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Online Training Module for Patients with Forearm Amputations for Efficient Use of a Myoelectric Prosthesis

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Abstract
The paper presents a telemedicine system with a dedicated module for training of patients with forearm amputation. The telemedicine system has general features for online consultation and a special module for patients with forearm amputation that have to learn to control a myoelectric prosthesis, though the blunt muscles. The training module includes sensors for EMG signals and a feed-back display. The patients exercise under the supervision of a doctor, in order to obtain significant signals and progressively train the muscles of the forearm. The paper presents the components of system and the experiments that proven the efficiency of long distance online assisted training.

Keywords: *telemedicine, prosthetis, online training.*

1. Introduction

The public health domain is and will always remain of high interest for many reasons, including its importance in the social progress, as heath is directly related to the work force. The real situation of the health of population depends highly on the quality of medical services, the efficiency of medical interventions and the number of patients that can be consulted and treated in a specific period of time.

In present days, the medical systems in many countries, including Romania, face critical issues like the lack of resources and the low number of qualified personnel (nurses and doctors). The health systems and the providers of medical services have to offer high quality services, with many clinical benefits, while the founded allocated by the health social services are low, and the costs of the services per patient is continuously growing. In such conditions, alternative solutions for consultations, treatment and for better care services for patients with disabilities (with no significant costs raising) should be conceived as developed as a priority.

High quality services for a larger number of patients and total lower costs are contradictory requirements with no easy solutions. Possible approaches include equipments and techniques with informatics and telecommunications components that may offer higher efficiency in treating the patients, if one doctor or supervisor can take care in similar (good) conditions a larger number of patients. If the doctor can perform some procedures without being permanently in the proximity of the patient, the costs can be lowered not affecting the quality of services. For instance, informatics or telemedicine systems may be successfully used for distance caring of the patients with amputations of superior limbs that are preparing for prosthetics.

2. The telemedicine system - structure and features

This paper presents a telemedicine system that has a special module dedicated to the patients that have amputated superior limbs, for training under direct supervision of a physiotherapist doctor, in order to have artificial hand prosthetics. The basic features of the telemedicine system were presented in previous papers [1]. It has a modular structure and includes an online application for patients registration, a data base for users and an online medical consultation module. The system was further improved with better graphic interface of the consultation module and new software modules for distance supervision and guidance of the patients with superior limbs amputated in order to help them learn to use the exo-prosthesis.

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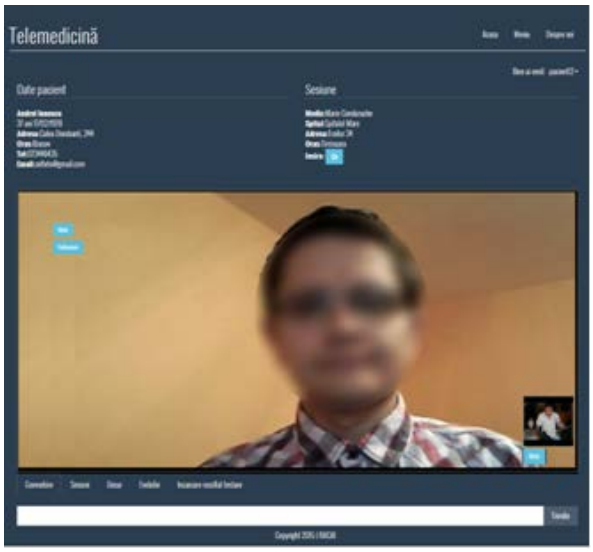

