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Robot-Based Strategy for Objective Assessment of Motor Impairments

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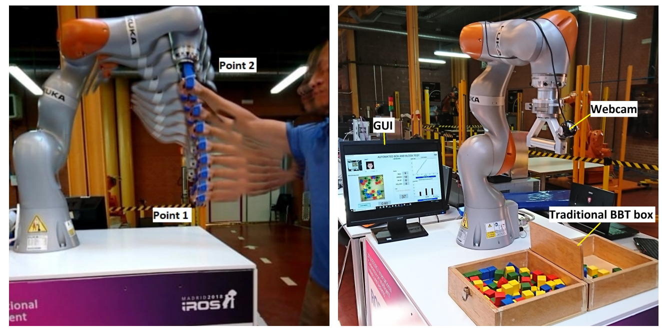
***Abstract*— Assessment of motor impairments is manually performed by clinicians based on traditional clinical scales. This manual process may be affected by the observer's subjectivity. This paper suggests a robot-based framework for the objective assessment of upper extremity (UE) motor functionality.**

I. INTRODUCTION

Currently, the assessment of physical functionality is performed by clinicians using standardised tests towards an objective evaluation. Since the process is manually performed, the evaluation may include some degree of uncertainty (subjectivity) that may come from movement variability, appreciation (inter-operator), etc. [1]. Most of the evaluation tests are composed of well-defined exercises (or procedures) based on numerical scales, which may be susceptible to be automated. This paper presents the ongoing research towards developing a collaborative robot-based platform for the assessment of UE motor impairments, such as spasticity or manual dexterity. As a design reference, standard outcome measures like the Modified Ashworth Scale (MAS) and the Box and Blocks Test (BBT) were considered. Fig. 1 depicts the robot configurations for assessment.



(a) Spasticity (MAS-based) (b) Manual dexterity (BBT-based)

Fig. 1: Robot configurations for motor function assessment

II. MATERIAL AND METHODS

A. Spasticity Assessment

Assessment of spasticity is strongly linked to the clinician's expertise, and thereby, it is affected by inter-operator variability. The strategy presented in this work aims to measure the muscle rigidity by performing limb mobilisation [2]. Robot-aided mobilisation (see Fig. 1-a) is performed in two stages: (1) learning and (2) execution. The learning phase is performed by the therapist showing to the robot the proper path. In the execution phase, the robot replicates with the patient the learned trajectories for evaluating. The force measurements from the robot sensors provide an objective metric related to muscle motion constraints. As a result, the degree of spasticity is given in terms of the MAS.

B. Eye-in-hand Strategy for Manual Dexterity Assessment

Mechanics of the BBT is to transport as many cubes, one at a time, from one compartment to the other in one minute. The therapist must manually count the number of transported cubes when the time is over. Thus, the evaluation is based on visual inspection, which can significantly affect its reliability. An alternative strategy is to employ the robot as a supervisor during the test performing. A webcam fixed on the robot tip is utilised to detect the cubes displacement. When evaluating, the robot automatically reach a standby configuration (see Fig. 1-b) and look for the box. A CIELab-based algorithm was implemented to automatically count the number of cubes [3]. A graphical user interface (GUI) provides the instructions and record results. An additional advantage of this robot-aided procedure is the possibility of limb mobilisation with the same setup.

III. RESULTS AND DISCUSSION

In this research stage, the implementation of robot programming by guidance and trajectory replication is successfully completed. Besides, it is shown the viability of using out-of-shelf devices like a webcam to extend the application of this framework to other tests, such as the BBT. Regarding traditional clinical practice, automated systems may reduce healthcare burden (time and resources) and enhance the management of electronic health record (EHR). More importantly, robot-based methods can provide the clinicians with objective, customisable and reliable tools for diagnoses. This ongoing research aims to combine, in the same paradigm, the clinical knowledge of standard clinical tests with the biomechanical capabilities of robotic systems.

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