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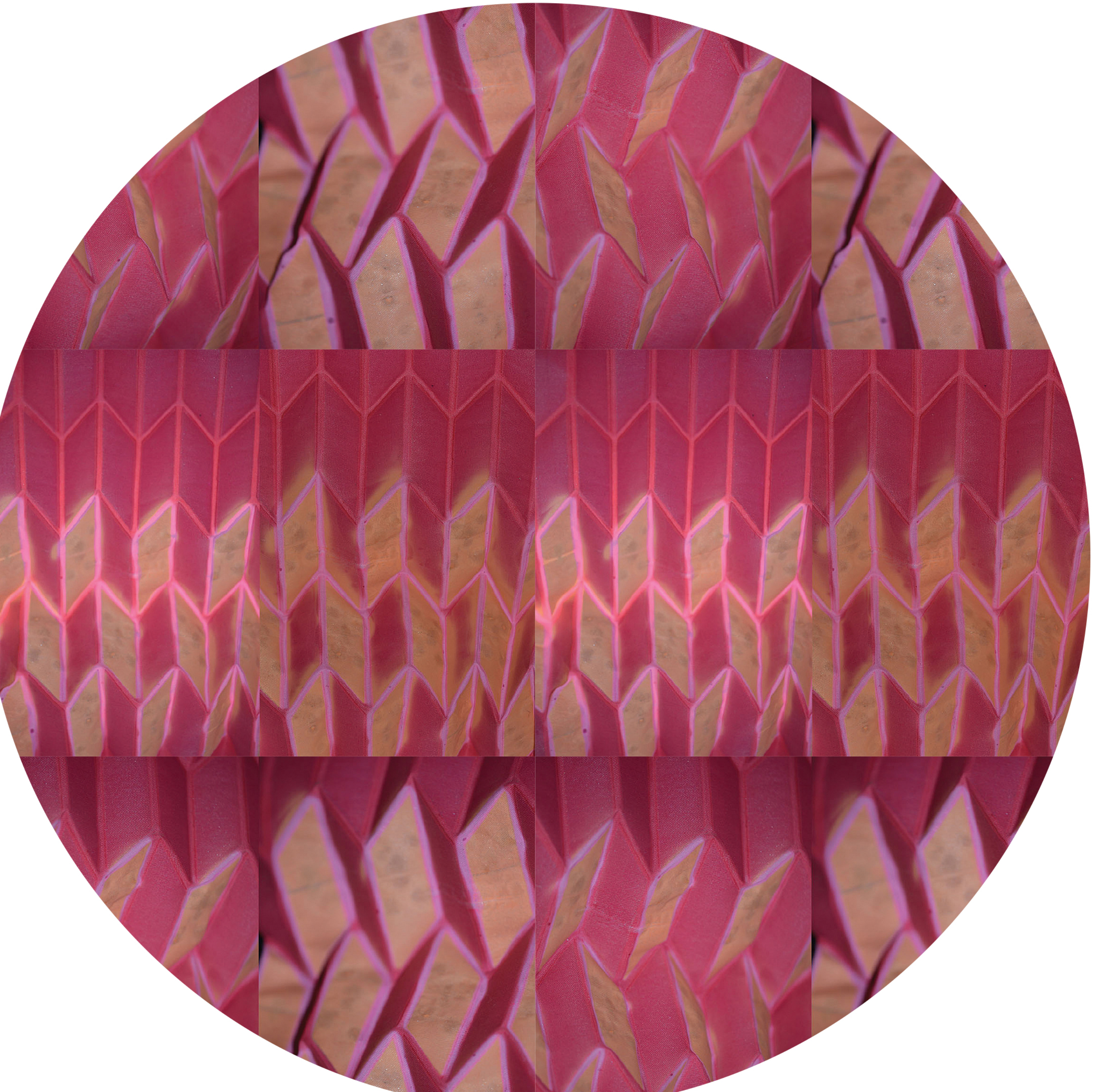
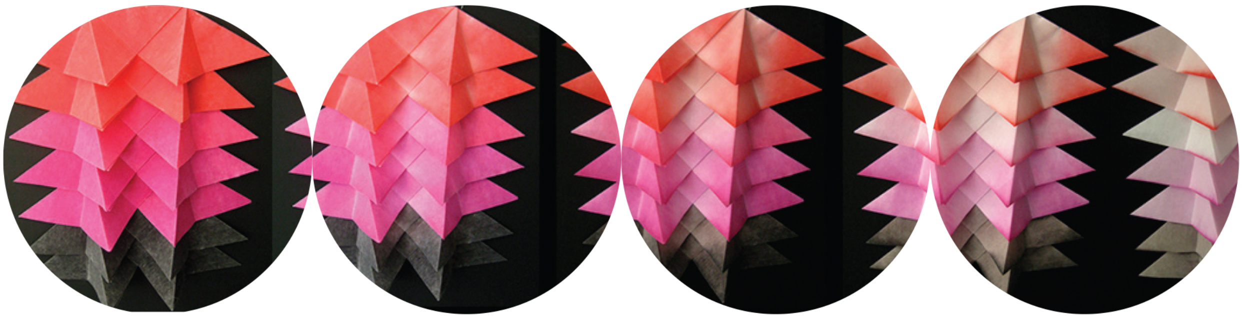


