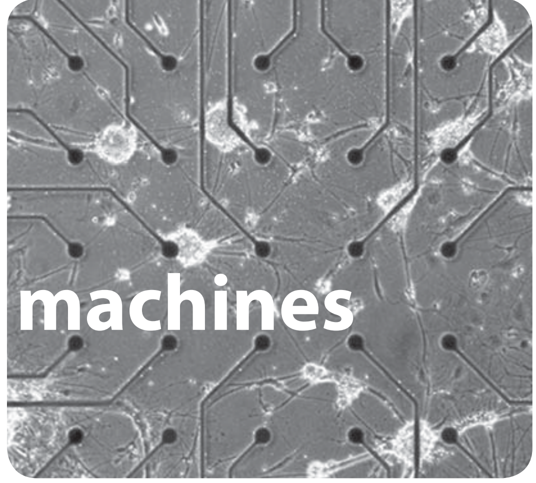
Feature

The moulding and melding of minds and machines



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Studies in contemporary ergonomics are clothed by the contextual impact of surrounding environments and socio-technical influences. However, at heart, ergonomics is about how individual human beings interact with the technologies they create. The coming millennium will see a much closer physical and cognitive association between human beings and the technologies which support them.

Evolving from a primary focus on physical interaction, the modern computer-based nature of work has seen a progressive emphasis in ergonomics on the cognitive aspects of human-machine collaboration. While many of us have witnessed this evolution, it is important that we continue to retain a balance of research on both mind and body. In recent years we have come to recognise just how 'embodied' cognition is and conversely, just how much the physical stresses and strains experienced by the body are contingent upon the way the brain self-appraises the situation in which it finds itself. Thus, the melding of mind and machine is at present, and will be into the foreseeable future, both a physical and a cognitive act.

Some of us can remember grainy television pictures which showed psychics purportedly moving small objects (most often matchboxes) with their minds. With straining facial expressions and waving hands, they would look to convince the unwary observer that the toppling box had been moved by mind alone (when in fact transparent nylon fishing wire or a surreptitious puff of air were used). But of course, almost anyone can topple a matchbox by the power of the mind - you simply reach out your hand and knock it over. This of course is not considered miraculous. Not miraculous that is, unless you happen to be severely physically disabled, in which case the ability to perform even this rudimentary physical action may be denied. These individuals are, to different extents, 'locked in', that is, control of the general musculature is beyond their unaided capacity. It is then in the replacement of normally existing abilities that we see a major emphasis of the current spectrum of research on brain-machine interfaces.

For such individuals whose brain functions normally but whose muscular control is constrained or denied, we have seen truly staggering developments. The interpretation by computer recognition systems of even minimal muscular control can return to a severely physically disabled person a whole repertoire of response skills. The coding of EEG traces, and specifically event-related EEG markers, can permit the beginnings of the interpretation of intention. Here, no muscular contraction at all is necessarily needed in order to translate the intention into the desired act. While the current level of interaction with these systems is neither as fast nor as accurate as normal bodily control mechanisms, the capacity to replace many functional abilities would seem to be a matter of technological advance and not one of superseding any intrinsic theoretical barriers. Thus, as more diagnostic methodologies are developed and existing approaches are rendered capable of use in the world outside the laboratory, the capacity to restore lost functions will continue to increase. As we are all collectively a generally ageing population, there will be ever more social demand for such restorative technologies to be applied beyond those who are radically disadvantaged to those who are only relatively disadvantaged by the normal processes of ageing.

There is another stimulus which serves to propel research in damage remediation. This comes from the tragedy of modern conflict. Here, we are seeing an evident increase in those who survive the trauma of attack. This is due to improvements in body armour and also in the capacities for emergency medical attention. Those who once died of their injuries now survive and these survivors often require prosthetic limbs. This unfortunate demand will expectedly induce speedier and more effective solutions to the problems of

An extended version of this article is available on the Society website at www.ergonomics.org.uk > News centre > News articles prosthetic creation and control, especially as institutions such as the US Veteran's Association (VA) invest more heavily in relevant research efforts.