Figure 1. The main window of the telemedicine system

The main window of the telemedicine system (figure 1) includes several functions for doctors and for patients. The online medical consultation takes place in the main window, that has several common features for communication programs, like the simulation display of both images of the person and the interlocutor (the small image in the right lower corner represents the patient), the MUTE option (that spots the microphone). However, the system is not symmetric: the interfaces for the doctor and the patient have different features implemented. The consultation interface has an additional window for the history of the patients: diseases, interventions, treatments, medical recommendations are all stored in this submodule. In the specific case of treatment and training of patients with amputations, all the recommendations are important in order to successfully guide in continuity the patient. The Conversation submenu include a window for text chat, additional to audio-video communication of the patient with the doctor. The submenu Sessions contains the history of previous consultations of the patient. When, displayed, each consultation include following data: a header with S (session number), name of the doctor (date and hour of the consultation) and the conclusions of the doctor, written after the session, with information regarding the general health state of the patient and the physical exercises recommended until the next consultation. After the consultation, the patient can read the doctor's conclusions, in order to follow the instructions and recommendations for training. The submenu File includes all health data of the patients, diagnostics, treatments, medication prescribed by all doctors that consulted the patient etc. and, in addition to the previous submenu, this one contains the complete history of the patient (not just since he/she uses this telemedicine system).

The Submenu Evolution display certain data significant for the health state evolution of the patient. The measurements are done under medical supervision by the patient himself/herself are here displayed in the temporal succession.

In addition to basic features of the Consultation module, there is the possibility to schedule the consultations (including a calendar). As the whole system is used by many doctors and the same terminal can be used by more doctors, the module organizes the time scheduling in order not to appear overlapping - reserving time intervals for the terminal (and the patient) after a consultation is planned. Each doctor can modify the positions that are not previously reserved by the patients. The patients can see the program of the doctor with available vacancies, in order to establish online their own consultation.

3. Online training module

The module for online long-distance training was designed for the patients with amputated superior limbs, in order to help them use a mioelectric prosthesis.

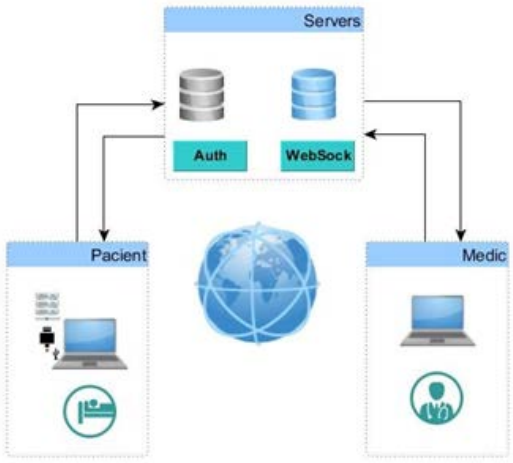

Figure 2. Architecture of the online training module

A forearm prosthesis implies that the patient use the muscles on the blunt in order to comment the

movements of the mobile elements of the prosthesis. The case studies in the domain of forearm amputations showed that the lack of exercise for the corresponding muscles leads to diminishing of the muscular capacity, atrophy or fibrosis. [2] The patient may use an exo-prosthesis only if the EMG signals collected from the forearm muscles are strong enough to be used for command generation. Especially in the cases when the amputation took place several years ago, the EMG signals collected from the blunt's muscles are to weak. Special training is recommended for such patients in order to better control the blunt muscles as intended and needed for the prosthetic commands.