PROTOTYPING 3D 'SMART' TEXTILE SURFACES FOR PERVASIVE COMPUTING ENVIRONMENTS

SMART COSTUMES | 3D TEXTILE DESIGN | THERMOCHROMIC | PERVASIVE | PROTOTYPING



ABSTRACT

THIS PAPER REPORTS ON INITIAL SPECULATIVE RESEARCH FROM A PROJECT WORKING TOWARDS A DANCE INSPIRED 'SMART' COSTUME THAT CAN BE ACTIVE AND RESPONSIVE IN A PERVASIVE COMPUTING ENVIRONMENT.

The current research aims to explore the 'performative' potential of smart materials to create aesthetic colour change qualities for textile surfaces. The research is supported under the 'Creativity, Design and Innovation' (CDI) theme at Heriot-Watt University, which is allowing the research team to address gaps in knowledge in the area of smart textiles research through a multidisciplinary approach. The combination of disciplines with design at the centre is pushing new design practice, which sits at the design/technology interface and promotes the use of emerging and enabling technologies, alongside unusual combinations of materials, and computer science. Presented here is current on-going research focused on engineering the surface properties of textiles through utilisation of emerging technologies and craft techniques, to generate different responsive modes. The use of a desktop 3D printer is being explored to apply polymers directly to a textile surface to facilitate the development of active and responsive three-dimensional surfaces. Ultimately, the aim is that these surfaces will be programmable and will respond within a pervasive computing environment.

INTRODUCTION

The research presented has brought together, textile designers, computer scientists and an electronic engineer in order to explore the development of smart textile surfaces and how they might interact in a pervasive computing environment. The broader overarching aim of the research was to explore the connections between smart textiles and the role of computer science in their development in order to gain a clearer understanding of the design/technology processes involved and at the same time establish the level of computing knowledge needed for practitioners working with smart textile development. It is hoped that ultimately the research will provide a multi-disciplinary knowledge base to share with other practitioners working in the field.

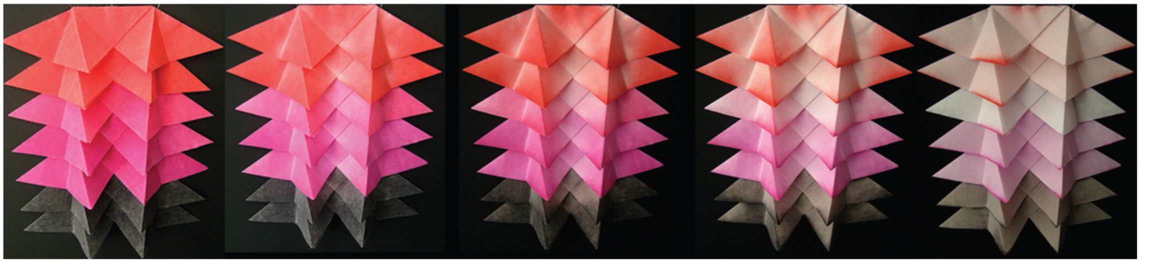
FOR OVER 10 YEARS THE FIELD OF 'SMART TEXTILES/ CLOTHING' HAS GROWN BUT STILL OFFERS HUGE CAPACITY FOR FURTHER DEVELOPMENT, HOWEVER PEOPLE ARE LOOKING FOR MORE MEANINGFUL AND COMPLEX USES OF SMART TEXTILES.

