Human Motion Analysis

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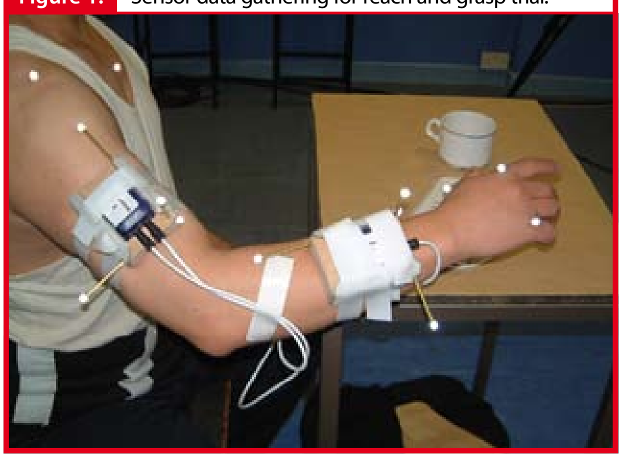
Huge market potential exists for products that will help the growing elderly population live independent lives for as long as possible. Sensors play an essential role in many of the diagnosis, monitoring and treatment devices to be used in the home. Some of the innovations in this area are reported.

New product opportunities

Sensor units are employed to determine human movement and position and for close monitoring to analyse, for example, back movement when lifting. For this type of application, sensor and system accuracy is important because acceleration signals are integrated to provide true position data. Traditional units are large and expensive, which limits their use.

In the past few years there has been rapid advancement in the development of microfabricated inertial sensors and microelectronics. This has enabled system designers to look at new application areas that previously were not feasible. Running in parallel with this sensor evolution has been the realisation that the rapidly increasing elderly population will need alternative forms of medical treatment. This new form of care includes a range of approaches collectively referred to as "Assistive Living." The aim is to help people to live at home for as long as possible by providing suitable diagnosis, monitoring and in some instances, treatment at home. This has led a number of groups to look at how specific human movement information can be used to monitor, diagnose and in some cases, raise an alarm. It has been found that a number of medical conditions have clearly identifiable movement patterns. For example, epilepsy, muscle degeneration and Parkinson's disease will all exhibit a specific movement pattern. In addition, activity monitoring relates directly to the human movement.

Figure 1: Sensor data gathering for reach and grasp trial.



This emerging field of Assistive Technologies (that is, products to provide assistance in the home) is now just starting to capture the interest of the National Heath Service (NHS), which recognises that it can have a significant impact on reducing the cost of care, particularly for the elderly population in the future. As a market with huge potential, it is also starting to interest industry.

For industry to be able to offer solutions to the NHS and individuals, new systems need to be developed. Concept solutions for some medical applications are being developed. Some of this work has been undertaken at national level and some through the European Union (EU) funded project Healthy Aims.[1]

Three-axis acceleration system

An accelerometer sensor unit[2] is undergoing trials at Salford University's (Salford, UK) gait laboratory. The unit provides three axes of acceleration and temperature data if required, and is linked to a PC via the USB port. The units are small compared with what is currently available: $41 \times 30 \times 14$ mm and have a range of 5 g (where 1 g is the acceleration due to gravity or 9.81 m/s^2), with a resolution of 12 milli-g. Acceleration data is digitally time stamped so that a number of units can be synchronised, and then data from all sensor units can be displayed on a PC as an acceleration/time graph and also stored for future use.

Stimulation implant

A new functional electrical stimulation (FES) implant for the upper limb is being developed[3] to help stroke patients who have lost movement in the hand and wrist. The implant will stimulate specific nerves to allow the wrist to rotate and the hand to open, thus enabling the patient to grasp objects. To achieve this, the implant needs to know when the patient wants to grasp an object. Inertial sensors are to provide the trigger signal.

The first phase of development has been to ascertain the type of sensors required and their optimum location (Figure 1). Phase two involves the collection of data using the accelerometer.

The type of arm movements a stroke patient would make was determined jointly with Salisbury Hospital (www.salisburyfes.com) and from this a test protocol established. Phase three aims to develop a suitable algorithm using the sensor data. This will then be coded into the firmware to produce the trigger for the FES.

Sensor units were placed on sample subjects and the acceleration data gathered. This data was compared with video data gathered from a Gait Lab optical-based measuring system man-ufactured by VICON (www.vicon.com) using signal processing developed by Salford University. The graphs in Figure 2 show good correlation between the video and sensor data, indicating that sensors could potentially replace the traditional optical-based measuring system. The benefit of this is that measurements can be taken anywhere, negating the need for an expensive gait laboratory. This application will be discussed in more detail in the Assistive Living session at the MDT Collaboration Forum on 16 February 2006 (www.mdtcollaborationforum.com).

