Knitted stretch sensors for sound output

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ABSTRACT

Stretch sensors appear to offer the physical computing and wearables communities a solution in their flexibility. This paper introduces an interdisciplinary project in which knit, weave and embroidery specialists were brought together to examine how a carbon rubber sensor might be integrated aesthetically and functionally into different fabric structures. Focusing on knit, it reports on the drawbacks of the original commercially available sensor, and presents an exciting alternative direction using knit structures to build custom flexible sensors.

Author Keywords

Stretch sensor, textiles, knit, wearables.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI)

INTRODUCTION

Our story begins in 2008 with a stretch sensor produced by Merlin Robotics [1]. Following a collaborative sci-art project with Merlin, Philip Breedon had become aware of this novel material, and was seeking textiles expertise to begin approaching its potential design space [2], [3]. With the input of Amanda Briggs-Goode in Textiles, a collaborative team was bthen rought together comprising Sarah Kettley (conceptualisation, wearables), Nigel Marshall (weave), Tina Downes (embroidery), Karen Harrigan (pattern & fit), and myself, Martha Glazzard (knit).

CARBON RUBBER STRETCH SENSOR

This uncompromising carbon impregnated rubber cord stretch sensor was most extensively tested in integration with knit and embroidery. Early findings included a problem with friability – it seemed the presence of the carbon particles caused snapping at key moments [2], [3]. Further, although there appeared to be no literature available at the start of the project, there is a serious issue with the return rates of resistance values. Subsequent discussions with other practitioners confirmed this as a reason for its not being more widely adopted [4], [5].

EXPLORATORY AESTHETIC APPROACHES

The collaborative aspect of the project was possibly the most challenging, attempting to juggle the workload with academic timetables and student demand. Though working across textiles, fashion and product design led to a large amount of knowledge exchange into fields in which members had little previous experience. We decided to create back panels to mimic the areas of muscle stretch in the human body and lay the sensor into applicable places (see Figure 1). I worked on developing channels on the Shima Seiki knitting machine [6] with areas of different stitches to emulate the back muscles with different proportions of stretch. The channels of tubular knitting to house the sensor were developed with not too much difficulty, and along with the final weave and embroidery pieces, was developed to a shared aesthetic. These concept pieces were shown at the new Inspace gallery in Edinburgh in 2009 as *Aeolia*, one of eight Alt-w projects supported by New Media Scotland [7].

Figure 1. Integration of rubber cord stretch sensor into (l to r) aesthetic embroidery, knit and weave structures.

In my view the major breakthrough in the project came when I was presented with a cone of conductive yarn. This was a direction inspired by work one on the European Eduwear project, where non-stretch conductive fibres had successfully been integrated into knit fabrics to create custom sensors [8]. I decided to continue with my earlier experiments with elastics, an interest that had also roots in my undergraduate work. As a result, though unknowingly, a knitted stretch sensor was created. Several versions of the knitted sensor were created, first focusing on an aesthetic we liked with a shell type edging or ruched areas (Figure 2), though this interfered with the electronic results so the end result was created in a more linear form for functionality over appearance.

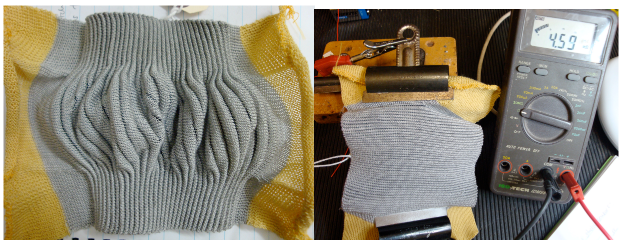

Figure 2. Bekaert conductive fibre and shirring elastic sample, and bulldog clip test set-up.

When tested in the electronics lab the knitted sensor provided more reliable results than the carbon sensor. Though the variable resistance created was not fully reliable, it had a faster recovery rate and produced stable enough results to warrant further work to enable a quantifiable output. Trying to take linear resistance readings appeared to give more reliable results than the carbonised rubber, but there was a persistent randomness that was hard to explain. Coarse lacing demonstrators had shown that expected resistance value change may be inverted when the number of conductive fibres crossing in a fabric is increased by mechanical force [2], [3]; these more sophisticated swatches also introduced a second non-conductive yarn and a regular twist on the scale of the sample (Figure 2) which appeared to be due to the steel twist in the Bekaert thread itself, which also affects the electronic properties of the thread and the larger fabric. The STELLA project has reported that most conductive materials increase their resistance with every stretch cycle [9].

TOWARDS PERFORMANCE

The first audio output was attempted at a 'Cryptic Nights' event in July 2009. The cellist Peter Gregson was performing at the event and due to previous experience with experimental technologies he was interested in integrating our stretch sensor into his performance [10]. This in turn led to new considerations to realise a final product:

- How much of the sensor to include in the 'garment'
- Placement of the sensor to produce adequate stretch to trigger results
- No opportunities for fittings with Peter
- How to house the wiring and power pack

The sensor was eventually used in small panels integrated into a base garment of Powernet, a synthetic, fray resistant, stretch fabric. The panels were situated at the elbows and in a strap across the back onto the upper arm to generate stretch when the bowing arm was moved. Adjustments were discussed so that Sarah could fit it to Peter so it was tight and therefore able to stretch in the right places (Figure 3). A channel was added inside the garment to house the wiring and a pocket at the centre back to contain the power pack and circuit board.

Figure 3. Fitting the garment to cellist Peter Gregson, showing the under shoulder and elbow sensors.

The major problem we fell upon was the conversion of the variable resistance to MIDI output, and the garment was shown at Cryptic Nights before this had been resolved. However, with some acting on the part of Peter Gregson and his sound technician Milton Mermikides, a 'Wizard of Oz' performance was successfully enacted [11]. As a result of this, sound designer Yann Seznec became involved in the project and implemented the necessary transition between the analogue sensor values using Arduino-to-Max [12] and Ableton [13]. Very quickly, the sonic output revealed n important finding, which our previous ad-hoc test set-up would never have made apparent (to us at least) (Figure 2). That is, the first upper and lower limits of the values are replaced after the first stretch cycles with new, more stable limits, and if this shift can be taken account of in the programming, recalibration can take place relatively simply [14].

CONCLUSION

The most interesting finding for us has been that while the knit sensors remain unreliable for applications where accuracy and repeatability are crucial (an obvious example being healthcare), their built in unpredictability occurs within reliable enough parameters to be a positive and exciting factor in the arts. This will form a starting point for my MA at Nottingham Trent, during which I plan to experiment with other conductive yarns [15] and return to the earlier, more elaborate looking forms to test their output. This includes working again with irregular results and utilising them within an appropriate form to produce performance art works. I am also keen to explore whole garments with integrated sensors and outputs.

Further, a contrast in design methodology has been raised in this collaboration and its difficulties have possibly limited our output. The question is raised between seeking aesthetic output and striving for quantifiable results first. The challenge as the research team continues to grow now, is to work with this tension as a positive rather than negative condition for creative production.

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