The project builds on several areas of the authors' prior research in smart materials/textiles, optical illusion and pervasive computing. Lynsey Calder has taken inspiration from previous work with geometric patterns and origami fold structures to develop new smart textile surfaces. The direction the project has taken relates to Calder's (2012) prior research in which she explored monochromatic optical illusions and geometric patterns to alter the perception of size and depth of a 3D object. This project, 'Smart Costumes' draws directly on influences from Calder's prior research to apply colour change to 3D textile surfaces. The aim, ultimately, to create an evolving textile topography which, through its colour-change function generates optical effects that distort the audiences perception of a costume's surface and the space in which it performs.

The work in progress presented in this paper demonstrates small prototyping based work packages that have placed a design researcher (Calder) at the heart of the project which includes:

- Fabric/costume development using thermochromic and fluorescent pigments;
- Development of integrated electronic systems that have potential to be controlled in a computing environment;
- Exploring transformation of 2D pattern to 3D structures (inspired by origami) using a desktop 3D polymer printer;
- Developing pervasive computing environments that sense and respond to colour change.

In the context of this research smart textile surfaces are defined as those that combine chromic materials, electronics and textiles. Worbin (2010) highlights that smart textiles can be seen as a textile that can change recursively between two or more states of expression. They often combine chromic materials, which change reversibly in colour in response to certain external stimuli and integrated electronic systems are developed to create the stimulus to generate changes in the materials. In this research we explore leuco thermochromic dye systems, which change from coloured to colourless on temperature change (as demonstrated in figure 1) in combination with heat-profiling circuitry based on systems developed by Robertson (2011).



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CONTEXT

Bringing textiles and traditionally hard/product specific technologies together often lacks aesthetic consideration, although it may result in interesting concepts, it appears to add to the barriers for these interventions (with textiles and technology) making a significant commercial impact (Dunne 2010). For over 10 years the field of 'smart textiles/clothing' has grown but still offers huge capacity for further development, however people are looking for more meaningful and complex uses of smart textiles (Bennett 2011).

There is minimal literature which focuses solely on smart textiles and performance in an interactive environment. One design practitioner at the interface of textiles and technology is Linda Worbin who has explored costume, colour change and performance, where she created six costumes with properties such as colour-change in response to UV light, heat and electroluminescence. The costumes were worn by actors and actresses who were given props to facilitate the reaction between the environment and the costume. The results were observed by an audience and everyone involved was interviewed, analysis showed that both parties, audience and actors/actresses were interested in how the interactions changed the performance and space (Worbin 2010).

Work by Robert Wechsler, artistic director of Palindrome, an interactive dance company, uses motion tracking that is controlled by the dancers' movements and sets a scene for successful dance related computing environments. Previous performances by the company Palindrome have included the use of sensors to pick up gestures and movement to influence music, sounds, stage lighting and projection giving another dimension to a traditional dance performance. Although Wechsler (2006) regards interaction and human motion as a means to control the stage environment as an ancient practice, he, along with Palindrome have pushed the boundaries with 'real time' motion tracking and provided inspiration for the potential pervasive environments in this current project.

Valerie Lamontage's current research into wearable materials and performance serves to open up the area of smart textiles and their performativity. Lamontage (2011) argues that there has been a progression from performance to performativity for wearables' research that can engage and form relationships between humans, nonhumans and materials. The term performativity is of particular interest in this research as it is described by Lamontage (2011) as '…a *quality* which is particularly adept at engaging with human/non human actions'.

Toolkits are available which enable a broad range of people to create wearable interactive garments such as the Lily Pad Arduino, an electronic toolkit developed by Leah Buechley (Buechley and Eisenberg 2008). Similar electronic toolkits have been developed as a result, such as, the 'Fabrickit', the goal being much the same, making it easier to integrate electronics into textiles, with the advantage of more robust connections (www.fabrick.it, accessed 2011). These developments are driving this field forward in terms of the underpinning technology and digital control mechanisms, however, how these technologies are used and integrated (with aesthetic consideration) is just as important.

