Proprioceptive Neuromuscular Facilitation Exercises of Upper Extremities Assessment using Microsoft Kinect Sensor and Color Marker in a Virtual Reality Environment

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Abstract**—** Proprioceptive Neuromuscular Facilitation Exercises are a series of stretching techniques that are commonly used in rehabilitation and exercise therapy. Assessment of these exercises for true maneuvering requires extensive experience in this field and could not be down with patients themselves. In this paper, we developed software that uses Microsoft Kinect sensor, a spherical color marker, and real-time image processing methods to evaluate patient's performance in generating true patterns of movements. The software also provides the patient with a visual feedback by showing his/her avatar in a Virtual Reality environment along with the correct path of moving hand, wrist and marker. Primary results during PNF exercise therapy of a patient in a room environment shows the ability of the system to identify any deviation of maneuvering path and direction of the hand from the one that has been performed by an expert physician.

Keywords**—** Image processing, Microsoft Kinect, Proprioceptive neuromuscular facilitation, Upper extremities assessment, Virtual reality

I. INTRODUCTION

Exercise therapy is one of the most important, and highly effective component of a rehabilitation program in patients with joints pain and limited mobility [1]. Among the exercises, Proprioceptive Neuromuscular Facilitation (PNF) can be noted, a treatment prescribed frequently for orthopedic disorders. It is safe and time efficient, but more importantly, it can provide the patient with relatively quick gains in range of motion and motivate them to continue with the rehabilitation program [2]. Although in this type of exercise, the movements should be done with a specific pattern, with numerous joints and muscles involved in shaping it, the assessment of patient's progress and judgment about proper performing movement is done only through observation by the therapist, which can be too subjective [3]. Besides, most of the patients are not capable of self-assessing their performance; hence, they have to exercise under the supervision of a therapist. This will result in a less-sustained therapy procedure, as the rehabilitation process is limited to the time that the patient spends at the clinic. Therefore, it seems that an automated system for evaluating such movements, not only can be more accurate, but also will provide the patient with the necessary feedback while performing the PNF exercises. Image processing might be the first thing that comes in mind. But 2D images do not suffice in measuring such movements: PNF exercises of the Upper Extremities should be done diagonally in the space and therefore *depth* changes in the moving segments of the image are important, yet they are not detectable. One device that has been considered in recent years for such purposes in the rehabilitation engineering field is the Microsoft Kinect Sensor (Microsoft® corporation, WA, USA). This inexpensive, relatively accurate depth sensing device is supplemented by a Software Development Kit that can provide programmers with 30 frames per second data on the 3D position of 20 joints for each of the two persons that stand in front of it.

A number of studies have used the Kinect s quantifying the physical postures in various sett during different activities such as exercising, walk running [4]-[10]. Kim et al. used it for evaluat performance of subjects in PNF. They implemen machine learning algorithm and trained it with position data from eight normal students, ea performed the PNF stretching 30 times, to cr that is capable of detecting the correctnes executed by a subject. They deemed the posit adequate for this purpose [10]; however, forearm around its longitudinal axis, measureable using these positions, is an imp PNF exercises.

In this research, with emphasis on all th correct PNF exercise, including rotation of combine real-time marker detection with the d capability of Kinects and its ability to recogn posture to develop a prototype software that can a user's ability in performing PNF

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