Chapter 10:

Wearable Technology: Garment-based sensing principles

Overview

Capacitive Sensing. / Resistive Sensing.

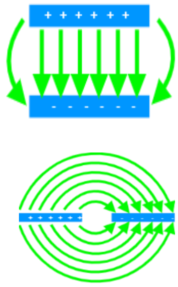
Capacitive Sensing

In the future, more and more sensing technology will be put into wearable clothes. There are two main important garment-based sensing principles: Resistive sensing and capacitive sensing.

Capacitive sensing:

Dielectric
Hum

Capacitive sensing is based on capacitive properties. A capacitor stores energy in an electric field. Therefore, parallel plate capacitors and the human body as the dielectric is used. The material should be a conductive plane. The dielectric changes the property of the capacitor. This can be used to store energy and measure changes in the human body. The field distribution in the capacitor adapts when changes in the human body occur and can be computed with the formula: $C = \sum \frac{dU}{dV}(x, y, z)\Delta x \Delta y \Delta z$



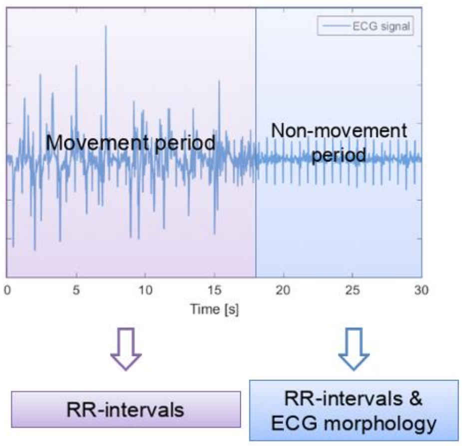
http://www.simpleskin.org

There are already some textile integrated systems on the market like sport-shirts and bras that can measure the heart rate and respiration. Current research is going deeper with the capacitive sensing possibilities. An example is the "FitnessSHIRT" which measures a single channel ECG & respiration.

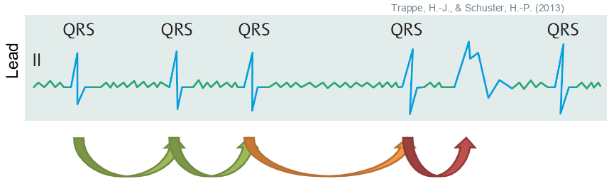
Shirt and bra to measure heart rate and respiration

FitnessSHIRT to measure single channel ECG & respiration

The main challenge in textile integrated systems is dealing with motion artefacts. Automatic detection can tell you where movement happened and where non-movement happened. With that, you can do a context-based arrhythmia detection. During the movement-periods, the RR intervals and during the non-movement periods the RR-intervals and the ECG morphology can be detected.



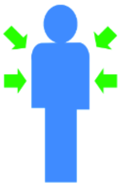
Trappe, H.-J., & Schuster, H.-P. (2013)



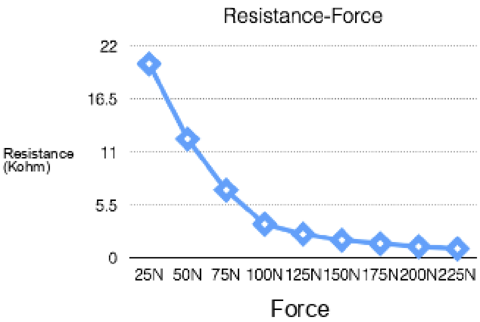
Pressure ↑ Resistance ↓
Conduct ↑

Resistive Sensing

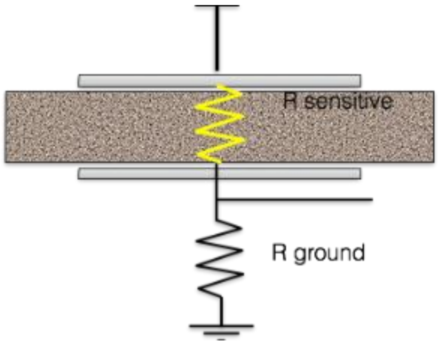
Resistive sensing:



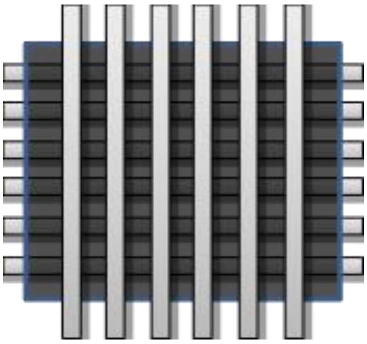
Resistive pressure sensors typically react to an applied pressure by a decrease in the contact resistance (or increase in the electrical conductivity) between the top and bottom sensing electrodes. The physics principle here is that you have some flexible carbon polymer, which is conductive and force sensitive. The higher the force, the lower the resistance of the carbotex fabric will be, as you can see in the top left image. To measure the pressure (top right image), you can use a matrix structure where you put different resistive sensing fibers on top of each other (bottom left image). Then you receive the force distribution (bottom right image).



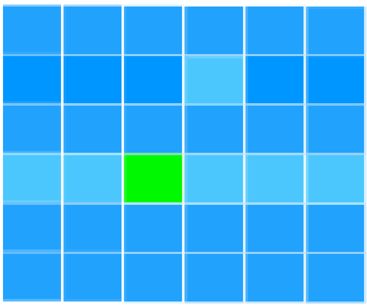
The higher the force, the lower the resistance



Measuring the force



Matrix structure of resistive sensing fibers



Matrix force distribution

An example for using resistive sensing is the touch enabled textile used in the gesture sleeve. Here, two layers of stripe electrodes are placed perpendicular to each other with a force sensitive fabric in between.