A WIRELESS INTERFACE FOR PROSTHETIC CONTROLLERS

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ABSTRACT

Currently, in order to fit and adjust powered prostheses, clinicians need to connect a prosthetic control system to a pc, requiring them to disassemble the prosthesis in order to connect the interface cables. This is inconvenient and time consuming for both the client and the clinician. An alternative to using a hardwired connection for accessing the control system inside a prosthesis was needed, since the hardwired connection effectively tethers a client to the pc, limiting the ability to move for testing and fitting the prosthesis. The cabling needed to be eliminated, and a wireless link was needed to perform the clinical adjustments that are necessary to optimize a client's device. We have developed a wireless prosthetic control system as an alternative to using a fixed, hardwired connection to interface the controller in a client's prosthesis to computer software for clinical fitting or evaluation. The new system uses wireless rf technology to eliminate the disadvantages of the hardwired connections. Wireless systems were developed for both the 928 MHz band and the 2.4 GHz band, and they are compatible with a prosthetic control software package currently used by clinicians around the world.

KEYWORDS

Disability, Prosthetics, Rehabilitation, Software, Technology, Wireless Communication, Controller

BACKGROUND

Current programmable prosthetic systems require that a client's controller be hardwired to a personal computer in order to communicate with or modify the control system. This tethers the client to the computer and requires some disassembly of the prosthesis during fittings and adjustments. The prosthetics community needs and wants a wireless link between the controller and the computer software used for fitting, testing, and system optimization. What this means to the clinical population is the ability to have their prosthetic fittings and adjustments done in a more natural and appropriate way. Without the wireless communication, they use a trial and error approach by iteratively taking off the prosthesis, hooking it to a computer, making adjustments to the controller, putting it back on and testing it. With the wireless communication, they can wear and operate the prosthesis as they normally do while adjustments are made and tested to ensure the system is optimized for the individual's needs and abilities.

METHODS

The wireless controller was developed as an extension to our current, commercial prosthetic controller module (the single programmable module, or SPM) and its associated user interface software (MyoWizard and MyoAssistant). This was done to minimize the risk of the development. The majority of the controller infrastructure was retained, but the hardwired communication elements of the controller were replaced with wireless components. Changes were made to the interface hardware. Modifications were also made to the interface software (in Visual Basic 6) and the communications firmware (in PIC Assembly code).

The SPM controller design was modified to replace the hardwired connectors and interface elements with wireless components. Then, the software and firmware changes were made to accommodate the new components. Circuits were built and tested with a commercial hand prosthesis (VASI 0-3 Hand). Three solutions were prototyped and compared in benchtop tests using performance metrics such as range and power consumption, as well as quality of wireless connection and reconnection. With the prototypes, we explored the use of the 928 MHz band and the 2.4 GHz band to ensure that the design could be relevant internationally. The Maxstream XBee 2.4GHz module proved to be superior to the other two in terms of quality of connection, in addition to having good range and power. The wireless controllers were developed to support both the MyoAssistant and the MyoWizard applications using the 802.15.4 ZigBee stack devices. An example of the preliminary prototypes can be seen in Figures 1 and 2.

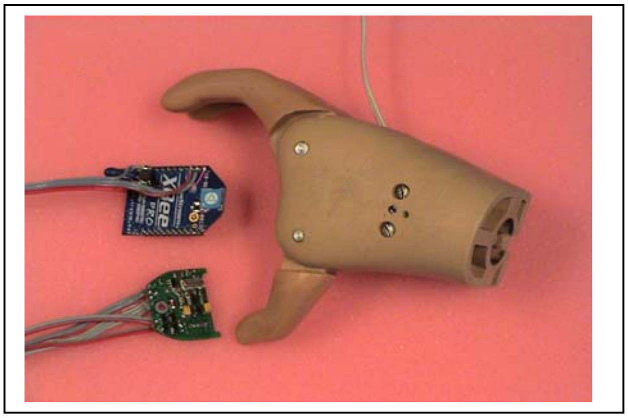

Figure 1: Prototype prosthetic controller with wireless interface and prosthetic hand for testing.

Figure 2: Wireless base station prototype for connection with computer and graphical user interface software.

Testing

Indoor range tests were conducted using a VASI 0-3 hand and an SPM controller programmed with a two input control strategy using a laptop running Visual Basic 6. Connection between the SPM and the laptop running the MyoAssistant controller interface software was established through a USB Serial port adapter. Appropriate voltage regulators (3.3V) and level translators (Xbee data inputs are not 5V tolerant and a simple voltage divider network was used) were built for each side.

Pairs of transceivers were tested for relative range of connection by moving the laptop away from the test bench where the hand prosthesis was situated. By observing the data window in the MyoAssistant software, it was possible to see where communications dropped out. The transmission path included steel studded drywall, doors, glass and concrete. Relative ranges were consistent with what was to be expected – good range with 33 cm modules and less with 12.5 cm modules, and ranges were extended with increased transmit power.

The more powerful Xbee-pro device required a 100mA Vreg. The Xbee units for Xstream required level translators for TTL signal from the SPM because inputs aren't specified as 5V tolerant. Serial modules where tested in the orientation that was most favourable for the device range – in these cases vertical. A summary of the prototype test results can be seen in Table 1.

Table 1: Relative Range and Power for Wireless Interfaces

Model	Radio-tronix 928MHz	Jennic 2.4GHz	X-Bee 2.4GHz	X-Bee Pro 2.4GHz
Line of Sight Range (m)	1500	400	100	1500
Indoor Range (m)	30	10	23	50
Current Draw (mA) Vin=3.3V	18	58	57	73
Quality Of Connection	Good	Acceptable	Very Good	Excellent

RESULTS

We have developed and tested several wireless interface systems for prosthetic controllers. Interfaces were developed and tested for both the 928 MHz band and the 2.4 GHz band. The prototype based on a 2.4 GHz Xbee system performed the best overall for the chosen metrics. The wireless SPM control system will enable clinicians to monitor and adjust the prosthetic system while it is in use and without tethering the client to the pc. This will be more comfortable and natural for the client, and it means that the clinician can better configure the prosthesis and get a better idea of how it's actually functioning. It also means that there is expanded functionality and that there is the future possibility of clients connecting to other wireless devices.

ACKNOWLEDGEMENTS

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