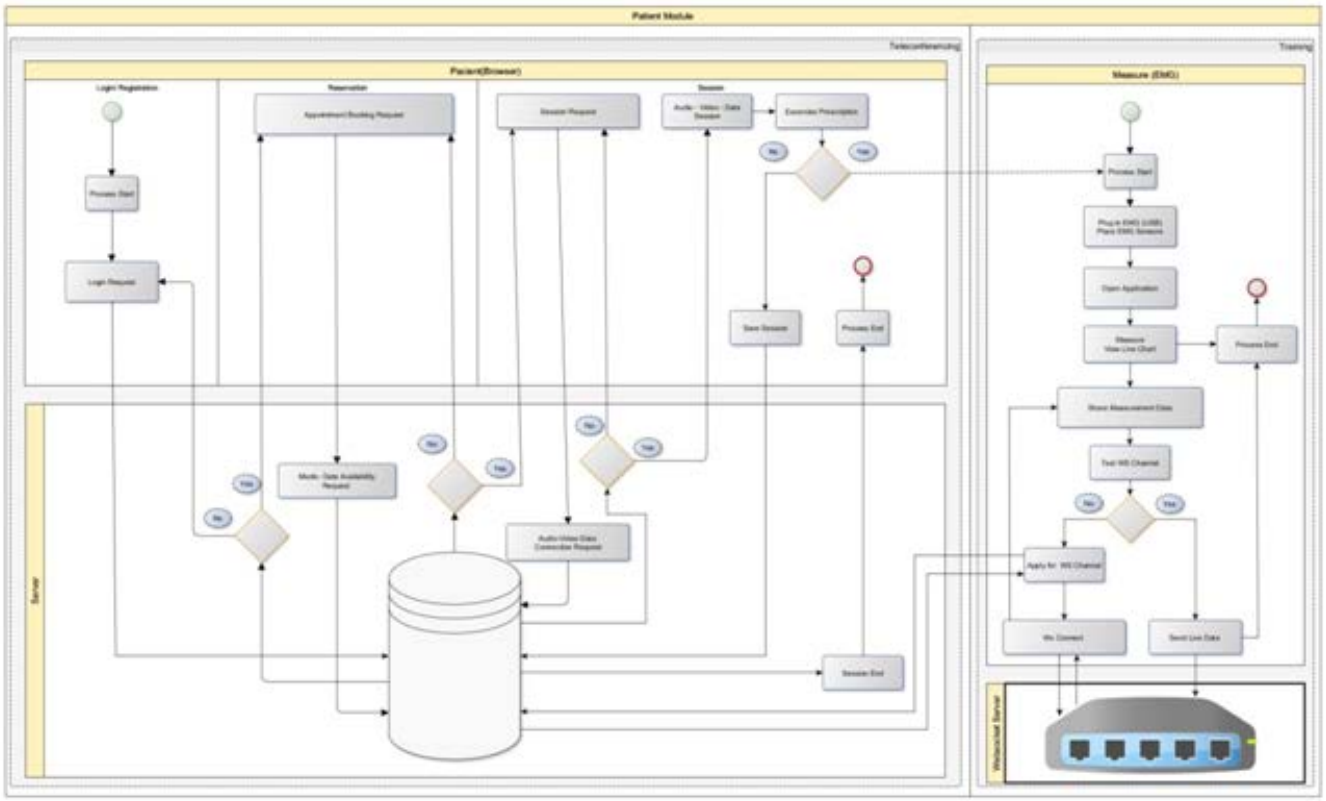

Figure 3. Functional scheme of the patient module and training module

4. Experiments - training sessions with disabled patients

The patients that volunteered for the training experiments had forearm amputation due to accidents that occurred more than a decade ago (or even two decades). Therefore they need systematic training in order to be able to command a myoelectric prosthesis. Figure 4 present the electronic configuration and the devices necessary for the patient (the components in our scheme are EMG electrodes from Biometrics LTD [3] and a data acquisition board from National Instruments USB-6003[4].

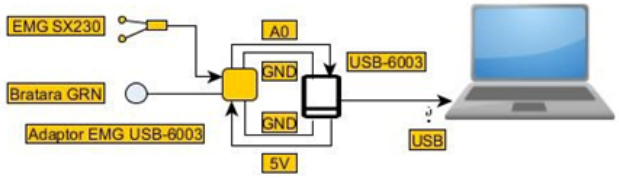

Figure 4. Devices necessary for online training

The patient needs a PC and high capacity internet connection, an EMG electrode and the data acquisition board. Except for the PC, the devices are provided by the system administration after his/hers registration in the telemedicine system. In the first session, the patient has to learn the different features and functions of the telemedicine system - this

introduction is assisted by the technical staff that supports the telemedicine project. After the beginning of effective consultations with a specialist, the patient learns step by step how to use the electrodes (how to apply it correctly on the blunt and how to connect it with the data acquisition board and PC) and to make the EMG measurements (see figure 5 and 6).
The patient learns to use the monitor functions and to correlate the muscular effort with the signals displayed. The intuitive interpretation of the electric signals is useful in the progressive training in order to obtain a more intense response. The doctor, specialist in recovery therapy, recommends specific exercises during online practice and the program of daily personal practice. The doctor sees online the results of the measurements and can give real-time indications for practical performances' improvement.

