IDEAS GENERATED DURING THE TEXTILE SENSORS AND ACTUATORS WORKSHOP, EPSRC Network: *Smart Textiles for Intelligent Consumer Products*

Project Stream 1 | Textile Sensors To Be Developed

Signals To Be Sensed Physical Sensors:	Platform Textiles To Be Developed Textile Sensors to be developed
• Respiration	Textile mechanical resistance
• Heart Rate	Textile electrode
• Pulse Rate	Textile electrode
• Movement/gesture	Textile accelerometer
• Pressure	Textile switch
• Audio – speech, intonation	Acoustic array
• Visual – facial expression, eye gaze	
• Brain activity/waves	
• Micro-tremors in muscles/fibres	Textile electrode
• Environmental- temperature, colour	Photochromic polymer fibres
• Rip/tear/strain	Optical fibres
Chemical Sensors	
• Perspiration	Galvanic skin
• Aroma	
Actuation in Response to Signals Physical Actuators:	
• Visual Display – colour, pattern, light	Colour-changing fibres/light emitting
• Tactility	Electroactive actuator polymers
• Shape	Electroactive actuator polymers
• Porosity	Electroactive actuator polymers
• Sound	Acoustic array
• Heating/cooling	Encapsulation
• Vibration	Electroactive actuator polymers
Chemical Sensors:	
• Aroma	Encapsulation
• Drug delivery	Encapsulation

IDEAS GENERATED DURING THE TEXTILE SENSORS AND ACTUATORS WORKSHOP, EPSRC Network: *Smart Textiles for Intelligent Consumer Products*

Project Stream 2 | SPORTS CLOTHING

The Idea | *PERFORMANCE-ENHANCING CLOTHING*

Improved Physical Performance and Appearance | a range of clothing that can improve performance in sport, leisure and everyday activities. This is a clothing range that should sense locomotion patterns and/or monitor body posture. It may aim to either enhance our performance or improve the perception of our physical appearance through facilitation of posture improvement and conditioning gesticulation and locomotion patterns.

Research Objectives | *WHERE TO GO/WHAT TO DO*

Although smart textiles are about to become feasible for mass production, their appropriate use is hindered by lack of definitive knowledge in different areas of human physiology/biomechanics as outlined below. Of course human body is an extremely complex system with myriad of individual variations. However, it is necessary to aim for definitive quantitative information that fills the necessary cells in the structure of a bigger project. If wearable technology is to help people perform better one needs to know the underlying performance mechanisms. Furthermore strategies for improvement should be automated and responding with on-line command/actuation. These strategy need to be based on analysis of individuals' features and self-adaptive.

Associated Research Areas | Developments Needed

Motion pattern recognition and classification
Baseline for individual locomotion patterns
Muscles physiology - force sharing, co-contraction, muscle synergy
Physiology of neural stimulation
Biomechanics of human movement
Energy expenditure and work physiology
Optimisation of locomotion patterns

Technological Developments Needed for Successful Product Launch

Sensor development
On-line analysis system with decision-making facilities
Actuators for locomotion instigation
Design of ergonomic clothing
Integration of sensors, analysis systems in textiles

Applications

- Business – clothes that make us maintain appropriate posture, instigate short exercises, positional readjustment
- Recreation – clothing that helps make the best out of limited duration exercise, helps to improve/achieve in the shortest time
- Leisure – clothing that can adapt to adverse weather conditions – humidity, cold/hot weather, etc.
- Creativity – dancing, for example, where grace of the movement is facilitated/enhanced
- Driving – helping to readjust the posture, monitoring alertness to avoid accidents, etc.
- Athletics – facilitation of performance improvement through analysis and implementation of improvement strategy through built-in actuators
- Medical – posture control, support of deficient joints, compressive bandaging
- Social Interaction – response to environment, weather, day-time, social situations

Expertise:

Design - Sharon Baurley, CSM; Philippa Brock, CSM; Philip Delamore, LCF; Sue Jenkyn Jones, CSM; Lisa Stead, CSM
Athletes/sportsmen – Scott Drawer UK Sport Institute
Sensors – Kistler Ltd; Motorola
Medicine
Computing
Textile/sensor/actuator materials
Technical textiles - Philip Crispin, Eleksen, George Stylios, Heriot Watt University
Electronics - Philips Research
Mobile communications -

Molecular electronics - Kodak
Wearable computers - University of Bristol
Thomography -
Processing platforms -
Biomechanics - Queen Mary University London
Product development - Carbonate; MIT; UK Sport Institute
Industrial partners -

Project lead: Peter Dabnichki, Queen Mary University of London

IDEAS GENERATED DURING THE TEXTILE SENSORS AND ACTUATORS WORKSHOP, EPSRC Network: *Smart Textiles for Intelligent Consumer Products*

Project Stream 3 | HEALTH CLOTHING

A range of topics emerged from the session:

- A smart garment that would assist the frail or elderly – detect posture, tremor, motion, etc. Prevent damage due to falls – wearable airbag system.
- Smart bandages – with sensors to monitor healing, pressure, delivery of drugs, etc.
- Detection of illness by conventional clothing – display and monitoring.
- Life shirts, etc. – monitoring of patients in hospital environment. Only for ambulatory – monitor after first stroke.
- Cost of embedded technologies and sensors – impact on the developing world.
- Importance of emerging technologies for textile surface modification – e.g. gas plasma treatment.
- Need for multi-functional textiles – with a range of applications.
- Need for new fibres with greater functionality.
- Supportive fabrics e.g. flight socks – area sensing – visual readout to confirm effectiveness.
- Reparability of textiles.

