It is ironic that biometrics, the science governing some of the latest developments in security, currently heavily focused on air transportation for obvious reasons, has been given a title that is itself the result of a linguistic hijack. Derryck Draper explains -

What's in a name?



CSIRO knee sleeve

Biometrics is 'the study of biological data by means of statistical analysis that is used to establish the inheritance of physical traits in a population'. And this has nothing whatsoever to do with the current application of the word to the development of security systems that are designed to facilitate either access to information or some activity such as boarding an aircraft. They do so by electronically establishing an individual identity from matching some aspect of anatomy or behavioural characteristics against a database. A distinction is often made between establishing an identity and authorisation – where the individual narrows the search by inputting a name or PIN as a primary requirement.

Bio-telemetry – signifying the measurement of the personal characteristics as presented against known data – is, I submit, a much more accurate word for the matching process. But in the face of several thousand pages of published information, the existence of a significant number of trade associations and the financial thrust into singular research, perhaps discretion is the better part of pedantic accuracy. Biometrics it is.

Current research and development has three threads. First, the security issues already mentioned. Second, military possibilities linked to communication, responses to physical trauma and establishing location. And third, the measurement of physiological responses during athletic activity, subsequently extended by intelligent textiles into every sporting endeavour.

Athletes will possibly only be concerned with the security aspects when withdrawing funds from an ATM, activating their ski pass or gaining access to the next Olympic village. Military links are more fundamental in that they provide the government-funded base for research that often has an extension into performance apparel. It is the third of our threads, applications in the context of athletic activity, that demands closer examination here.

Tell me – how do you feel now?

For the final third of the twentieth century, the recorded assessment of physical reactions at any given moment during stressful activity – such as running, jumping or throwing – usually depended on a hard-wired connection to static instrumentation, which in itself probably contributed as much to the stress element as the activity undertaken. Any success was limited by the complexity of the measuring equipment and the size and weight of the machine/body interface.

The development of 'chip' technology and the latest work on fuel and solar cells as a source of electric power has almost made a mockery of those problems. Wearable communications and ultra lightweight sensor modules have given both sports scientists and subjects a high level of physical freedom, with the expansion of the technology into everyday life more than just a possibility. To quote Dr Barry Holcombe, of the Australian CSIRO facility, speaking at a recent Electronic Textiles workshop:

"We are on the verge of a textiles revolution. Our clothes are set to become active participants in our lives and activities — warning us when we are becoming stressed or sick, actively protecting us from the weather."

But on another occasion, and not that long ago, Holcombe had written:

'Developments in intelligent textiles are likely to be driven from a number of different directions. The one that catches most media attention is wearable electronics - clothing that integrates communication, navigation,

computing power and entertainment into a single system. Whilst the concept is attractive, my feeling is that such products are a long way off - possibly as far as 20 years. The technological hurdles to be overcome before garments that incorporate these functions are at the stage of being able to withstand the rigours of normal wear and tear and be resistant to processes such as laundering and ironing are enormous. Even if developments in conducting and semi-conducting polymers bring unit costs of electronics way below those of current technology I doubt if they will ever be cheap enough to be considered disposable. Developments will be incremental, starting with discrete systems that are complex and obvious in the clothing and progressively moving toward complete integration as the necessary textile technologies evolve.'

