Auxologico Italiano”, Piancavallo (VB). DAUIN and DNLM are both involved in the PNRR Initiative “Ecosistema NODES – Nord Ovest Digitale e Sostenibile”, and the proposal will benefit of this cooperation. ACTIVITIES: YEAR 1. Task 0: analysis of the state of the art on PD rehabilitation needs and strategies. Definition of the rehabilitation protocol set-up. Arrangement of the tasks to be administered to the patients (in strict cooperation with the clinical staff). Definition of data to be collected during rehabilitation tasks and their usage to implement patients’ follow-up. Task 1: preliminary implementation of exergames in virtual reality both for training and as a support for motor condition assessment. Task 2: Experimental tests (with proper approval of ethics committee) involving a limited number of parkinsonian subjects and healthy controls, in hospital. Preliminary results on the system’s ability to quantify specific and statistically significant features of motor performance and monitor changes as the disease progresses over time. The patients will be selected and invited by the clinical staff, based on proper inclusion and exclusion criteria. This task will be continued in successive years. YEAR 2. Task 3: Refinement of exergames involving more rehabilitation tasks. Implementation of AI algorithms that enable adaptive modification of the exergame, depending on the patient’s physical and mental status. Task 4: Implementation, validation and testing of rehabilitation efficacy and disease progression markers on a larger number of patients (in hospital and/or outpatient structures). YEAR 3. Task 5: Final refinement of the rehabilitation and monitoring tool and its testing at home on a subset of patients. Validation and testing. Analysis of patients’ acceptance via proper questionnaires. Task 6: critical analysis of the results, proposal of integration of the algorithms with heterogeneous data present in the patient’s clinical records. N.B: Due to the complexity and novelty of this topic, the Task description is forcedly preliminary and may be subject to modifications depending on the obtained early results. We plan to have at least two journal papers published per year. Target journals: IEEE Transactions on Biomedical Engineering IEEE Journal on Biomedical and Health Informatics IEEE Access IEEE Jour

Skills and competencies	Preferred skills: - Expertise in the fields of Motion Analysis and Biomechanics, motion capture systems, Signal Processing, Image and Video Analysis, Statistics and Machine Learning (e.g. feature selection and ranking, supervised and unsupervised learning)

competencies for the development of the activity	- Good knowledge of C, Python, Matlab, Simulink programming languages; - Experience in the use of commercial RGB-Depth cameras (e.g., Azure Kinect, Intel RealSense, Orbbec) and their specific firmware - Good relational abilities and knowledge of the Italian language, to effectively manage interactions with patients during the evaluation campaigns - Knowledge of neurological evaluation scales (e.g., UPDRS, MESUPES and Berg Balance Scale)