Patient monitoring strategies in chronic disease

This work, focusing in particular on COPD, aims to investigate the feasibility of using unobtrusive technologies (smartphones, sensor network technology) in order to provide useful and modular patient training and monitoring methodologies that allow to capture physiological information (i.e., heart activity, oxygen saturation, breathing sounds), physical activity, patient data, and environmental context.

Signal processing and machine learning methods will be investigated to develop reliable algorithms to derive COPD relevant indicators and trends including patient characteristics, physical state, activity and behavior patterns. The information extracted will be mapped to clinically meaningful metrics of the overall physiologic and functional status of COPD patients. The development of daily routine analysis and automatic segmentation based on physiological information will be used to obtain objective patient's behavioral assessment and new markers of patient's improvements under laboratory (pulmonary rehabilitation) and (if possible) free living conditions. The algorithms will be the basis for risk classification of patients for developing an exacerbation and continuous home coaching and training.

Chapter 1: Introduction

- Chronic diseases - COPD
- Social and cost burdens
- Needs of a paradigm shift from hospital to home

Chapter 2: Smartphone monitoring and training approaches

- CRNTC+: it is possible to use a smartphone framework for the rapid prototyping of healthcare application. (Pervasive Health 2013)
- COPDTrainer: importance of using a smartphone to train chronic patients (Ubicomp 2013)

Chapter 3: Review on Hierarchical Activity recognition

- What are the frequently used methods for recognition at sensor level?
- We assume that researchers base their algorithm on an existing method (HMM, etc.). What do they modify to achieve better results? (i.e. are there part of the algorithm that are modified the most in order to adapt the method to the requirements/purpose of their investigation?)
- Why do researchers use a hierarchy? Why it is useful? What are the benefits of using a hierarchy in terms of recognition accuracy?
- How are activities modeled/mapped to a hierarchy?
- Are the (sensor) systems analysed practical for continuous long-term activity monitoring? If not, which is the main limiting factor?

Chapter 4: Analysing COPD activity pattern (*Dataset*: more than 1000 patients recorded continuously for ~8 days. *Data*: motion data, skin temperature, energy-expenditure, metabolic equivalent tasks, galvanic skin response. *Patients info*: gender, BMI, MMRC, FEV1, DLCO, GOLD stage, Long-term oxygen therapy user, and Rollator user).

- Show that activity patterns are important health markers of patients suffering from COPD
- Activity pattern discovery in order to find unknown pattern structures directly from low-level multimodal sensor data.
- Activity patterns will be automatically derived in an unsupervised fashion by means of clustering techniques to generate a vocabulary of labels.
- The label set will be then used with hierarchical activity model algorithm for pattern extraction

Chapter 5: Exercise training and energy conservation techniques as part of rehabilitation, can be considered to reduce the task-related dyspnea sensation and, in turn, improve the performance of Activities of Daily Life (ADLs) in COPD. Its effects have never been studied.

- Show that the effects on the performance of domestic ADLs in patients with COPD after a program of high-intensity interval training in combination with occupational therapy.
- Extend current knowledge about the measurements that may be used in documenting clinical improvement as result of pulmonary rehabilitation based on multi-sensor physiological input.
- Confirm the hypothesis that an improved sub-maximal performance capacity following rehabilitation and the correct use of energy conservation techniques will result in a lower task-related metabolic load and reduce the burden of ADLs in patients with COPD

Chapter 6: Development of reliable state estimation algorithms combining physiological measures with physical activities performed to assess patient's health state and progress during the rehabilitation period.

Chapter 7: Investigate the feasibility of a “homemade” stethoscope-like microphone connected to a smartphone for breathing sound analysis (data collection on healthy subjects, signal processing, extract RR and differentiate breathing phases).

- Detection of cough and breathing sounds in patients suffering from COPD. This could lead to an alternative disease indicator that could be extracted from normal respiration sounds only.
- Relate worsening of coughing events (number, intensity, duration) with hospital-readmission
- Generate an “acoustic COPD score.” To derive the acoustic COPD score it's necessary to study reported findings in textbooks and journal articles. It will be clear from that review that cough, wheezing and squeaking noises are commonly reported findings and that higher rates of wheezes and squeaks per breath are associated with a higher likelihood of COPD.