Smartphone-compatible Rehabilitative Robotic Gloves with Non-invasive Closed Loop Haptic Feedback

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Abstract

The scope of our design is to improve the micro-movement, dexterity, and coordination in the fingers of a multiple sclerosis (MS) patient for being able to perform daily tasks requiring precision in movement such as using devices like a smartphone and achieve tasks such as writing, dressing or holding objects. We sought to improve the dexterity by having a robotic glove which actuates the fingers over a full range of motion across one degree-of-freedom, and is controlled based on the patients myoelectric signals, thereby fine tuning movement and adding to the strength. The entire set up has to be smartphone-compatible since this opens more possibilities to improve the quality of life of the patient. We, additionally, aim to remove the accidental screen presses caused by muscle twitches in these patients. This can be achieved by using an insulating glove and adding two parallel conducting plates, with a foam dielectric between them, in each fingertip to measure changes in applied force with respect to time. Since capacitive touchscreens operate via changes in electric field, we can select which key presses are registered by passing some current through the insulating surface whenever the condition for registering is met. For restoring the sensation of holding objects and also making movement more controlled, we used haptic feedback to provide sensation from the robotic glove to the user. This may alleviate pain, muscle fatigue and promote body ownership, thereby restoring a sense of autonomy to the user. The closed haptic feedback process can be accomplished in two steps: sensation (tactile) and stimulation feedback to the user. Feedback stimulation can be achieved through direct neural stimulation (invasive) and indirect (non-invasive) surface stimulation. The need and desire to restore natural feelings to the user is great since it promotes the concept of body ownership and grants a sense of independence to the user. Many invasive techniques have been researched and employed in past trials for direct stimulation into the brain. However, the need for non-invasive techniques becomes critical since an invasive approach carries many risks, some of which include: infections, surgical complications and a lack of understanding of how sensory information is encoded and decoded by the brain. In conclusion, this implementation should enable MS patients to use a smartphone-compatible device to satisfy their everyday needs and this idea may be extended to open possibilities for employing machine learning to investigate typing usage and patterns, as well as finger movement statistics.

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