IT-REHAB – Integral Telerehabilitation System

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***Abstract*—The main functionalities of the physical rehabilitation module of IT-REHAB are briefly described in this paper. IT-REHAB is a telerehabilitation system under development for patients with physical or cognitive rehabilitation needs. It supports wireless biomechanical and physiological data collection and includes advanced functionalities based on a custom-designed Medium Access (MAC) protocol for improved bandwidth utilization and an immersive user interface that incorporates virtual reality elements for a motivating experience. Moreover, it includes affective computing technologies for pain intensity estimation, wearables for easy sensor devices setting up, and real-time communication between patients and therapists.**

***Keywords*—telerehabilitation; eHealth; assistive technology.**

I. INTRODUCTION

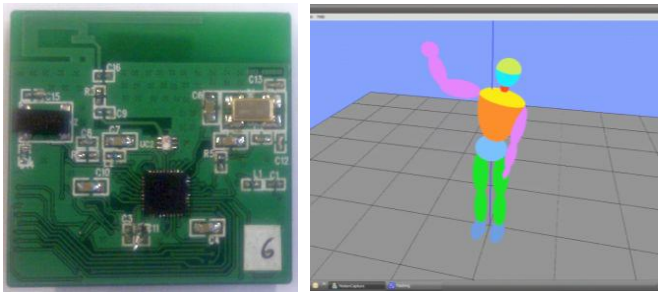
Degenerative joint diseases are among the most common diseases in elderly patients, affecting mainly those joints subjected to weight bearing as knees and hips. Osteoarthritis is the leading cause of intervention. Specifically, knee arthroplasties are among the most common orthopedic surgical procedures in Spain [1]. Actually, in recent years, around 50,000 primary and revision hip and knee arthroplasties were annually performed by the Spanish National Health System [2].

Patients submitted to orthopaedic surgeries frequently need a large number of physiotherapy sessions. Providing for these needs leads to significant psychological and financial burden on the patients, their families and the health care system.

IT-REHAB is a telerehabilitation system which is being developed to support patients with physical and cognitive rehabilitation needs. This paper describes the main functionalities of the physical rehabilitation module of IT-REHAB, which allows patients to conduct physiotherapy exercises under remote supervision of their therapists. While a patient exercises, the system continuously measures the extension of the movement of the monitored body structures. Moreover, it will be able to monitor physiological parameters and to estimate pain sensation through video image analysis.

II. THE IT-REHAB SYSTEM

IT-REHAB includes physical and cognitive rehabilitation modules. The physical rehabilitation module is based on the motion capture system developed by Afonso el al. [3]. This system is based on kinetic sensors that capture the 3D orientation of any segment of the body and transmit it, in real-time, to a base station. The system achieves accuracy better than 2.5°. Figure 1 shows (a) a wireless orientation capture board and (b) the prototype user interface developed for testing purposes. The cognitive rehabilitation module will follow the development of the physical rehabilitation module.



(a) (b)

Figure 1. Orientation capture board (a) and prototype user interface (b).

Besides supporting remote rehabilitation, the system allows therapists to supervise the performance of several patients on joint physiotherapy sessions. The possibility of patient interaction may prove stimulating for those recovering from interventions and also for chronic patients, such as those with chronic pulmonary obstructive disease (CPOD). However, as orientation capture devices generate a large amount of wireless traffic, it is necessary to guarantee

minimum bandwidth requirements to assure that data packets are not lost.

The IEEE 802.15.4 protocol, a widespread wireless communication standard for low-rate, low-power consumption Wireless Personal Area Networks (LR-WPANs), already provides a reservation-based data transfer scheme named Guaranteed Time Slot (GTS). However, the GTS scheme presents some drawbacks, such as inefficient bandwidth utilization and support to a maximum of only seven sensor devices.

The eLPRT (enhanced Low Power Real Time) protocol [4] implemented on the orientation capture boards provides a new reservation-based MAC (Medium Access Control) protocol that introduces several performance enhancing features in comparison to the GTS scheme. Namely, it includes various mechanisms designed to enhance data transmission reliability against channel errors, improve bandwidth utilization and increase the number of supported sensor devices. In the current implementation, up to forty nine sensor devices can simultaneously operate.

The patient interface under development will include virtual reality elements, which provides an immersive, interactive and motivating experience to patients. Moreover, the system will allow therapists to select exercises and control practice intensity and feedback to create personalized treatments. It is expected that these advanced features will positively contribute to improve user compliance and treatment results, as the outcomes from the research conducted by Merians et al. [5] suggest.

Additional features to be implemented include physiological data monitoring, such as heart rate and oxygen saturation (SpO_2), and a novel mechanism to estimate pain intensity from facial expressions obtained from video images captured during therapy sessions [6, 7, 8]. This last feature is being developed by the Multimodal Information Area of Gradiant, which has relevant knowledge in human sensing, face analysis and affective computing [9, 10, 11].

IT-REHAB will additionally include wearable pieces that will allow easy motion capture devices setting up. Finally, it will support data transfer and storage for adequate patient follow up and evaluation.

III. Related Work

Most projects [12, 13] and recently launched systems, such as [14], aim solely at the home environment and require individual positioning of several orientation capture devices. IT-REHAB overcomes these limitations by providing an environment where multiple patients can be supervised in joint rehabilitation sessions. Moreover, the use of wearable pieces will contribute to facilitate positioning motion capture devices on body segments. In addition, IT-REHAB will enable estimating pain intensity based on video analysis and real-time monitoring of some physiological parameters.

IV. Conclusion and Future Work

IT-REHAB will lead to convenient care of patients who need rehabilitation for long periods. It includes innovative technologies and advanced functionalities that open new possibilities for patients, therapists and health care systems in general.

Future work includes the development of the patient interface and the algorithms for pain intensity estimation as well as the assessment of the acceptance and the performance of the system in real scenarios. Related projects include the development of a system to enable COPD patients exercise at home. It uses the Kinect, from Microsoft, or a similar user interface for image capture, and includes a software module that evaluates the similarity of a patient gesture with a gesture template.

V. References

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