

DESIGNING SMART TEXTILES FOR THE DETECTION OF LONELINESS IN OLDER INDIVIDUALS

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Abstract

As mental health is lately of increasing concern, loneliness in elderly people has become a critical issue. Loneliness can lead to adverse health situations for the ageing community, with depression and anxiety being the dominant ones. These conditions are known to trigger a cascade of emotions which are often translated into alterations of some physiological signals such as heart rate and blood pressure, respiration rate, skin temperature, sweating and hormonal levels. These changes can be monitored via several means like electroencephalogram (EEG), electrocardiogram (ECG), blood pressure measurement, electromyogram (EMG), galvanic skin response (GSR) and sweat analysis. Effective monitoring with wearable sensors can reveal alterations in the levels of the monitored signals and help family, carers and doctors to tend to the person's needs. The present study aims to design and develop a smart textile with various embedded sensors that will collect and monitor the physiological signals of older adults with loneliness. The designed individual sensors are screen printed on thin films and integrated in textiles to capture key signals related to heart rate, body temperature, breathing rate etc. In this work, a smart textile with ECG, motion, pressure and temperature sensors will be developed with encapsulation to protect electronic parts and extend their life cycle.

1. Introduction

Loneliness is a global public health issue that is subjective and can be exhibited differently for different people.¹ It is one of the main issues for elderly people² which can lead to adverse health situations such as heart disease, diabetes, depression and anxiety.³ Except of the already well-known physiological signals that are associated with heart disease and diabetes, even more can be linked to mental health conditions. These conditions are known to trigger a cascade of emotions which are often translated into alterations of some signals such as heart rate and blood pressure, respiration, skin temperature, sweating and hormonal levels variations⁴. Changes like these can be monitored via several means such as electroencephalogram (EEG), electrocardiogram (ECG), blood pressure measurement, electromyogram (EMG), galvanic skin response (GSR) and sweat analysis.⁴ This means that even if emotions and mental health issues can be suppressed or masked intentionally, the alterations in the levels of the monitored signals would be revealed. The use of digital technologies to detect physiological signals and activity patterns in the elderly can offer the potential to identify when support is needed¹ and notify family and carers early, allowing them to intervene early, tend to the person's needs and help them with any difficult situation they are going through.

The present study aims to correlate the aforementioned changes in signals and activities in older adults with loneliness through the use of sensors and the generation of algorithms. Albeit being beneficial, the monitoring has to be discreet and not cause any obstructions to the person's everyday life and activities. For this purpose, we plan to build sensors embedded in textile and/or garments; these can be in close contact with the person's skin and give information rapidly about changes in the monitored signals. They are advantageous compared to sensors comprised in devices because they are discreet, can be worn in all daily activities without causing any obstruction, it's easier to not be forgotten and they can monitor multiple physiological signals simultaneously in real-time.

2. Results and Discussion

2.1. Method

The sensors of this study will be screen printed on textiles and coated accordingly for increased washability. The designed sensors aim to detect heart rate, body temperature, breathing rate, activity levels, sleep patterns and cortisol excretion in sweat. Therefore, we are going to develop the following five categories of sensors: ECG, temperature, motion, pressure and sweat hormones detection.

2.2. Design

In this paper we are discussing the development of an ECG, temperature, motion and pressure sensor and their integration in a complete circuit.

The ECG electrodes proposed are simple rectangular structures with a total surface of 6cm². They were originally designed for on-wrist use⁵ but in our case they were modified in order to offer us the possibility of adhering them to the subject's chest. The electrodes will provide information on the heart activity of the subjects, including heart rate, inter-beat intervals and heart rate variability. Our motion sensor, when placed on a garment like a vest, can give us information on the frequency of talking or crying by monitoring upper body movements or even the breathing rate if it is positioned on the ribs; when placed on a sock or a legging though, the data received will be related to the activity level of the individual. Its design is that of a meander, a structure that offers higher resistance. The observed changes to the resistance are a result of the deformation of our sensors and upon fine tuning we will be able to differentiate the signals received and determine the interaction levels (talking), crying outbursts or the various types of body movements (walking, jogging, running etc).⁶ The temperature sensor has a similar design and its function is based on the changes caused to the sensor's resistance by the changes in the temperature of the adhered surface. When placed close to the skin, it is able to detect changes in the subject's body temperature. All three sensors are made with silver, they are screen printed on flexible thin film (TPU), later adhered on fabric and encapsulated. They all work based on the resistive principle and according to the literature they offer advantages such as simple structure, low cost, easy integration and relatively easy signal acquisition. But their working stability and power consumption are still issues that need to be addressed.⁷

On the other hand, the proposed pressure sensor is a piezoelectric one with an interdigitated electrode (IDE) structure and an electroactive layer. It is also screen printed on flexible thin film and the materials used are the polymer mixtures PEDOT:PSS and P(VDF)-TrFE. Piezoelectric pressure sensors' signal is generated in response to a mechanical deformation without an external voltage supply, allowing them to be self-powered and energy-autonomous.⁸ A pressure sensor, when embedded on a vest, as previously, can give us information about the changes in the breathing rate whereas, when it is incorporated on a sock or insole, can supply data similar to the ones of the motion sensor, related to the activity level of the person. Moreover, pressure sensors can be placed on specific pieces of furniture like a couch or a bed; in this case they will allow us to monitor the time spent by the individual on each furniture and determine patterns potentially contributing to a sedentary lifestyle (lengthy periods of time spent sitting or lying on the bed).