Making objects and or textiles talk to each other and their environment may have previously been an area left to specialists, however, with friendlier programming language and accessible literature, designers are now able to approach prototyping with more confidence and be in control of a holistic design process. In Tom Igoe's book 'Making Things Talk', projects are set out using Arduino to create elements that can communicate with each other and in doing so can teach the craft of using sensors and networks to create exciting outcomes (Igoe 2011).

One emerging technology that has potential in the development of smart textiles is 3D printing. 3D print technology has become

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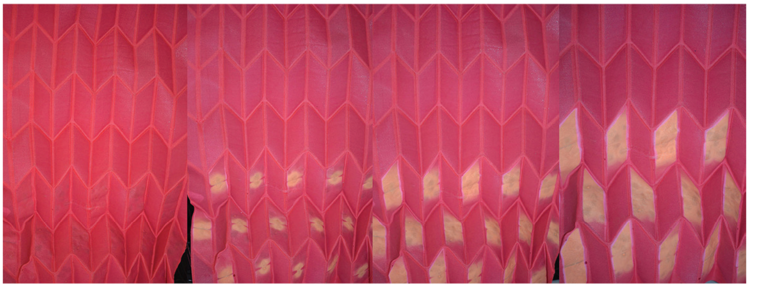

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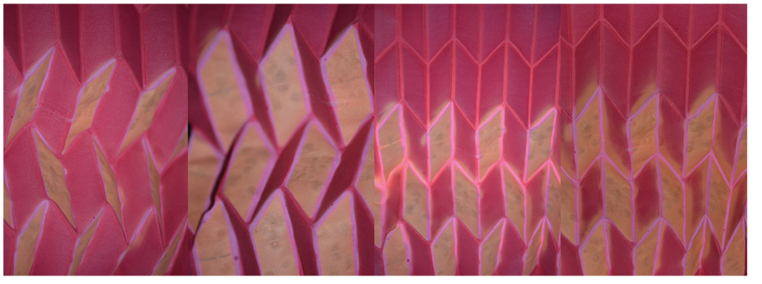

more accessible in the creative industries in recent times with the increased availability of desktop rapid prototyping. The ability for designer-makers to adapt current practice in line with manufacturing technologies opens up several possibilities for practitioners wishing to bridge gaps in disciplines. Increased access to continually evolving open source hardware and software make it possible for designers with no experience of 3D modelling or programming to create plausible concepts and explore customisation and adaptation of desktop manufacturing to suit their individual practice. This exciting revolution could potentially change the way in which the creative industries work and opens up further collaborative possibilities (Ratto 2012).

Anouk Wipprecht is at the cutting edge of the fashion/design/technology interface. With a background in fashion design, Wipprecht now works mainly in collaboration with various designers and engineers to achieve a combination of engineering, science and interaction design. Her artistic creations go beyond wearables and she has described them as systems for the body (Wipprecht 2012). Using new smart materials to build prototypes, Wipprecht (2012) has worked with V2_Lab, Institute for the Unstable Media and Studio Roosegaarde amongst others.

There has been an emergence of niche companies utilising technology and smart materials in fashion, such as Rainbow Winters. The founder, Winters (2012) uses fashion as a platform to explore the emotive and aesthetic capabilities of emerging technologies through illuminated textiles, sensors, colour-changing inks & nanotechnology. Also, Studio Nancy Tilbury has carved a niche service in which she explores future Fashion Interactions. Her work is focused on responsive, computational textiles/materials and their relationship to future fashion, sportswear and wearable health devices (Tilbury 2012).

The research presented in this paper is informed by wide-ranging literature, however, it is grounded in knowledge gained through previously published research on the application and potential of smart materials on textiles and the prior experience of the team in pervasive computing. Sharing knowledge and bringing often-separate disciplines together to build a broader and more in-depth knowledge base is tackled through the prototyping work packages documented in the following sections. They have been utilised to begin to develop responsive textile surfaces that could potentially be used as a ‘smart’ costume for a dance (inspired) performance. The performance space is intended to be the pervasive computing environment, which would enable the ‘performative’ qualities of the materials, such as colour-change to be activated and controlled within that environment.

