ELECTRONIC BRIDGE FOR SPINAL CORD INJURY
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Introduction: Brain-computer interfaces are currently the popular approach to provide a means of communication for individuals with high level spinal cord injury. Studies have also suggested that extracting relevant locomotive information may be possible with signals from the spinal cord instead of through EEGs and related methods. The overarching goal of this research is to recover the function of the paralyzed muscles by bridging the spinal injury with an electronic circuit that we build in this project. The volitional signals generated by the subject will be processed by the electronic circuit and used to control the electrical pulses applied to the distal portion of the spinal cord. Neuroplasticity has been shown to be an effective way of rehabilitating spinal cord injury; studies have shown neuroplastic tendencies both locally within the spinal cord and also extending to higher-level function in the cortical and subcortical levels of the brain.

Materials and Methods: The circuit used to bridge the spinal cord consists of: a high pass filter and amplifier with a gain of approximately 100; a low-pass filter and half wave rectifier that changes the input into a slow changing wave (top right in Figure 1); an oscillator that creates 100μs pulses at a frequency of 200 Hz (bottom left in Figure 1) when the rectified waveform is above 1.5V (or other custom threshold); and a voltage-to-current converter stage, the output of which is used to stimulate the spinal cord. The pulse width is chosen based on the strength-duration curve for extraneural stimulation of mammalian neurons.

Results: The combination of rectified waveform and oscillator, when on, produces an output waveform with 100 (microsecond) pulses ranging from 40-60μA. Our circuit was able to successfully detect high levels of neural activity and output a pulse according to our output specifications. The circuit function was also simulated using a Matlab code to gain a better understanding of each circuit block and test them under different conditions.

Conclusion: The circuit takes input signals, filters out the noise, and produces the specified pulse output with the current amplitude varying depending on the input voltage. One potential problem with this circuit is that it has a fairly limited voltage range set by the threshold voltage and the power voltage to the circuit. This will result in some undesired customization in each implementation of the circuit. Future designs should aim to automatically adjust the input window according to each subject. In proceeding studies the output signals will be tested on rats to see if it can induce motion and evoke a neuroplastic response in which the rats learn to gain neural control of the timing of the motion induced in their limbs.

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