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A PHYSICAL CONTROL INTERFACE WITH PROPRIOCEPTIVE FEEDBACK AND MULTIPLE DEGREES OF FREEDOM

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The use of the drug thalidomide by pregnant mothers in Britain resulted in a variety of deformities including the birth of children having no arms. Such children were provided with powered artificial arms with up to five degrees of freedom simultaneously controlled in real time by shoulder movement (ref. 1) and whose operation could be learnt by children within a matter of hours. The ease with which this manipulation could be learnt and used may have been due to the system used to provide feedback of position and force to the user's skin and joints. In this way, the physiological sense of proprioception was extended from the user into the device, reducing the need for visual feedback and conscious control.

With the banning of thalidomide, this technique fell into disuse but it is now being re-examined as a control mechanism for other artificial limbs (refs. 1-5) and it may have other medical applications to allow patients to control formerly paralysed limbs moved by electrical stimulation (ref. 6). It may also have commercial applications in robotic manipulation or physical interaction with virtual environments.

To allow it to be investigated further, the original pneumatic control system has recently been converted to an electrical analogue to allow interfacing to electronic and computer-assisted systems. A harness incorporates force-sensitive resistors and linear potentiomenters for sensing position and force at the interface with the skin, and miniature electric motors and lead screws for feeding back to the user the position of the robotic arm and the forces applied to it. In the present system, control is applied to four degrees of freedom using elevation/depression and protraction/retraction of each shoulder so that each collar-bone emulates a joystick. However, both electrical and mechanical components have been built in modular form to allow rapid replication and testing of a variety of force and position control strategies.

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