Skin elongation sensor

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Introduction

- Wearable flexible and elastic sensors for monitoring skin health and safety while using assistive technology, such as orthoses, prostheses and exoskeletons are needed [1]
- The device-skin interface is poorly understood for exoskeleton technology [2,3]
- Current skin elongation sensors are prototypes that require expensive equipment to manufacture them and designs are protected by patents [4,5]

Aims

- Fabricate a soft, flexible and elastic skin elongation sensor
- Use materials and methods that will enable the fabricate of the skin elongation sensors at low resource settings

Methods

- Conductive thread and yarn, conductive textiles and carbon fibre were chosen and tested as transducers for the skin elongation sensors
- The sensor mould was manufactured in a CNC machine
- A silicone elastomer used for special effects, animatronics skins and medical prosthetics was used to encapsulate the conductive materials. This silicone has a shore hardness of 10A and was thinned with a silicone thinner to lower its viscosity
- Based on the following requirements, one prototype sensor was chosen:
  1. Conductive material should not interfere with the inherent elasticity of the silicone containing it
  2. An ideal skin elongation sensor should require minimum electronics, where the use of a simple voltage divider will be preferred over the need of using an instrumentation amplifier
- A tension test was performed on the chosen prototype while connected to an Arduino card acting as an analog data acquisition card and data acquired through a programme in NI LabView. This test was performed to obtain elongation (mm) vs force (N) and voltage vs time curves. These curves were used to calculate, in Mathworks Matlab, the calibration equation of the sensor in order to display a curve of force vs time through NI LabView.

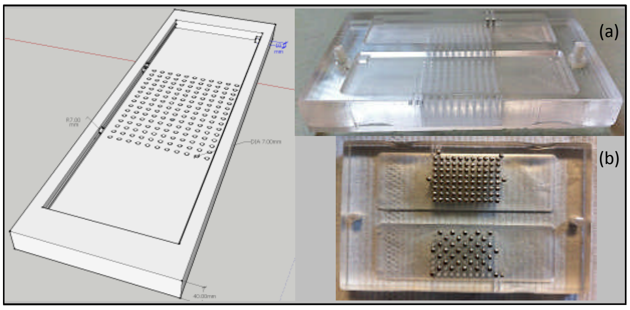

Figure 1 Mechanical drawing of mould and CNC manufactured acrylic mould top view (a) and bottom view with pins (b)

Results

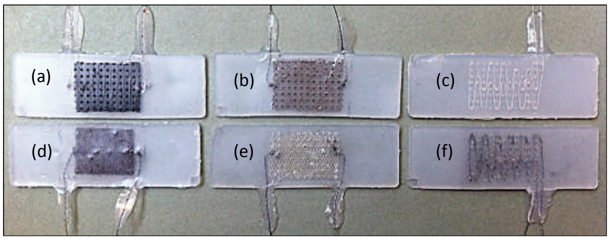

Figure 2 Six sensor prototypes based on (a) carbon fibre, (b) Shieldex® 2611, (c) Shieldex® conductive thread, (d) Electrolycra®, (e) MedTex® 1133 Mesh and (f) Adafruit® 2 ply conductive thread

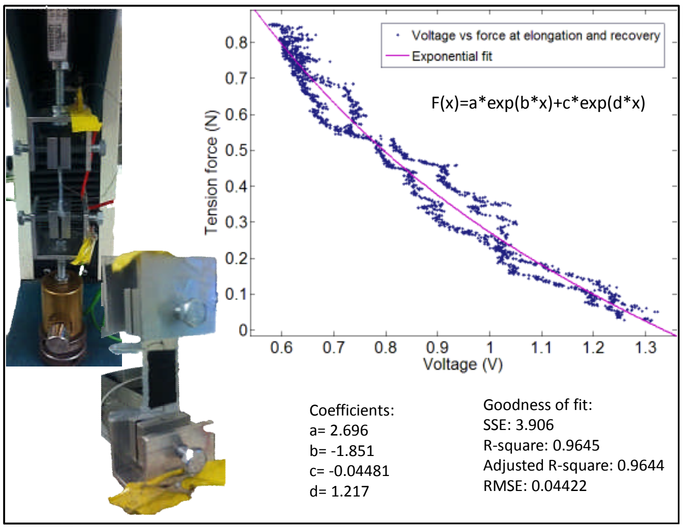

Figure 3 Tension test (5mm/min, 11 mm displacement) and result as voltage vs force for stretching and relaxing curves with exponential fit curve

Material name	Resistance (Ω) unstretched	Resistance (Ω) stretched to 50%	Conductive material description
Carbon fibre tow	3.13k	1.42k	Carbon fibres
MedTex® 1133 Mesh	21	19.3	Silver plated nylon knit mesh
Shiledex® 2611	350	89	Silver plated nylon knit mesh
Adafruit® conductive thread 2 ply	28.7	18.8	Stainless steel plated
Conductive thread from Shieldex®	24.8	18.7	Silver plated
Electrolycra®	97	248	Silver plated

Table 1 Conductive materials description and resistance of skin elongation sensors at stretched and un-stretched conditions

Discussion and Conclusions

- The carbon fibre sensor offers greater resistance value thus it offers the opportunity to bypass the use of instrumentation amplifiers. Other prototypes could still be used but will require amplification of the signal.
- For any application, it is desirable to have as less electronics as possible thus the carbon fibre prototype will be considered for further development and testing.
- Replacing CNC machining by 3D printing is under investigation
- These sensors will be useful for characterizing skin stretch where technology is in contact with the skin such as with orthoses, prostheses and exoskeleton technology. Also useful for robotic tactile sensing.

References

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Acknowledgments

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