Other applications

It is recognised that there are many other applications where the accelerometer sensor system could be used. A "Plug and Play" system has been developed that can be used by groups investigating aspects of human movement. The system collects and displays the required motion data and stores it for future analysis.

The sensor module could also be used as a tool by system developers in the same way that Salford University used it for the FES application. Specifically, when a system is to be developed that will utilise sensors, but it is not known how many sensors are required or their location, the developers will use the maximum number of sensors in a variety of locations and from this determine which sensors are required and where to locate them. This will help instigate new medical system developments for niche applications. Alternatively it could be used for diagnosis or monitoring the efficacy of a specific treatment.

Other human-motion applications are being investigated where knowledge of acceleration would be useful. For example, sports fitness centres to monitor exercise routines and compare with other people's or their own performance on a different day. The traces in Figure 3 show the three axes of acceleration obtained from

Figure 2: Linear acceleration of the forearm in reach and grasp task (glass).

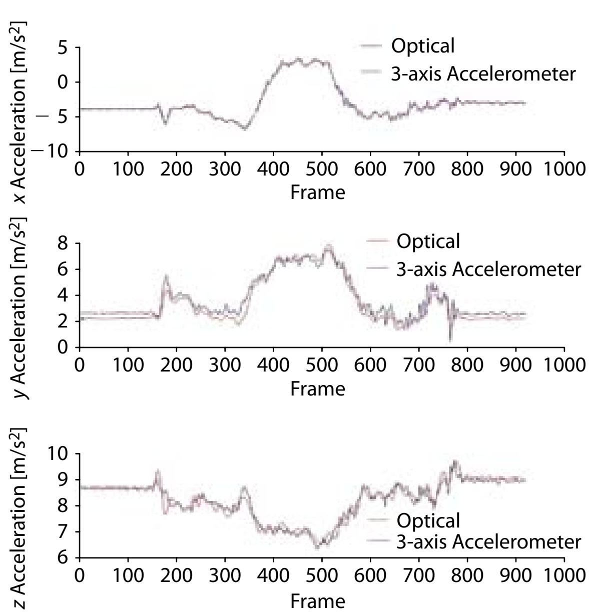
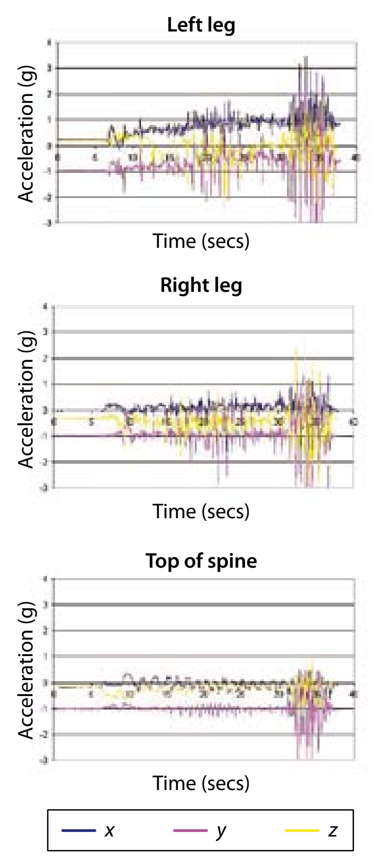


Table I: Example applications of new "Plug and Play" diagnostic and monitoring equipment.

- Companies developing training aids for sports, for example, running and athletics
- Companies interested in developing systems for motion sickness or deep vein thrombosis
- Physiotherapists monitoring conditions such as knee osteoarthritis
- Gait analysis
- Companies developing sports equipment, for example, rowing machines; data from a person using a rowing machine can be compared with data from a real oarsman, ideally, to show good correlation between the two
- Companies interested in industrial injuries such as repetitive strain injury could use the sensor unit to monitor actual movement
- Analysis of a golf swing, with sensors located on the person and possibly in the club.

Figure 3: Three axes of acceleration.



both legs and the top of the spine when running across the room and then stopping. This information could be used, for example, when training athletes, where movement on both legs should be comparable and the gait cycle can be determined.

The future

The recent developments in micro-electromechanical systems will enable system designers to develop a range of new "Plug and Play" diagnostic and monitoring equipment for medical, sports and general health and well-being applications. Some of these applications are outlined in Table I.

Reference

1. The €26-million Healthy Aims project started in December 2003 and is funded under the FP6 IST Microsystems call. The project covers the development of diagnostic tools and implants for a range of medical applications. It involves 28 partners across the EU and is due to run for another two years.
2. European Technology For Business (ETB) www.etb.co.uk
3. Finetech Medical Ltd, Welwyn Garden City, UK, www.finetech-medical.co.uk, working with Salford University www.healthcare.salford.ac.uk/crhpr and ETB.

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