The patterns of the proposed sensors are shown in Figures 1 and 2.

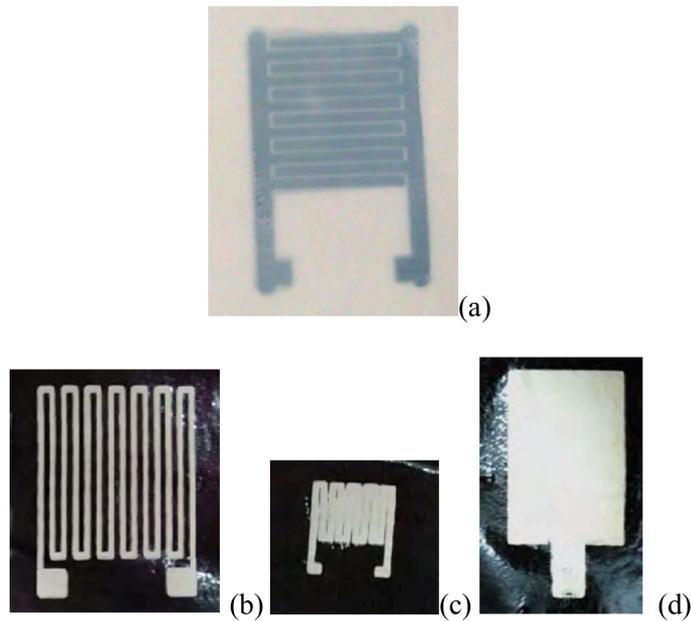
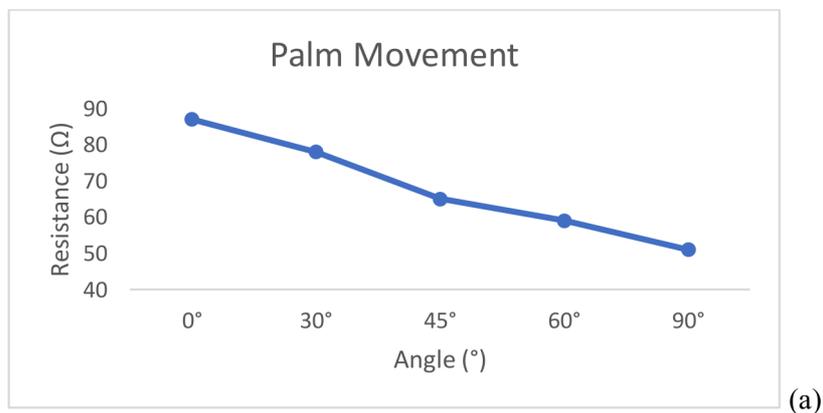


Figure 1: (b) Resistive motion sensor, (c) Temperature sensor and (d) ECG sensor

2.3. Evaluation

The printed sensors have been evaluated for their ability to detect the corresponding signals in real-time conditions. Examples of the evaluation results are given in Figures 3-5.



