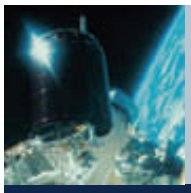

Networks for Engineers

Hot Spotter

by Stuart Shepherd

The Institute of Engineering and Technology May 2007.

Industry is no stranger to thermal imaging. Although the technique was first used for military purposes during the Korean War, refinements in thermographic cameras have since seen it applied to preven-tative maintenance, non-destruc-tive testing, structural analysis and energy auditing.

The ability to convert infrared emissions into temperature-graded images has been used to detect stress, wear and fracture, as well as showing up tell-tale 'component ready to fail' hot spots in items such as electrical insulators and air-conditioning units.

Until recently, at least in the UK, thermography's potential for revealing industrial injury has largely been ignored. The work of former British Coal electrical engineer Andy Lawton could change that, and may stimulate a broader debate about how thermal imaging can contribute to screening and diagnosis.

Lawton runs TEST Ltd, a medical-device validation service. He was already familiar with the conventional use of thermography to monitor fluid flow through pipework when he saw it being used to screen sports injuries in private medicine.

"Aware of the changes in 2005 to legislation on the use of vibrating machinery that require employers to provide health surveillance," he says, "and not forgetting friends and former colleagues from the coalfields suffering with the debilitating effects of vibration white finger (VWF), I looked at what thermal imaging might offer."

VWF often develops from prolonged use of heavy-duty breakers and other power tools. Fingers become blanched, numb and painful due to circulatory and nerve damage, which can be irreversible. Compensation payments to UK miners, made following recognition of the condition as a prescribed disease in 1985, exceeded £100m by 2004.

"Having spoken with Meditherm, a clinical infrared camera manufacturer," says Lawton, "I could see that the technology, backed up by published studies, has a lot to offer in terms of meeting the growing need for vibration exposure screening that construction and demolition companies face."

The mobile screening service he now offers is made possible by the portability of modern thermal-imaging systems. Hardware/software packages, including a small camera and a laptop to handle storing, transmitting and receiving images, now cost around £20,000.

CARRIED AWAY

It wasn't always like this. Early infrared cameras needed liquid-nitrogen cooling, which made them bulky, dangerous and hard to move. Dr Peter Leando, managing director of Meditherm and one of a few pioneers who dedicated considerable time and money adapting these industrial monsters for medical use, recalls his early experiences: "I first employed thermo-graphy in the mid 1970s, while working as a medic on the North Sea oil rigs.

The industrial Agema cameras, costing about £180,000, were used to save money on production down-time, looking for friction heat on bearings in order to replace them before they broke."

At that stage medicine had already experimented with thermal imaging. A large study in the US looked at using thermography to detect breast cancer but, with a wide range of equipment and protocols in use and unskilled people trying to read the resultant images, concerns about reliability and repeatability became overriding. In spite of its early promise, the study failed.

In the meantime, Dr Leando and his colleagues had started to use the technology to improve the decompression time and experience of divers. Thermal imaging let the medics see nitrogen gas, coming out of saturation in the blood and forming micro-bubbles, as a cold spot on the thermogram – a clear sign that it was time to recompress the diver. This close monitoring of divers gave medics better control of the process and could cut decompression times by days.

IN THE CLINIC

Back on dry land, the doctor and a team of fellow experts took a more academic approach to the medical potential of thermo-graphy, adapting the features and functions of industrial cameras that worked against their clinical use.

"While other materials have different rates of emissivity to which the camera has to be calibrated, the human body is an almost perfect emitter of infrared radiation, almost a black body," he says, referring to the ideal source of thermal radiation that underpins Planck's law. "Given that, thermography lends itself well to a whole range of medical applications, but to ensure accuracy you want a medical camera to capture as near to 100% of those emissions as possible."

The lenses of the industrial cameras had a problem doing this, so Meditherm's scanning radiometer does without them. Instead, a patented 'flying spot' system uses a high-precision mirror to bounce an infrared beam onto a concave mirror, from where it is focused on to an actively cooled single-element detector. A stepper motor swings the mirror up and down as it scans the area under investigation – hands and forearm in the case of VWF – taking 48,000 temperature measurements in seconds.

"The human body is thermally symmetrical," says Dr Leandro, "so, for screening the important thing is to get views of both sides. You then have comparative values from left to right and it is the differential that we are interested in, both as a baseline and then over a period of time."

Where other diagnostic tests are concerned with structure and look at anatomy, clinical thermography looks only at the blood flow in the skin to test physiology and sympathetic nervous system responses. Thermograms show where there is a problem. A cold area may mean reduced blood flow as a result of nerve irritation. Hotter spots may be the result of inflammation, or problems with E F internal organs or soft tissues. Fortunately, thermography is non-invasive and does not exacerbate any conditions.

VWF is especially difficult to see in its early stages in people used to working out of doors. Thermal imaging can help spot those who are most at risk. Introducing the technique alongside other surveillance methods is also bringing

valuable attention to a potential health and safety time-bomb.

HEALTH MONITORING

Both the scanning radiometer and its counterpart – the focal array microbolometer – are well establi-shed in the US and Australia as clinical instruments. Across the UK's National Health Service (NHS) however, thermo-gra-phy is offered in just a few centres. The cameras are used on patients with peripheral cir-culatory diseases, neurolo-gical diseases and complex pain syndromes.

Work by a team including Dr Francis Ring, head of the medical imaging research unit at the University of Glamorgan and former head of imaging at the National Hospital for Rheumatic Diseases, Bath (where William Herschel first discovered infrared) may instil more confidence in an under-used technology.

"We have been looking at all the areas in the technique that are subject to variability, with the aim of developing a protocol or standardisation to minimise what builds up to a sort of unre-liability factor," says Dr Ring. "Our knowledge of thermal physiology has improved dramat-ically, though. The high-speed, high-resolution proce-dures now do everything in fractions of a second to accuracies of 0.1°C or better without a problem, and bear no relation to the kit we wrestled with back in the 1970s."

The vascular centre at St Bartholomew's hospital, London, was one of the first centres in the UK to use thermal imaging. Dr Art Tucker, principal clinical scientist, has been working with the cameras for the past 16 years but his forebear, Ernest Cooke, after whom the centre is now named, pioneered their use and discovered that they could detect deep vein thromboses in the days before ultrasound.

"Thermography has a very wide usage," says Dr Tucker, "but the failings of the American breast cancer study chopped the legs from under it. I hope, however, to develop a programme to use it as an adjunct – not a replacement – to mammography. This would be useful for women who don't like radiation, whose breast tissue is too dense or for men who develop it but cannot opt for a mammogram. It also has potential for tracking the treatment of the disease. We must remember, however, that there are no non-invasive techniques that can give all the answers."