Three concepts emerged:

1. Reactive Clothing – pressure, compression and rigid – trauma prevention and care

Interested participants would include Leeds, Reading, CSM, Queen Mary and TechniTex. Brian J. McCarthy of TechniTex agreed to progress the proposal.

2. Platform Textiles – medical applications – allow plug and play – e.g. base technology into various clothing formats – e.g. hollow fibre for specific chemical additives, addition fibre development.

Interested participants would include NWTexNet, UMIST and Heriot-Watt. Dr Bert Mather from Heriot-Watt agreed to progress the proposal.

3. Clothing reacting to your health or state of mind and sexuality – emotional and 'well-being' – reactive dyes e.g. humidity colour changes – conducting fibres with fibre as communicator.

Interested participants would include CSM et al. Dr Joan Farrer from CSM agreed to progress the proposal.

Expertise:
Textiles – North West Textiles; Heriot Watt University; TechniTex
Textiles and electronics –University of Leeds
Materials –UMIST; University of Reading; Queen Mary of University of London
Textiles/fashion and sustainability –CSM
Nanomaterials –QinetiQ
Medical product design – PDD

Project lead: Brian J. McCarthy, TechniTex

IDEAS GENERATED DURING THE TEXTILE SENSORS AND ACTUATORS WORKSHOP, EPSRC Network: *Smart Textiles for Intelligent Consumer Products*

Project Stream 4 | ENVIRONMENT

Our group discussed a number of aspects essentially focussing around 'industrial' textiles rather more than clothing or 'consumer' textiles. This was principally driven by the inclusion of Engineers from the MoD, Arup and academics from Engineering Departments with research related to structural membranes and biomimetics. This constituency also lead to a biased list of topics of interest for future research. These were:

•'Living fabric'
•Biomimetic fabric - fluid-structure interaction, breathability
•Rip-repairable fabrics
•Self-repair
•Strain measurement/monitoring - fibre optic sensing, array sensors
•Damage indicating fabric - "bleeding"
•'Structural' integrity monitoring
•Dynamic changing of the structure of a material - morphing to change the fabric properties

Expertise:
QinetiQ, Cody Technology Park Farnborough
Arup Research+Development, London
School of Textile and Design, Heroit Watt Univ.
Biomimetics, Reading Univ.
Eleksen

Project lead: Peter Gosling, Structural Mechanics, Newcastle Uni.

In terms of grant applications, there would seem to be a good group of people together here already to put an application to EPSRC in the biomimetics / smart materials type area that could cut across both pure engineering and the social sciences field. (If the latter were included we would need to bring in more non-industrial textile experts).

IDEAS GENERATED DURING THE TEXTILE SENSORS AND ACTUATORS WORKSHOP, EPSRC Network: *Smart Textiles for Intelligent Consumer Products*

Project Stream 5 | CLOTHING & EMOTION

The Idea | *emotionally-responsive clothing*

Emotion management through emotional intelligence | a research programme to develop a range of textiles and clothing that can sense, communicate, express, monitor, modulate, influence, compliment, enhance, suppress and respond to human emotions for a range of applications. A central focus is to establish whether or not a *language of emotions* can be determined; and whether wearers can use this emotional intelligence to manage and use their emotions to positive effect.

Applications
•Mainstream clothing/fashion, leisurewear, e.g., teen market – clothing that changes according to mood, feelings, and emotions, and environmental context to help influence mood
•Urban camouflage, e.g., expressing/communicating or suppressing emotion according to urban context; clothing that changes according to environmental context to help influence mood
•Communication clothing - mobile communications integrated into fashion, e.g., exchanging emotional information remotely
•Gaming wear, e.g., emotional intelligence is used to play computer games
•Children's clothing, e.g., learning *tools* for autistic children
•Sportswear, e.g., stress management for performance enhancement and monitoring
•Workwear, e.g., stress management; clothing that changes according to environmental context to help influence mood
•Ubiquitous *healthcare/wellbeing* clothing, e.g., stress management; clothing that changes according to environmental context to help influence mood

Research:
•Identify possible emotional meanings based on physiological and behavioural information according to context; can these signals be translated into a *language of emotions*?
•Can a catalogue of appropriate outputs/responses be determined and mapped with the language of emotions into a model, so that clothing becomes truly responsive to the body and the environment?
•Can a clothing system *learn* from its wearer, so that emotional identification and response become unique to that person?

