

# IoT for Healthcare: Smart Physiotherapy

Octavian Postolache

*Instituto de Telecomunicações, IT-IUL, Lisboa, Portugal*  
*ISCTE – Instituto Universitário de Lisboa, Lisboa, Portugal*  
*Email: opostolache@lx.it.pt*

**Abstract – IoT and Cloud Computing are very promissory technologies regarding patient monitoring and information management especially for particular case of physical rehabilitation. In this context, the presentation includes a short description of the existing IoT technologies and me and my group in the field of IoT for healthcare particularly related to the design and implementation of smart objects and environments for physical rehabilitation and performed signal processing focussed to extract metrics that can be used to characterize the physiotherapy process.**

**Keywords – IoT; smart sensors; smart environments; RFID; WSN; smart walker; natural user interface, serious game.**

## I. INTRODUCTION

Nowadays, Internet of Things (IoT) can be considered an important technological revolution related to smart city, smart home, smart factories and smart ports implementations. The design and implementation of smart sensors and the integration on the level of healthcare systems become a reality, different implementations are reported in the field of cardiac and respiration assessment in unobtrusive way but also in the field of physical rehabilitation. According with the level of the user motor impairments smart objects such as smart wheelchair [1] [2] are considered for people with important motor limitation, or smart walker [3] or crutches [4] that are considered as walking aids during the gait rehabilitation period. The personalized of physical rehabilitation environments for user needs may be expressed by integration of smart objects in real scenario but also the appropriate design of virtual environments that support different natural user interfaces as Kinect sensor are considered for the modern physiotherapy that increase user motivation providing high level of physical rehabilitation sessions effectiveness through specific serious games [5][6].

## II. IOT ENABLED PHYSIOTHERAPY

The presentation will focus on IoT enabled physiotherapy equipment and appropriate embedded and high level software associated with the acquisition of

relevant data from the patients under rehabilitation process based on the interaction between the patients with real objects and virtual objects. The IoT data flow can help the physiotherapist to perform objective evaluation of patient progress, and later to perform right choice of rehabilitation training plan that may improve the patient rehabilitation outcomes.

Several solutions materialized by tailored environments for virtual and augmented reality serious games including smart equipment [7] and natural user interfaces that are used to extract information about patient balance [6] and movements' characteristics are discussed. Special attention will be granted during presentation to serious games that are using the Leap Motion Controller and Kinect Sensor as natural user interface. A set of serious games designed to provide physical rehabilitation support for the patients that suffered stroke events or for the children with cerebral palsy will be presented including elements of objective evaluation of the rehabilitation process [8][9]. Wearable inertial measurement units are used for validation of measured angles and velocities of the used natural user interfaces used on the virtual reality serious games [10] and used to characterize the lower limb and upper limbs movement. The possibility to integrate the information provided by daily used smart physical rehabilitation equipment, such as smart walkers and crutches, wearable muscle activity monitors, force platform, wearable accelerometers will be discussed. Signal processing techniques applied for motor activity signals [11] but also advanced data analysis specific for IoT technology will be presented.

## III. CONCLUSIONS

The smart equipment for physical rehabilitation with Internet connectivity as part of real and virtual scenarios may contribute to improve the quality of service in this field, increasing the motivation of the patients, decreasing the rehabilitation period, stimulating also the collaboration between physiotherapists. The data provided by smart equipment and smart environments associated with the physiotherapy sessions, are processed and stored on the cloud side, that can be accessed by the physiotherapists through web page or mobile APPs, in order to visualize session reports and to contribute for the

optimal choice of the physical rehabilitation plan for the best physical rehabilitation outcome.

#### IV. ACKNOWLEDGMENT

The work was supported by Instituto de Telecomunicações and Fundação para a Ciência e Tecnologia, projects PTDC/DTPDES/1661/2012 and PTDC/DTP-DES/6776/2014. Special thanks goes to all the members of the TailorPhy project.

#### REFERENCES

- [1] O. Postolache, P.M. Girão, J M Joaquim, E.C. Pinheiro, G. Postolache, Physiological Parameters Measurement Based on Wheelchair Embedded Sensors and Advanced Signal Processing, *IEEE Trans. on Instrumentation and Measurement*, Vol. 59, No. 10, pp. 2564 - 2574, October, 2010,
- [2] E.C. Pinheiro, O. Postolache, P.M. Girão, “Empirical Mode Decomposition and Principal Component Analysis implementation in processing non-invasive cardiovascular signals”, *Measurement*, Vol. 45, No. 2, pp. 175 - 181, February, 2012,
- [3] J. M. Dias Pereira, Vítor Viegas, Octavian Postolache, Pedro Silva Girão, “Combining Distance and Force Measurements to Monitor the Usage of Walker Assistive Devices”, *IEEE International Instrumentation and Measurement Technology Conference (I2MTC)*, Torino, Italy, May 2017.
- [4] E.Sardini, M. Serpelloni, M. Lancini, “Wireless Instrumented Crutches for Force and Movement Measurements for Gait Monitoring”, *IEEE Transactions on Instrumentation and Measurement*, Vol. 64, No. 12, pp. 3369-3379, Dec. 2015.
- [5] L. de Vito, O. Postolache, SR Rapuano, Measurements and Sensors for Motion Tracking in Motor Rehabilitation, *IEEE Instrumentation and Measurement Magazine*, Vol. 1, No. 6, pp. 30 - 38, June, 2014,
- [6] O. Postolache, P.M. Girão, J. M. Dias Pereira, G. Postolache, Postural Balance Analysis using Force Platform for K-Theragame users, *IEEE International Symp. on Medical Measurements and Applications - MeMeA*, Benevento, Italy, Vol. 1, pp. 1 - 6, May, 2016.
- [7] P.M. Girão, O. Postolache, G. Postolache, J. M. Dias Pereira, Unobtrusive Solutions for Health Monitoring and Physiotherapy, *Medições e Ensaios*, Vol. 1, No. 12, pp. 4 - 14, January, 2016.
- [8] O. Postolache, Instrumented Equipment and Mobile APPs for Objective Evaluation of Physical Therap, *International Conf. of the IEEE Engineering in Medicine and Biology Society - EMBC*, Milan, Italy, Vol. 1, pp. 1 - 1, July, 2015
- [9] R. Madeira, O. Postolache, just Physio kidding - NUI and Gamification based Therapeutic Intervention for Children with Special Needs, *International Symposium on Pervasive Computing Paradigms for Mental Health MINDCARE*, Barcelona, Spain, Vol. 1, pp. 1 - 5, November, 2016.
- [10] V.V. Viegas, J. M. Dias Pereira, P.M. Girão, G. Postolache, O. Postolache, Smart Transducer Interfaces Applied to Health Monitoring, *IEEE Instrumentation and Measurement Technology Conf.*, Pisa, Italy, Vol. 1, pp. 1 - 6, May, 2015,
- [11] Majd Alwan et al., “Basic Walker-Assisted Gait Characteristics Derived from Forces and Moments Exerted on the Walker’s Handles: Results on Normal Subjects”, *Medical Engineering and Physics*, No. 29, pp. 380-389, 2007.