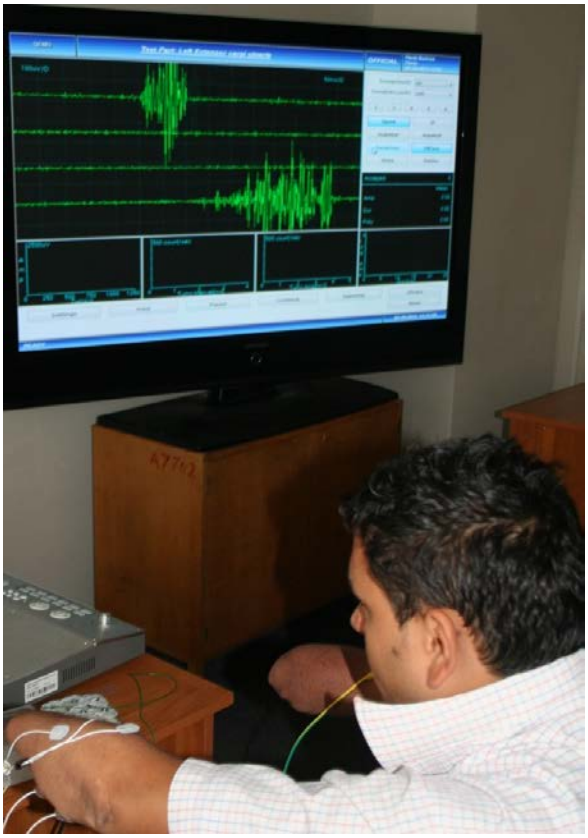

Figure 5. The patient learns, with online assistance, to contract the muscles in order to obtain higher EMG signals

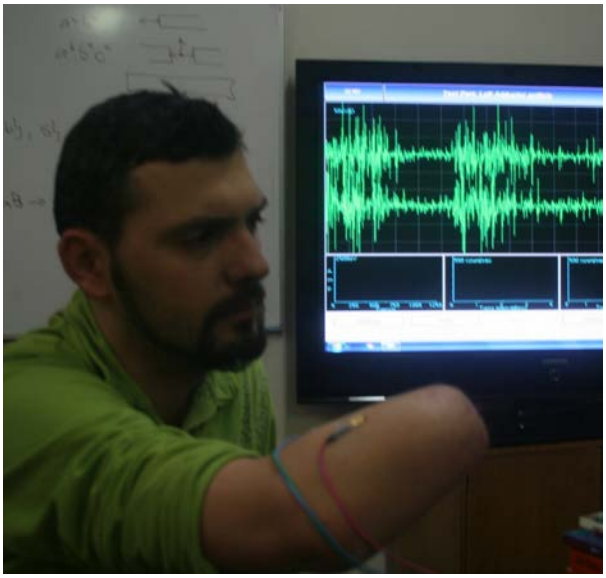

Figure 6. Another patient, after several weeks of progressive supervised training, learned to better control his muscles (see the higher signals on the display)

The practice is progressive for different groups of muscles that will, in the end, permit the control of the exo-prosthesis in order to have different movements of the artificial arm and hand, including the command of the fingers of the prosthesis through the EMG signals. It is a long time process that requires medical supervision - all results are recorded and interpret by the doctor in the online training sessions.
The telemedicine system offers several functions for scheduling of consultations and online sessions, for recording medical data and organizing data and files. The history of the treatments, recommendations, analysis, performances is stored and available for doctors and (partly) for the patient, while high performance personal data protection is provided.

5. Conclusions

The telemedicine system presented in this paper has various general features, and a module dedicated specifically to patients with forearm amputations. The goal of this module is to train the muscles of the blunt in order to prepare the patient to use an external myoelectric prosthesis, that uses the electric signals in the muscles in order to control the components of the prosthesis. The components of the training

module allow the patients to mount the sensors and make measurements themselves (or assisted by family members in the case of both arms amputations). The doctor explains the way the system functions and guide the patient to gain progressive control of the muscles. The online training simplifies the procedure for the patient, saving a lot of time and allowing him to practice in the home comfort.

The system is fully functional. The patients with amputated limbs trained online and the doctors confirmed their constant progress in improving their EMG signals in order to have a myoelectric hand and forearm prosthesis.

Acknowledgments

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