Expertise:
Social science -
Psychology - HP Labs
Design - CSM, LCF
Bio sensors -
Technical textiles - Eleksen, Heriot Watt University
Wearable electronics/GPS - Philips Research
Mobile communications -
Nanotechology - QinetiQ
Polymer materials - Queen Mary University London
Molecular electronics - Kodak
Wearable computers - University of Bristol
Affective computing – Imperial College
Signal detection theory (getting it right) -
Processing platforms -
Bio-mechanics - Queen Mary University London
Civil liberty design (social acceptance) -
Product development - Carbonate, MIT, UK Sport

Project lead: Sharon Baurley & Lisa Stead, CSM

IDEAS GENERATED DURING THE TEXTILE SENSORS AND ACTUATORS WORKSHOP, EPSRC Network: *Smart Textiles for Intelligent Consumer Products*

Project Stream 6 | ENVIRONMENT & EMOTION

The Idea | Pattern Recognition of Emotions and Expression

- **Aims:**
  Fabric in multiple layers allows the possibility of including complex sensing local computation and actuation into a simple multi layered building component, which can be fixed at any angle. The aim of this proposal is to examine whether this material can identify "emotion" from human behaviour and provide a varying output, which can be recognised as the "emotion" of a space.

  The research questions include:

- Is a "Turing test" of emotions possible by a space or by space users?
- Does this vary by age, culture, circumstances or physical space?
- Input: movement, sound, touch and local physiological sensing.
- Computation: distributed, woven in.
- Output: colour change, shape change, light change, speakers and sound, haptic change.

- **Research method:**
  - Constructing one to one samples and testing with different users.
    Expertise required: designers, architects
  - Computer science for expert systems,
  - Electronic engineers
  - Psychologists for evaluation

Expertise:
Materials –University of Reading; QinetiQ; TWI;
Textiles – Mediatex/TechniTex
Textile Design – CSM; Heriot Watt University
Built Environment Design – Bartlett, UCL; CSM; Foster and Partners; ARUP
E-Textiles – Eleksen
Civil Engineering – University of Newcastle
Affective Computing – Imperial College London
Automotive – Consultant to BMW
Communications – British Telecom
Media – Piranet

Project lead: Steven Gage, Bartlett/UCL

TURING TEST FOR 'EMOTION'
A research question: Is it possible to develop a version of a 'Turing Test' that relates to the 'emotional' states of inanimate objects? The specific area of enquiry relates to spaces and objects in the built environment. Objects and places have been described as angry, calm, joyful and frenetic in the past – often because they contain anthropomorphic sculptures and paintings, sometimes because of attributes of shape, light and colour.

Historical examples are usually static, although there are examples of spaces changing dramatically through the opening of doors or shutters. In static architecture the only autonomous moving parts are people and animals, solar and weather systems and the process of gradual decay. Literature abounds with descriptions of the transformations of places at dawn and dusk for example.

Our understanding of emotion is usually informed by transformation, as someone changes from calmness to joy, for example. Recent technical development in the design of the fabrics used in the built environment has enabled the possibility of a range of transformations. We use the term fabric broadly, to include a wider range of materials from metal meshes to furnishing fabrics and weather membranes. These fabrics are

laminated and interleaved to create a vast range of composite materials. We can specify materials which change colour, surface texture, local and overall shape. We can specify materials, which emit and absorb sound and light in varying degrees, changing from opaque to transparent, for example. Both local and global shape change can occur in fabric more easily than in rigid or elastic mono materials. Thick fabrics can incorporate rigid elements (like boning in corseting) and elements which change in length. The result is a network of easily activated 'limbs'; pleated and padded materials can accommodate shape change and movement using techniques derived from dressmaking and origami.

A vast array of sensors can be woven in to detect local conditions and monitor transformations including the local behaviour of people. Cheap, small, uniquely addressed computers can be incorporated to locally respond to changing conditions. Emergent properties are possible. Some of the potential behaviours of this changing material architecture could be driven by external environmental factors e.g. to increase shading and insulation. Others could be more direct responses to occupancy e.g. acoustic conditions vary according to the number and noisiness of occupants. Others could respond to other human functions, such as the speed and nature of human movement.

At what point do users read these changes in the space as 'emotional reactions'?
There are good reasons why architects and designers seek to affect the emotional reading of spaces and places, to heighten awareness and to give pleasure, to induce caution or a sense that the environment needs to be protected, and the idea that a place could have a 'personality' or 'personalities' extends the dimension of design considerably. Can this be done with any reliability?

The research question can be broken down as follows:

1. Can emotions be attributed to a space? I.e. are 'angry' or 'happy' spaces possible?
2. Is this attribution constant, or does it vary by age, culture, circumstance, place or physical and mental well-being?
3. Is this attribution enhanced by changes in a space as a perceived result of observers' behaviours, and how important is interaction and feedback?

This research proposition can only be undertaken using mock-ups, where real or virtual spaces are created to be explored by different observers.
It is multi-disciplinary, and needs to involve the following broad areas of expertise.

1. Architects and designers with experience of working with interactives:
2. Computer scientists/electronic design engineers.
3. Psychologists. Because the potential range of sensory experience this work could include experts in synthesisia.