FABRIC DEVELOPMENT

Silk twill fabric samples were screen-printed with a combination of thermochromic and fluorescent dye systems. Interestingly, after printing, the silk fabrics took on the handle of paper, naturally lending themselves to the printed origami fold structures. This enabled them to be folded with more ease than an unprinted sample. The sample shown in figures 2a and 2b was printed with a specially prepared print paste containing red thermochromic slurry activated at 31°C, orange and pink fluorescent pigments (which emit light under black light conditions).

This combination provided a transition from magenta to a fluorescent orange and pink. As the red thermochromic (which resembles magenta in this combination) goes through a transition to colourless (on temperature change) the orange and pink fluorescent pigments are revealed. This combination is designed to create, firstly, a colour change and secondly an emissive fluorescent effect.

ELECTRONIC PROTOTYPING

The method used to develop the electronic circuits that are intended to be activated within a pervasive computing environment exploit a relatively simple heat sink based system. The prototyping involved making individual heat sinks from self-adhesive copper cut to the size and shape of the individual elements of the geometric facets and applied directly to the back of the fabric samples as shown in figure 3.

Each individual heat sink is made up of two halves of copper tape, which replicate a section of the folded faceted structure. The two halves of the copper heat sink are joined by a small surface mount device (SMD) resistor (1mmx3mm) with a resistance value of 150Ω, which is soldered between the two halves as shown in figure 3. This method exploits the thermal conduction properties of copper; the resistor provides the heat when powered which spreads into the copper shape creating a colour change silhouette on the reverse side of the fabric. Insulated copper wire was used to connect each individual heat sink to make a chain (parallel circuit) that was powered by a portable variable power supply. Each row of facets that needs to be heated requires the same process.

DESKTOP 3D PRINT PROTOTYPING ON FABRIC

A workshop 'Crafting the Future' held at The Dutch Electronic Art Festival (DEAF) 2012 explored desktop 3D polymer printing directly onto textiles. The workshop enabled some initial origami structures to be produced, which are shown in figure 4.

Inspiration from this workshop has driven the research in another complementary direction, which is to explore desktop 3D printing to create the structural and component elements of a smart textile surface. An Ultimaker desktop 3D printer has been procured and built and is currently at the early stages of being tested for prototyping 3D polymer printed structures directly onto a range of fabrics. Figure 4 demonstrates the potential of the aesthetic and functional possibilities of combining this emerging technology as a means to pattern or construct 3D textile surfaces.

PERVASIVE COMPUTING ENVIRONMENT

To bring these fabric elements to life in a performance space it is anticipated that the textile/costume will react and respond to signals that it sends and receives from various sensors that are embedded in an environment. On-going research is based on using the Microsoft Kinect, a motion sensor device which can detect movement, speech and faces, to detect a colour change in the completed fabric samples. Initial studies have focused on establishing how the Microsoft Kinect performs in tracking a 'smart' costume that has thermochromic colour change elements (which are non-emissive) under different lighting conditions. A computer application was created using Kinect API an application that is capable of detecting, tracking and measuring colour (Red, Blue and Green) via the Kinect sensor.

SUMMARY

The research reported is in the initial phases and therefore it is too early to draw conclusions, however, we can highlight the next stages. The project will continue to explore how textiles, electronics, 3D print and pervasive computing come together through the development of a smart costume. The next stage of the fabric development will start to consider how structured surfaces can be designed as part of a costume inspired by the work of Anouk Wipprecht, V2_Lab and Studio Roosegarde. The electronics are being designed alongside the fabric and will continue to be prototyped in a relatively low-tech way to enable proof of concept. The visible nature of the heat sinks draws parallels with Wipprecht's (2012) work by openly showing the electronic working systems.

