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WEARABLE SENSORS AND FEEDBACK SYSTEM TO IMPROVE BREATHING TECHNIQUE

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Breathing is an important factor in our well-being as it oxygenates the body, revitalizes organs, cells and tissues. It is a unique physiological system in that it is both voluntary and involuntary. By breathing in a slow, deep and regular manner, the heartbeat become smooth and regular, blood pressure normalizes, stress hormones drop, and muscles relax. Breathing techniques are important for athletes to improve performance and reduce anxiety during competitions. [1] Patients with respiratory illnesses often tend to take shallow short breaths causing chest muscle weakness, reduced oxygen circulation, shortness of breath and fatigue. Proper breathing exercises can help to reduce these symptoms as well as strengthen muscles, improve posture and mental ability. This work presents a wearable system which monitors breathing technique and provides straightforward feedback to the user through a graphical interface.

A vest integrating stretch sensors has been developed using piezoresisistive materials to detect body movements. [2] Breathing rates are measured by detecting the expansion and contraction of the ribcage. The vest is made from a stretch knit fabric (80% nylon, 20% lycra). Carbon-loaded elastomer (WACKER Elastosil) is coated onto the front of the vest in strips at the chest and abdomen, as shown in Figure 1. Stretching the sensor causes an increase in the resistance which is measured by a microcontroller (Arduino) using a potential divider circuit. Conductive thread (Berkinex) is used to connect the sensors to the microcontroller. The Lilypad Arduino is specifically designed for wearable applications as the pins are connected to by stitching with conductive thread. The data is transferred to a laptop using an RS-232 serial cable. A Bluetooth modem (BlueSMiRF) can also be used for wireless deployment.

The signal is filtered using a low-pass Butterworth filter and the filtered signal is cross-correlated with a reference signal to assess the performance of the user. A Flash application is used to present feedback to the user in a graphical format as shown in Figure 2. An avatar displayed on the screen encourages diaphragmatic breathing. To do this the abdomen of the avatar expands and contracts in line with the sensed information obtained in real time from the vest. The user's goal is to perform deep diaphragmatic breathing in synchronization with the avatar. A real-time representation of the user's breathing technique is represented on the avatar. After a period of six breaths the user is given a score based on their performance.

The advantage of this system is that it is low-cost and the sensor garment is flexible and comfortable to wear. The use of a Flash application makes the software easily accessible. Further work is focusing on assessment of sensor robustness and the importance of garment fit for clinical trials. Discussions with healthcare specialists are in progress to obtain early feedback on system usability in a clinical setting.

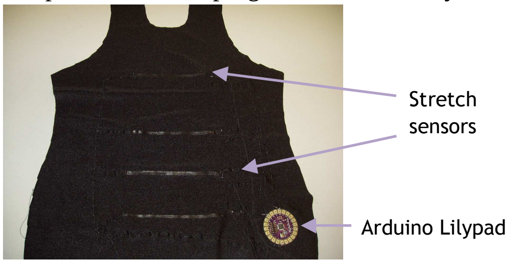

Figure 1. "Smart" vest to monitor thoracic and diaphragmatic movements during breathing

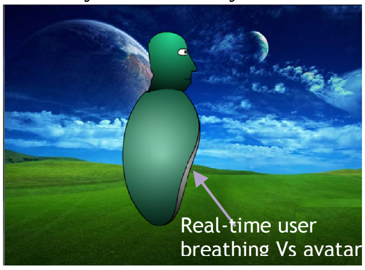

Figure 2. User interface to encourage diaphragmatic breathing technique

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