A major problem is the biometric signal-to-noise ratio, and the associated barriers concerning the speed and accuracy of the interpretation of any remaining viable brain output. However, once that signal has been elicited from the human and coded as input to the machine, its effects are indistinguishable from the command of any non-disabled person. In this respect, technologies to remediate any medical problem also contribute to a fundamental store of knowledge about brain-machine interaction for everyone. After all, if the system can tap the intentions of a 'locked-in' individual, precisely the same algorithms can be used for so-called 'normal' populations. This naturally leads us to the next step, which moves from restoration of normal functioning, to systems which vastly extend what is considered 'normal' human capacities.

The real revolution in brain-machine interfaces is liable to come in the motoric effects of the physical output; an emerging discipline called neuro-ergonomics, which is more than the sum of its component parts of neuroscience and ergonomics. The field is increasingly multidisciplinary; incorporating comprehension from genetic contributions to the cognitive processes of a single individual, to the functioning of these processes on an interpersonal, global level.

In the welter of excitement about theoretical and conceptual progress, we can often overlook some issue that can appear deceptively simple. Among the foremost of these is just exactly how do you physically connect a brain to a machine? We might seek to attach bothersome and frustrating individual electrodes to sensitive and inconvenient bodily locations. More permanent connections for necessary prosthetics are also often difficult and frustrating for the operator to live with. Indeed, the current state of some interactive brain-machine technologies seems to allow humans to overcome certain circumstantial inabilities only by creating an entirely new set of constraints resulting from the new restrictions in mobility. Within itself, the body works well. However, when forced to tolerate artificial attachments, it tends to reject them, albeit not in the obvious biochemical manner of internal agents. Bio-engineering advances are addressing such issues and it is now easier to get signals out of or into the body than ever before. But this limitation is as much a human-machine interface issue as any that are dealt with in traditional ergonomics.

Efforts to create such a collaboration of this nature are, in fact, already underway by pioneering bio-psychological scientists. Researchers are working to merge living human tissue with a mechanical interface in order to 'smooth the way' as it were for the machine's transition into the body (see image). Once such a prototype system is put into place, the next logical conundrum will be how to maintain this complex, multimodal and foreign entity within a human body which is bent on its expulsion. Insight into these biotechnical interface issues, the manner in which these in-dwelling augmentations function, and their capacity to integrate with the other bodily systems, is critical if any such merger of brain and machine is ever to work.

Up to this point we have talked about the growing intimacy of brain and machine in which the compromise is very much one made up of changing the machine design. In other words, the machine is always manipulated to suit the characteristics of the brain. But what happens if this is reversed? Can we imagine situations in which brains, or some part of the brain, are grown to suit machines? It seems that the process of evolution per se, is devoted to just such a pursuit; altering the brain to successfully suit the environment.

As we look to the future, we must recognise that machine prosthetics are only one method amongst a whole technological arsenal that can achieve the goals of manipulation and change. While one goal may well be to assist people in becoming the best humans they can be, a different goal would instead be to raise the criteria for what constitutes the 'best human'. The answer would arguably be a combination of how we were created with that which we create. This being said however, we run the risk of discovering that the best human is not human at all, but rather some form of cyborg or even an elaborated biological entity living via the support of multiple technological systems. This raises the issue of where the near-term boundary of science fiction becomes the further threshold of science fact. If this is our future evolution, then the best humans would not be those who use machines to enhance the quality of their natural talents, but rather those who use machines to increase the quantity of those talents, whether natural or not. ❖

Image shows integration of biological and computational systems. Reproduced with the Permission of Mike Serra and Tom Shea, Center for Cellular Neurobiology & Neuro-degeneration Research, University of Massachusetts, Lowell.