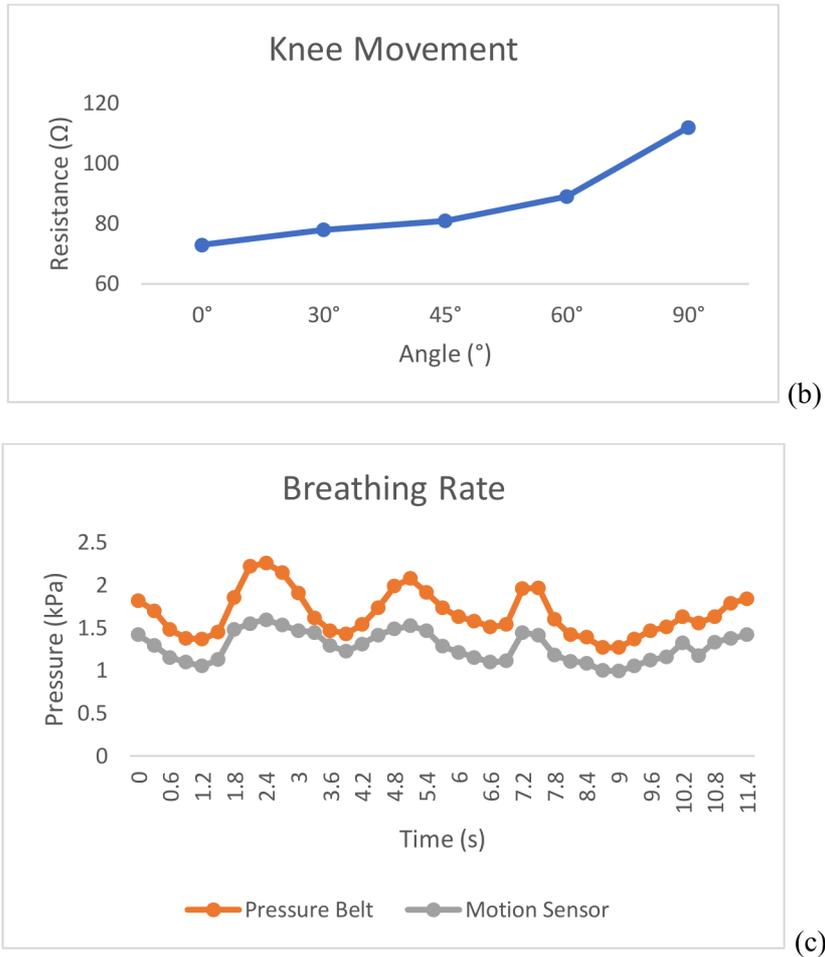


Figure 2: Signal detection of motion sensor (a) Palm movement (b) Knee movement (c) Respiration rate vs the commercial Pressure Belt

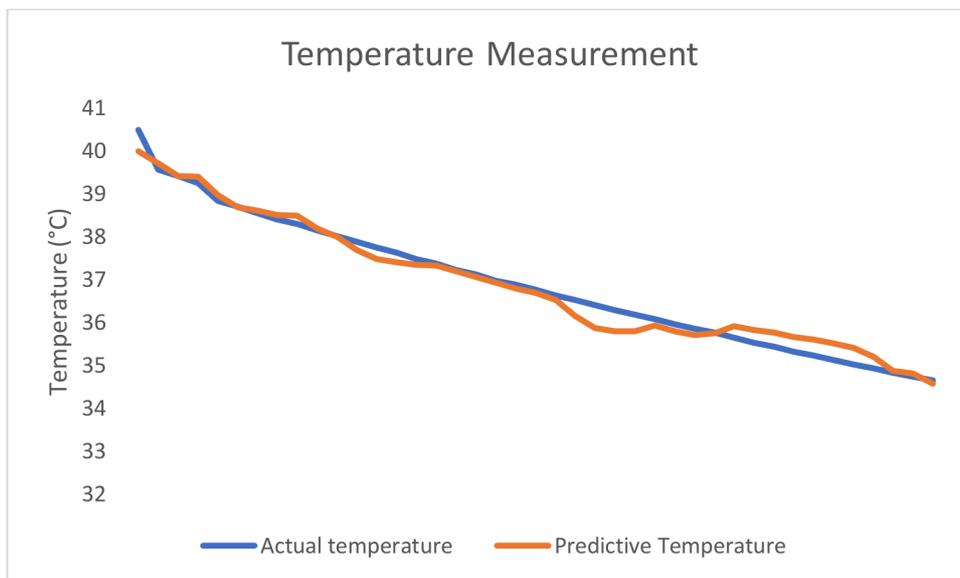


Figure 3: Measurement of the temperature as predicted by our sensor (orange line) and comparison with the temperature detected by a commercial temperature sensor (blue line)

The results presented in Figure 2 were obtained from testing our strain motion sensor under various conditions. The sensor was placed on the subject's palm (3(a)) and they were requested to open and close their hand. The resistance of the sensor was measured in each hand position and the results were plotted against the angle of the hand and they show that the resistance is reduced when the sensor is contracted. Later, the sensor was put on the side of the subject's knee and they were requested to move their knee from full extension (which would see the sensor flat) to 90° angle that would result to a hyper-extended sensor. In this case, we observe again higher resistance in the positions where the surface of the sensor is larger.

The same sensor was also put on the subject's ribs and the change in the resistance was monitored to test whether the use of this motion sensor was possible for the measurement of a person's breathing rate. The results show that the resistance of the sensor varies during breathing and that makes our sensor a good candidate for detecting the person's respiration rate.

The temperature sensor was tested in a similar way and the results shown in Figure 3 confirm a positive relationship between temperature and resistance.

3. Conclusions

In this work we demonstrated the production of four different categories of sensors and their embedment on fabric substrate. Future work includes the creation of garments that will bear these sensors along with an integrated communication system and their subsequent evaluation in real-life conditions.

Acknowledgments

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