Autonomy, Motivation and Individual Self-management for COPD Patients, the Amica Project

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Abstract. AMICA Project targets to improve the quality of life of patients suffering from Chronic Obstructive Pulmonary Disease (COPD). Incorporating advanced signal analysis algorithms and custom designed monitoring devices with a Telemedical Platform (TP), an innovative system is under development to help elderly persons to reduce hospitalization time. After a brief analysis of COPD the sub modules that compose the TP will be described, along with the used technologies.

Keywords: e-Health, Telemedical Platform, COPD, monitoring device.

1 Introduction

COPD is also known as Chronic Obstructive Lung Disease (COLD) which is an umbrella term used to describe chronic lung diseases that are characterized by progressive obstruction of the airflow into and out of the lungs and increased shortness of breath [4]. COPD is an insidious disease, which is often diagnosed after some of the lung capacity is already lost. Other diseases related to COPD include emphysema and chronic bronchitis. Very little has been learned in past years about COPD, because the number of related studies is very limited. However, today, things are improving with some very encouraging studies, clinical trials and research for medications and treatments. COPD, though considered a chronic, debilitating and sometimes fatal disease, can be managed, controlled and slowed down [5].

Most significant COPD symptoms are coughing that produces large amounts of mucus, wheezing, shortness of breath and chest tightness. Smoking is one of the main causes of COPD. Most of the individuals diagnosed with COPD are active or old smokers. Long-term exposure to other lung irritants, such as air pollution, chemical fumes, or dust, also may contribute to COPD. The disease is usually diagnosed in middle-aged or older people. However, treatments and lifestyle changes can help the patient feel better, stay active and slow the development of the disease [11]. One of the main factors that contribute to a longer and healthier lifestyle include early detection of the problem, following of the medication treatment faithfully, acquiring of healthy eating habits, stop smoking, increase of personal exercise, education about each aspect of the disease and the related problems, and prevention of infections in order to limit exacerbations which can lead to additional lung damage.

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2 Background

Related research targets to reproduce hospital environment at the patient's home, using sensors and medical devices that require medical protocols to be used properly and the presence of skilled health professionals. Other solutions are based on nursing outreach programs. In both cases, the dedicated systems are expensive and the patients' health conditions do not improve a lot [6].

The use of Information Computer Technologies (ICT) in routine practice is particularly limited in the field of respiratory medicine. Some researchers have focused on tele-consultation between professionals working at different levels of the health system. Other studies in respiratory telemedicine deal with the telemonitoring of lung transplant recipients and patients with chronic obstructive pulmonary disease, asthma, or cystic fibrosis [13, 14] With the exception of spirometry self-testing in the context of home telemonitoring, monitoring of physiological respiratory signs have been limited to a few preliminary studies on the application of new technologies in home mechanical ventilation. None of the applications have been incorporated into routine practice [10-12].

The AMICA Project targets to merge professional COPD supervision with patient self-management (PSM) in one complete, easy to use and cost effective TP. The use of advanced mobile devices for telemonitoring each individual's conditions targets to reduce hospitalization time of the patient. The complete platform will include a monitoring device, a base station, a communication module, a signal analysis module and a web platform for data exchange and surveillance [8-9].

3 Platform Analysis

AMICA TP is composed of distinct modules performing dedicated tasks. Each module has a dedicated role, although all of them communicate and exchange data through a common platform, developed for the purposes of the project.

3.1 Signal Acquisition

Spirometry is the golden standard in the management of COPD patients, but the patients' perception of the lung capacity does not always coincide with spirometry results. During the initial phase of clinical trials during fall 2009, a patented multifunctional sensor used for the signal acquisition [3]. The sensor was capable to capture tracheal sounds and accelerations. In order to capture the data, a housing of the sensor was especially designed in order the miniaturized sensor to fit and to be easily used by elder people. Captured signals were transmitted by wire to the base station (described below), although the final product will make use of wireless connectivity protocols, such as IEEE 802.11 and Bluetooth, to transmit the signal from the sensor to the base station.

The evaluation of the captured signals indicated that the information provided by the accelerometer did not significantly improve the accuracy of the recordings. In that sense, accelerometer data acquisition decided to be abandoned and more effort agreed to be dedicated to the signal analysis.

3.2 Base Station

Many research projects have worked towards telemedical platforms during the last years. User interfaces implicate many problems and are generally not well accepted in the "real-world" of medical applications. The HMI mechanisms of mobile devices that are not adapted to the needs and requirements of patients, especially for elderly people. The hardware used for the implementation of the Base Station (BS) of the AMICA Project is customized for the needs of the system and the design is modular in order to easy allow upgrades.

The portable device will be situated in the home of the patient. It will be used for signal acquisition, collection of the questionnaire answers and data transmission to the central server of the system (CSS). A prototype has been already designed and is equipped with a large touch sensitive display of 7" diagonal dimension. The hardware is customized to allow the reception of transmitted signals by the sensor, digitize them, using an ADC, and perform the communication with CSS via an installed GSM modem.

BS will include advanced software for the Human Machine Interaction (HMI). The software will provide instructions to the patient on how to use the sensor, in order to record tracheal sounds and will facilitate the patient to fill the medical questionnaire related to the disease progress. All data are saved locally and then are securely transmitted to the database of the system. Questionnaires have been defined and validated by the doctors that participate to the project. At the moment, the interaction between the end user and the Base Station is performed through the touch screen interface but a bi-directional voice interaction interface is under development.

3.3 Telemedical Platform Framework

Telemedical Platform Framework is used for secure data storage and transmission to the CSS. It is also used to execute the signal analysis. BS stores the data locally and then using secure connection transmits the data to the central system database, located in a secure place inside the hospital. Encryption is used, to guarantee the privacy of the data. Raw data from the sensor are analyzed by the signal analysis algorithm (performance and primary results are currently examined) and the results are stored into the system database [1-2]. Demographic data, medical history, medical exams, medication and medical scales are gathered to create the Patient Electronic Health Record (PEHR). PEHRs can be accessed by the authorized users, using an internet browser [7].

The users of the system are divided into three distinctive roles: Administrators, Physicians and Researchers. Administrators are responsible for the overall system security. Physicians are fully authorized to examine patients' data, register new patients, record medical exams and medication changes and access questionnaire results and signal analysis data. A Researcher may access the data but cannot identify the patient, as any identification information has been removed.

3.4 Signal Analysis

Signal analysis takes place in the CSS. The raw signals are recorded by the sensor and are transmitted to the CSS along with the answers to the questionnaires. Signal analysis is currently initiated by the researchers, but for the final product they will be

automatically triggered upon the data arrival on CSS. The duration of sound recordings must be at least 10". A recording duration between 10 and 30 seconds seems to be enough for feature extraction. The algorithms are currently under evaluation. The features to be extracted will include ECG signals, lung sounds and heart rate. The results are compared to the physiological parameters and an estimation of disease progression is provided. Feature extraction aims to identify early signs of exacerbation and so to alert the physician to act and prevent patient hospitalization.

4 Future Work

Currently, BS station hardware is ready and software for HMI is under development. Sensor design is almost complete and ready to be manufactured. During the second phase of clinical trials feedback will be received by the end users and modifications will take place. Signal analysis algorithms results are under evaluation and will be reevaluated to optimize prognosis results. After the second phase of clinical trials, during fall 2010, the results will be collected and will be used to finalize AMICA TP development.

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