Respiratory Rate Estimation using a Pressure Sensor Mattress

Artemisia Sarteschi
matr. 829677

Sleep is one of the most important physiological functions. Sleep quality can affect physical and mental wellness; for this reason, it is crucial to monitor vital signs without interfering with natural sleep. The state-of-the-art to monitor physiological data during sleep is polysomnography , which involves recording sleep stages, respiratory rate, heart and other parameters. However, this procedure is time-consuming, complicated, expensive, invasive for the patient and only sometimes available in hospitals. For this reason, it is nowadays acceptable to use cardiorespiratory polysomnography that does not track neurophysiological variables. This type of polysomnography involves a cannula, chest belts and electrodes for an electrocardiogram (ECG) but does not involve an electroencephalogram (EEG). Another reason why this kind of instrument is widely used is that inside the population, we have a higher percentage of sleep-related breathing disorders that can be studied and monitored with this instrument, like sleep apnoea/hypopnoea syndrome (SAS), where the individuals experience a collapse of the airway in deeper sleep states. The ability to monitor it allows for a faster and closer intervention in severe cases. The sleep cycle of a person is divided into two phases Non-Rapid Eye Movement (NREM) and Rapid Eye Movement (REM); this second phase is further divided into three other stages (N1-N3). Different muscle tones, brain wave patterns, eye movements, and heart and breathing rate alterations characterise every phase and stage. Focusing on one of the vital signs that characterise the different sleep stages is the respiratory rate which slowly becomes more stable going from the awake to the REM phase; this characterisation of the different stages gives the possibility to understand in which stage a person is based just on the respiratory signal. As said before, the state-of-art is a cumbersome device that requires cables attached to the users' bodies and often interferes with natural sleep.

[parte sulle altre cose e le cose di privacy]

For this reason, this thesis aims to study the possibility to use an unobtrusive sensor placed over the usual mattress to retrieve respiratory rate without discomfort for the person lying down on it.

The sensors in this project appear like a thin mattress similar in size to a common one that can be easily installed with adjustable straps. In particular, the sensors are pressure-sensor textiles from *SensingTex*®; in our case, was used the Pressure Mat Dev Kit, that has a sensor area of 192 x 94 cm filled with 1056 sensors (hereafter also referred to as "Channels") with a total sensor area density of 4 sensors for 10cm^2. The raw data extracted from the mattress can be viewed together to visually see the position of

the person since the sensors are pressure sensors the different pressures exerted by the presence/absence of a body on it or by its parts are given as a number inside an interval. So it is possible to create a heat map (or heatmap) to show the variation in colour of the intensity of the pressure, which can create the shape of a person on the mattress.

Looking closer into signals of singles channels is possible to see a pattern that resembles a breathing rhythm, similar to the data that can be retrieved from the nasal pressure exerted on the cannula of cardiorespiratory polysomnography. This pattern was the key factor in deciding to use this sensor mattress (hereafter also referred to as "Sensor Mat" or "Mat"). In the laboratory where this project was carried on, was available a rocking bed (Somnomat) involved in a study of an intervention for sleep apnea, it was decided to address another question or if it is possible to retrieve the respiratory rate while the rocking bed is moving. The possibility of integrating SensingTex® with Somnomat could be significant to have a closer and faster intervention on sleep apnea.

The total number of sensors is 1056; this leads to the necessity of an algorithm to discriminate the ones from whom it is possible to extract valuable information about the respiratory rate of the person on the mattress. Many of these channels are with null or stationary information; others present just interference from the mattress itself. From just a few sensors, it is possible to retrieve a respiratory pattern and extract the respiratory rate per minute (rpm).

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Therefore becomes necessary to design a metrics to asset the best channels,

x—-X

To obtain them from all the possibilities, we have defined our confidence metric to assign each sensor a percentage of confidence that it will be a suitable sensor. [**parlare del somnomat**].

Since no data and polygraphs were available from the same person on the SensingTex was necessary to collect new data, this gives us the possibility also to understand if this kind of Instrument could work with a lab project called Somnomat. A special rocking bed [**parlare del somnomat e di come potrebbe essere integrato**]. The protocol involved 6 participants (three female /three male) between 20-30 years of age. It was divided into two phases: one with the sensor mattress over a standard bed and the second on the rocking bed while this was moving. Each participant had a fixed set of positions that had to be while lying on the mattress. We also decide to insert variability into the data since, during sleep, respiratory rate increases in different stages. In order to do that, we ask a participant to perform a set of five jumps before lying down in the first phase of the protocol; for the second part, we ask them to turn around on the bed and stay on it while it is moving without performing any activity.

the data collection also involved Cardiorespiratory polysomnography. In our case, we use the nox a1 and noxturnal app. **chennal selected and canulas**

x—x

the data coming from the data collection was cleaned in this methods, than was used this approach to smoot or filtering the singal. than was use this to asset the number of

breath

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