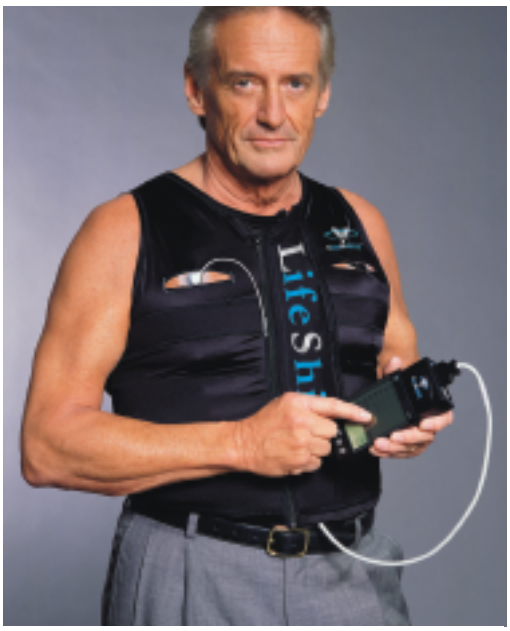
Converging parallels

In the past we have discussed the possibilities in the development of base-layer garments that are capable of monitoring the physical condition of the wearer and reporting back to a receptor station. At the time, such items were apparently no more than a gleam in a technologist's eye, but the god of parallel development has again touched the earth and two products have been launched within as many months. VivoMetrics Inc, of Ventura, California, and Sensatex Inc, of New York, have both recently released details of textile-based wearable communications systems capable of providing a physiological monitoring function in base-layer garments.

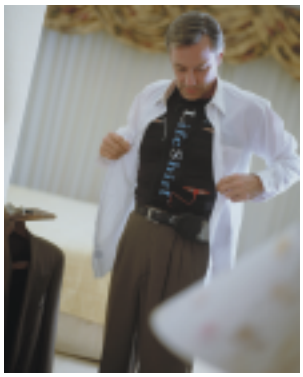
The LifeShirt from VivoMetrics has been developed in tandem with the US Air Force Institute of Technology within the parameters of health monitoring for Service personnel and 'at risk' civilian patients. Based on inductive sensor technology, the shirt uses copper wires woven with elastane yarns into narrow bands of fabric placed strategically around the upper torso as part of a T-shirt design. As the bands expand and contract they create the magnetic field that in turn produces sufficient electromotive force (emf) to power the sensors. A waist level bus connection links to a handheld computer and processes data onto a 64Mb flashcard from whence it may be sent to a processing centre via a modem, direct telephone link or postal delivery.

The medical applications for the LifeShirt are the driving force behind its development. Vital signs monitoring for those suffering from heart disease or respiratory infections plays a conclusive part in further diagnosis and treatment. As a piece of military equipment it will use the heart and respiratory monitoring functions as the means of building a general picture of the wearer's fitness for duty. An additional Global Positioning System sensing function enables commanders to locate personnel on a continuous basis.

The extension of the last package into sports medicine and athletic performance monitoring is almost a certainty. It is not difficult to visualise applications in adventure racing and long-distance running, and the outcome of a number of fatal incidents in the past could have been avoided had such a piece of equipment been available. However, it is a fact that practitioners in these areas of human endeavour may well feel that a communicating T-shirt is the last word in 'nannying'.







The LifeShirt from VivoMetrics

From nanny to motherboard

Textile technology, wearable electronics and the wireless transfer of data form the operational aspects of the SmartShirt system from Sensatex. Sub-headed as a 'wearable motherboard', the sensor-linking element is a mixture of fibre optics and conducting yarns that was developed at the Georgia Institute of Technology under the guidance of the US military's Defense Advance Research Projects Agency (DARPA).

The technology package can be incorporated into almost any fabric suitable for manufacture into the shirt format and is said not to affect the hand or visual aspect of the finished garment. Power for both 'motherboard' and the shirt's data controller is provided by a rechargeable battery housed within the latter's pager-type body.

SmartShirt data is transmitted as an instantaneous readout to an appropriately sited computer or base station using wireless telegraphy and an interface, which may take the form of a wristwatch or a pocket PC. A spokesperson for Sensatex said that the company plans to focus on the health and fitness market to help athletes increase team training efficiency, ensure physical safety and provide sports entertainment. Individually it is possible to use the system to improve physical fitness, enhance the recreational sports experience – and even lose weight.

Both the US-developed garments depend on built-in circuitry prepared from conductive materials to which sensors are attached. Barry Holcombe mentioned conducting and semi-conducting polymers in his comments and some readers may find it surprising that this technology has not, apparently, been considered for the





SmartShirt system from Sensatex

products in question. The properties of these yarns, as demonstrated in the SOFTswitch fabrics launched jointly by UK-based Peratech and WRONZ Euralab last year, would seem to make them at least worthy of serious consideration. Euralab's Dianne Jones said that the working partnership (now SOFTswitch Ltd) is actively working on bringing the pressure-sensitive nature of SOFTswitch to bear onto the problems of taking objective physiological measurements and transmitting them wirelessly to a display or analytical function. She also said that the ability to adjust the level of sensitivity within the finished fabric meant that heart-rate, breathing, temperature and blood flow-rates to different parts of the body are all well within the scope of operation.

