The capaciflector: A new approach to respiration monitoring

Intern: Omar Emara

Supervisor: Professor Neil White

Collaborator: Professor Harry Akerman (UHS)

The cost to the UK of dealing with respiratory illness is increasing. Around 12 million people per year seek medical treatment for a respiratory complaint, and the cost of dealing with respiratory disease is rising in line with that of heart disease. The Department of Health has identified the importance of a personalised approach to care. With more effective management of respiratory conditions, treatment costs can be reduced along with mortality, emergency re-admission rates, and demands for invasive treatment. The project concerns a novel form of wearable respiration sensor, which is an example of a smart textile and allows respiratory function to be reliably and continually monitored within a community, home or hospital environment. The sensor is a compact, low-power and novel device based on a capacitive proximity sensor initially developed by NASA in the 1990s, but has previously not been used for measuring respiration. The development of novel respiratory sensors is of great importance since respiratory parameters are widely used in clinical practice, but existing sensing technologies are expensive and obtrusive for widespread use. Respiratory rate (RR) is routinely used for diagnosis and prognosis in hospital healthcare, where it is one of the most important early markers of deterioration and predictors of mortality. However, outside of critical care RR is measured manually only once every 4-6 hours, which is both resource-intensive and exposes patients to delays in time-sensitive interventions. RR is also predictive of deteriorations in the community setting, such as exacerbations in chronic obstructive pulmonary disease (COPD) and rapid increases in RR have been shown to be a key marker for sepsis.

The capaciflector is a device that can be placed on the body (typically the chest), either directly attached or on the outside of clothing. It produces a change in capacitance in proportion to the movement of the chest. The device comprises multiple layers of metal electrodes and insulators as shown in figure 1. The sensor is of a similar size to a standard ECG electrode and is unobtrusive for patients, unlike chest bands or facemask-based devices. A joint research study between the University and UHS has evaluated the performance of the device by positioning 4 devices at different locations on a patient’s torso and monitoring the output from the capaciflector and comparing the results with those of a pneumotachometer – a clinical, facemask device that provides a gold standard reference measurement. The initial results have shown only a 4% difference between the total number of breaths measured. We believe that it is possible to improve the performance of the capaciflector by developing a bespoke suite of advanced signal processing algorithms, that can account for movement artefacts of the chest/clothing, which manifest as high frequency noise superimposed on the capaciflector signal.
The effects of high frequency noise are shown in figure 2. The plot is a snapshot of approximately 5 breaths. The blue line is the ‘raw’ signal and the red line is a filtered response. In order to determine the respiration rate (RR) of a patient, it is essential that the peak values of the waveforms can be clearly established in order to calculate the number of breaths in a one minute period (breaths per minute or bpm). In the example plot shown, we also noticed a correlation between the high frequency component of the raw signal and the rotational speed of the exercise bike on which the patients were seated.

Figure 2. The raw and filtered signals from the device