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Switched on

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Marconi's heart was in the right place when he patented a radio transmitter and receiver in 1897 but today that vital organ could cause problems. The asymmetric arrangement of human organs is just one of the aspects that frustrates designers of wearable wireless communication devices.

Philips Electronics, Zarlink Semiconductors, GE and many others would welcome the development of wearable devices that can transmit and receive relatively large volumes of data. A wristwatch video monitor could show high-definition moving images captured by a hat-mounted camera with no wires between the two. And synchronised audio could be delivered wirelessly to headphones from a microphone placed close to the action.

The trouble is that for wearable wireless communication devices to be practical and affordable, the antenna must be optimised. It is no good having a cumbersome aerial that requires a big battery. This is where our bodies let us down because human tissue is good at absorbing electromagnetic radiation. It is also why Professor Peter Hall at Birmingham University and Dr Yang Hao at Queen Mary, University of London, are collaborating in research, supported by the companies and the government.

'The human body is very lossy,' said Hall. 'And the signals between wearable devices can fade depending upon their location on the body and the way the person moves.'

Even placing them on different areas of the chest can produce different results. 'When we look at a person they appear to be symmetrical but their internal organs are positioned asymmetrically and they have differing characteristics,' said Hao. 'For example, the heart behaves differently electromagnetically to the lungs.'

So the team is researching ways to optimise antenna of wearable devices to reduce signal fade caused by positioning and movement. Much work has already been done on the 2.45GHz frequency used by Bluetooth but this is too narrow for the data rates needed in the communication of live video.

There are two main approaches. The first is to develop an antenna configuration that confines the energy to the surface of the body so that little is lost in the tissue. The second is to look at meta-materials that effectively reflect energy away from the body so that it is not absorbed. If these can be optimised then signals will find a reliable and robust path around the wearer without the signal fading.

Antenna diversity is a well-known technique for reducing fading and the team will investigate how it can be used on the body at various frequencies. The release of the spectrum from 3GHz to 10GHz by the US Federal Communications Commission has made ultra-wideband systems a possibility and its high-capacity potential, low power and good anti-fading properties make it ideal for future on-body systems.

'What we've done so far is use a much bigger antenna for our research than would be desirable, it's 5-10cm square,' said Hall. 'A mobile phone antenna, in comparison, is one cubic centimetre. We will have to look at the effects of smaller antenna and at other frequencies, in the ultra-wideband range of 3GHz to 10GHz. The body's electromagnetic parameters change significantly over that range.'

They will determine the best radiation pattern using statistical methods for a range of body types and postures and various frequencies. For example, operation at 40GHz or 60GHz would give the possibility of high data rates and low interference between body networks close to each other but will suffer from fading problems.

The researchers have three tools to assess their designs. Manikins can be used for static measurements. Some may be filled with liquid so their electromagnetic parameters more closely match those of human bodies and, in the lab, fresh animal tissue can be used for other checks.

Second, numerical models of humans, derived from data acquired through MRI scans, can reveal how simulations of new antenna designs perform when worn by a moving person. 'This is computationally intensive,' said Hall. 'We have access to the university cluster and to a voxel phantom, a computer model of the body diced into 5mm cubes each with different properties depending on whether they are bones, organs and so on. But it takes half an hour to generate a single frame of movement so we don't do many.'

Fortunately there is an alternative. The antenna can be attached to human beings and the performance of the new designs assessed in vivo. The next phase of the research will begin in April and will take three years.