Stimulating the strain

The ability of ICPs (Inherently Conducting Polymers) to act as the sensing and actuating elements within intelligent material systems is the basis of the work of the IPRI (Intelligent Polymer Research Institute) at the University of Wollongong, New South Wales, Australia. The thrust of IPRI's activities to date has been to develop ICPs that are capable of being reprocessed to allow them to integrate with other host materials already credited with desirable mechanical properties.

As a practical demonstration of what can be achieved, the Institute points to the emergence of fibre actuators where textiles take on an active role in response to external stimuli, and where it has already patented several technologies. A cited example is sensors built in to an outer shell garment to detect differences in temperature and relative humidity levels between clothing layers. The developed signals trigger the outer fabric and the insulation layers to adjust themselves to optimum comfort levels by means of physical changes in the structure of the yarns and fabrics. In time, it is suggested, it will be possible to 'switch on' water repellency as the rain hits the fabric.

In this, and other projects, IPRI is in a collaborative alliance with Australia's CSIRO, which in November 2001 announced the launch of the 'intelligent knee sleeve', a biometric application that is not concerned with either security or performance measurement - at least, not directly so.

Reportedly poor landing techniques in sports such as rugby, soccer, Australian Rules football, netball and basketball are responsible for the majority of knee injuries, at a cost of several million dollars worldwide in medical treatment and player lay-offs. The knee sleeve was developed to combat this particular problem. It uses textile strain sensors, textiles which have been subjected to a process that ensures their electrical resistance changes with the extension of the fabric. It emits an audio tone that alters with the strain applied to the knee as a player lands – one harmonic for 'good' and another (or nothing) for 'bad'.

We are told that the users rapidly adjust their balance and body angles on landing to produce only the 'approval' note and thus correct any postural misalignments or bad physical habits. The electronics are solid state at present and therefore not capable of being laundered, but Barry Holcombe suggests that developments in the immediate future will see the sensors integrated into the base textile. At the same time the conductivity can be achieved via pressure sensitive polymerics and the current button batteries replaced with super-capacity rechargeable fibre modules.

Holcombe continues:

"The knee sleeve work has already shown us that even professional athletes can improve their coordination and technique using devices like this. There are a host of potential sports applications beyond things like the intelligent knee sleeve. For golfers, a training garment that contains an array of suitably located sensors could provide real-time feedback on the position of the various parts of the body in relation to that required to achieve the optimum swing.

Recovery from injury often requires progressive build up in movement or power of particular limbs and muscles. This could be easily achieved using sensors at the appropriate point or points in a garment or sleeve that fits over the affected area and is linked to some form of audible or visual feedback."

Performance in partnership

In addition to providing performance data to the coaching team, there is also the question of communication in the other direction - providing personal motivation and psychological support to sports practitioners as they strive for greater, faster and higher. This requirement has led to a number of apparently unlikely commercial pairings, the latest being Nike and electronics giant Philips.

The partnership is developing a range of wearable communications – 'smart clothing' in parlance – using conductive fibres and digital technology. The first products will be jointly branded MP3 and MP3-CD players light enough to wear around the arm while participating in fitness regimes. But the full intention is to produce apparel-based products that will '…combine communications, connectivity and information to motivate athletic activity'.

The Brussels-based Starlab has also carried out a great deal of work in using the new technologies to explore the field of 'smart clothes' in its i-wear programme, whose members include adidas and Levi Strauss. One of the consortium's recent developments is a garment that identifies and memorises the objects the user is carrying or wearing: the device can thus broadcast an alert if keys, diary, etc., have been forgotten or lost.

These garments, and certainly others which perform some higher levels of computing activity, will almost certainly need to use the identification aspect of biometrics. Conductive polymer fibres can already transmit recognition data to off-garment locations; to apply the same data to enable an on-garment sensor is no great problem. The athletic apparel that only works for the owner is almost upon us.