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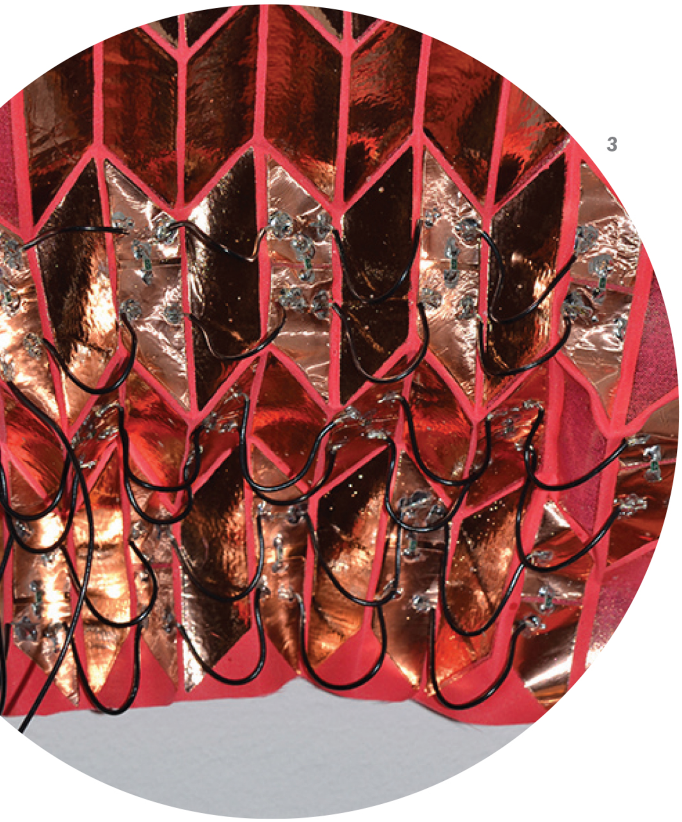

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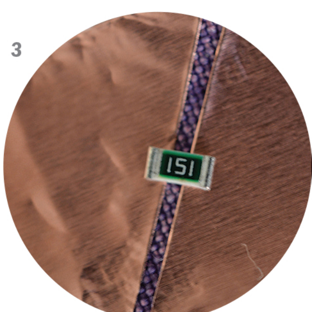

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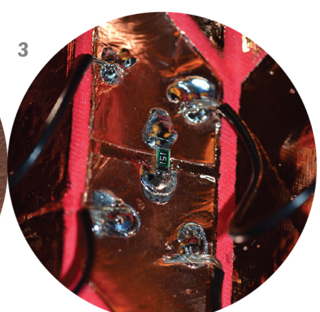

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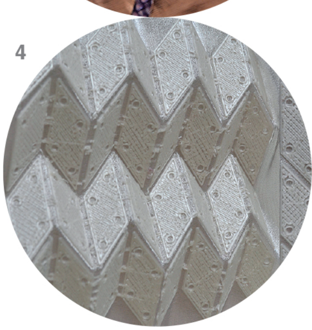

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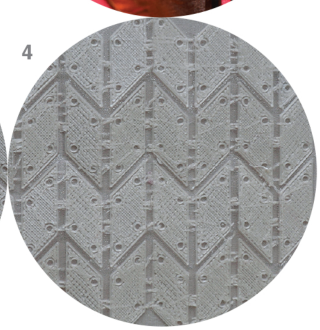

The electronics are to be combined with various sensors and Arduino to establish parameters for actuating colour-change in the conceived pervasive computing environment. Something yet to be defined will act as a trigger and 'talk' to the costume and the ways in which it will do this are still in development. The utilisation of the Kinect sensor as a means to detect colour change in an environment is currently being tested in combination with different light sources. Various costume colour change states will be created through use of heat, light and movement to test further the parameters of the Kinect in a pervasive environment.

As this is an ongoing research collaboration combining different disciplines and novel processes we aim to exploit new ways of communicating our ideas through conceptual mock-ups and prototypes. These will take influence from the work of Studio Nancy Tilbury and her work with Philips by showing a purely conceptual idea and future concept through the artistic and creative use of photography and video manipulation of imagery. The range of influences and inspiration for this work and the continued development of the project are reported in an informal blog format 'codedchromics', which will present significant results at the culmination of the project (codedchromics, 2013).

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FIGURE CAPTIONS AND CREDITS

Figure 1: Thermochromic non-woven (30cm x 60cm) shoulder piece showing colour change.

Figure 2a: Thermochromic and fluorescent silk fabric sample showing transitional colour-change.

Figure 2b: Thermochromic and fluorescent silk fabric showing fluorescence under black light.

Figure 3: Heat-sink development shown on the reverse of the fabric.

Figure 4: 3D Printed origami sample approx. (15 x 15 cm) folded and unfolded – PLA polymer on organza.