so it can drive a computer or consume information is much harder to achieve, and it requires a lot of basic research to understand the I/O required.

It's a task akin to being offered a new type of interface to a computer with no guidelines on how to write a driver or data on which pin does what — and the pins number in the millions.

Nonetheless, several researchers around the world are working on the problem.

At the University of Technology, Sydney, researchers have created a "brain cap" (see "Resistance is futile", *APC* January, page 86). The device measures brainwaves and displays them onscreen. By thinking in different ways or outing their bodies into different states of exertion and/or arousal, wearers can change the electrical emissions and, inspired by the feedback loop of watching the results onscreen, can learn to control their brains sufficiently to turn a switch on or off.

Medtronic's InSync Defibrillator gets to the heart of cardiological issues.

DIGGING IN

Others are working directly on the brain. Researchers at the University of Pittsburgh have wired a prosthetic arm to a monkey's brain. The team placed electrodes in the motor cortex — a region of the brain that drives movement — but they don't know exactly which neurons are responsible for the job. The software interprets neuron-firing patterns into instructions to the arm. The poor monkey, meanwhile, has to be motivated by food to fire up its brain but reportedly got the hang of it within days.

Similar experiments are taking place on humans, too. US company Cyberkinetics has created a machine it calls BrainGate, which it bills as a "neural interface device". Accounts of trials with the machine — which can only be tested under exceptional circumstances and on people with very little to lose — report that its implant requires open brain surgery so that banks of electrodes can be inserted.

The electrodes are placed where doctors hope neuron clusters drive certain functions and connect back to the rest of the world via wires that snake out of a small hole left in the skull. But as there's no way to tell if the neurons really are responsible for the desired physical activity, the surgery can be futile. Early cases have, however, proved successful, and subjects have been able to manoeuvre motorised prosthetics or move a mouse around a screen — a boon for the disabled.

While these brain implants are producing impressive results, they are also throwing up new problems. Electrodes left in the brain accrue a covering of organic material that dulls their effectiveness. And it is impossible to know if the region of the brain chosen for an implant will produce useable levels of neuron activity, never mind neuron activity that can be controlled to create desired outcomes.

BEYOND THE BLUE SKY

Efforts like BrainGate are considered important but are recognised as "bleeding edge" research. While progress is slow, companies like Medtronic are already implanting computers by the million each year.

"We implanted 5.5 million devices last year," Oesterle says. "About a third of those included integrated circuits and were programmable."

Why program a machine that lives inside humans? "You do not want an implant that lasts forever, because the software and algorithms change so fast and improve every year," Oesterle says. Medtronic devices are therefore upgradeable using radio.

"These things all have radios in them that work over several metres," he says. Dedicated devices send the medical equivalents of firmware upgrades so pacemakers can keep up with the latest innovations.

"We can change the rate of insulin delivery in a pump by radio," he says. Batteries can also be recharged this way.

But Medtronic is already well beyond simple devices like pacemakers and pumps. It sells

Putting your body in the computer

Feeling sick? Reckon it's a bit more than a common cold? Before you book a visit to the GP, why not lick a CD and pop it into your PC for a quick diagnosis?

That's the vision of Cameron Jones, a chancellery researcher in the Computational Nanotechnology Group at Swinburne University's Faculty of Life and Social Sciences.

"Quite a lot of researchers are looking at CDs because, when they rotate, it creates a phenomenon called 'plasmon resonance', which focuses a laser beam in an even finer way than is possible using dedicated laser optics," Jones explains.

The utility of this extra focus is that the laser in a CD or DVD player can become a kind of microscope that, instead of finding the pits on a disc, bounces its light of substance on the disc and interprets the reflection.

Jones' vision is that people could take a swab from their throat, then wipe it on a CD or DVD and pop that in the PC. When the disc spins up, the software analyses the results of the laser bouncing off the human saliva and throat cells to figure out if they have a common cold or a more dangerous infection that's worth a trip to the doctor for some advice and prescription medicine.

Jones says "quantitative studies of cell shape" are the key to the idea, as by using nanotechnological techniques to figure out what a cell looks like when it is about to emit a cold/bacteria-fighting enzyme, it becomes possible to give software a model of what to look for in the swab.

Special discs – with grids burned onto their surfaces that act as invisible graph paper – will also be necessary to help the laser determine the location and qualities of samples.

"CDs and DVDs are ubiquitous in the developed world and people know how to manipulate media," Jones says. "The nirvana of home medical testing is a way to empower people to take care of routine things by themselves or at the pharmacy. So a lot of work is going into simple IT-based concepts about how we can reduce healthcare burdens."