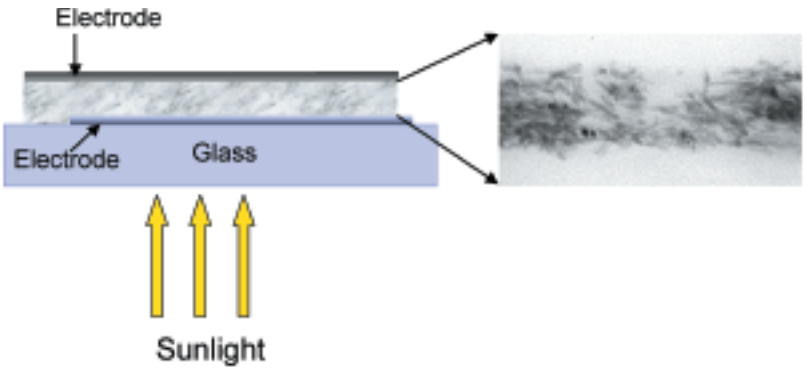
You got the power

The supply of an appropriately lightweight source of emf is another opportunity being actively researched by a number of diverse industries. Aerospace and automotive technologies are possibly the most power-hungry with every day familiarity, but the potential in the wearable communications market for an ultra-lightweight source is driving research forward rapidly.

Sunlight is undoubtedly the cheapest source of energy and the ability to harness its power has been with us for many years, but always at a weight-laden price. However, a recent outcome of work undertaken on the Berkeley campus of the University of California suggests that it will soon be possible to produce cheap plastic solar cells with sufficient flexibility to enable them to be painted onto any surface.

A product developed with nano-technology, the cells are only operating at 1.7 percent efficiency for the present, but the ongoing programme suggests that 10 percent efficiency is within reach. A member of the development team, Janke J Dittmer commented:

"The beauty of this [development] is that you could put solar cells directly on plastic, which has unlimited flexibility. This opens up all sorts of new applications, like putting solar cells on clothing…"



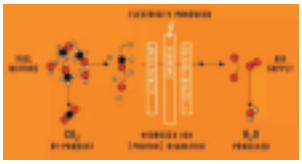
Work undertaken on the Berkeley campus of the University of California suggests that it will soon be possible to produce cheap plastic solar cells with sufficient flexibility to enable them to be painted onto any surface

The research into low bulk, lightweight and rechargeable energy storage modules to power the application of biometrics is being pursued with the same vigour as the work on the main projects. Currently, however, the lack of suitable products constitutes a substantial block on progress towards the full viability of wearable computing power as the means of processing physiological data at source. The answer may lie in recent work on the micro fuel cell concept as epitomised by the programme being run by MTI MicroFuel Cells Inc, a subsidiary of Mechanical Technology Inc of Albany, New York State.

Fuel cells create energy through a chemical reaction between a fuel, in this case methanol, and a catalyst. Recharging is by means of a fuel cartridge that removes the necessity for a lengthy recharge and proximity to a primary power source.

The company has recently announced the award of $500,000 to augment and support a joint $9.3 million research and development programme by MTI MicroFuel Cells and DuPont. The two companies received an award of $4.6 million in August of last year from the Advanced Technology Program of the National Institute of Science and Technology. The prime objective of the work is to develop an advanced micro fuel cell system as a power source for portable electronic devices such as mobile phones, personal digital assistants, convergence devices, laptops and other portable electronic devices.

In March 2002, MTI Micro demonstrated a second-generation micro fuel cell prototype that was over 20 percent smaller than its original model, offered the same capacity and included the sophistication of integrated electronic controls. The company has set a 2004 target for entry into the mass-market.



MicroFuel cell schematic from MTI

It's fun

In researching this feature it has become obvious that all concerned demonstrate enormous enthusiasm for their work, its outcomes, and the possibilities for future developments. There is a consistent air of excitement that is generated by the certainty that they are only just beginning to tap the potential in intelligent textiles. There's a lot of fun in the future.