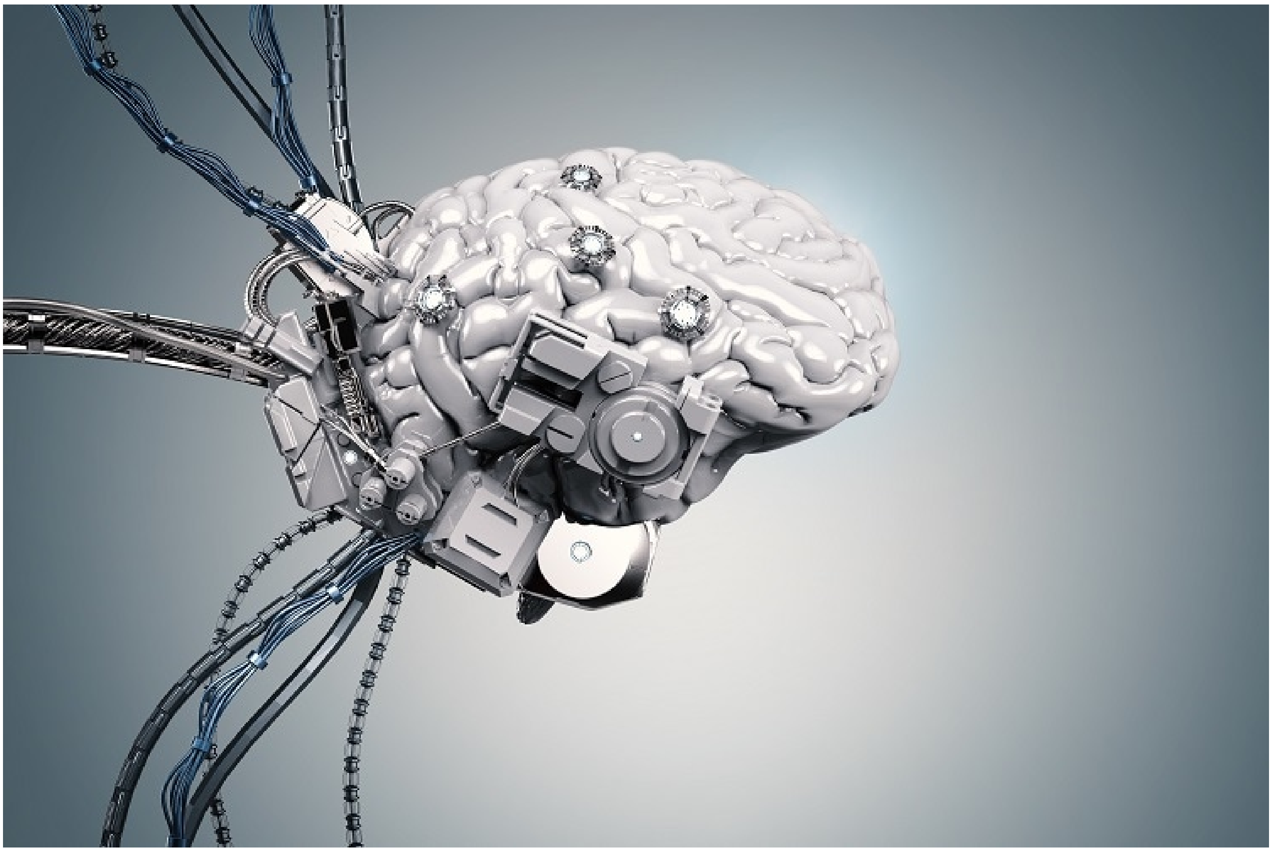
Application to Robot Control Using Brain Function Measurement by Near-Infrared Spectroscopy

By Benedette Cuffari, M.Sc. Apr 3 2019



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In recent years, research on the brain, computer interface (BCI), has been conducted quite extensively. While some of the earlier BCI studies utilized electroencephalogram (EEG) data, other studies have reported the use of near infrared spectroscopy (NIRS) as a useful and informative method.

Because NIRS is a non-invasive technique and only requires the use of small-scale instruments, it can be incorporated into a wide variety of BCI applications, especially when compared to those based on EEGs.

Challenges Faced by Previous BCI Studies

Previous BCI studies required the researchers to be extensively trained to ensure that they were capable of handling BCI instruments in a skillful manner. More specifically, the individual handling BCI was required to control his or her brain signals in an efficient manner.

For example, if the person using the BCI's brain signal had limited motor control of their arms or legs, the BCI would not work effectively. Therefore, the person in which the BCI was intended for was obligated to undergo extensive and grueling sessions of complicated training prior to handling the BCI.

To alleviate these challenges, scientists have recently been successful in their development of more practical BCIs that were simple to use and operate through the performance of simple actions, such as the movement of the individual's arms or legs.

Using Brain Signals on Pyramidal Area to Develop NIRS-Based BCI

Researchers at the Nagaoka University in Japan have published their research on NIRS-based BCI that has several potential applications to control the 'on' or 'off' functions of the BCI. This research can be found in the Proceedings of the 29th Annual International Conference of the IEEE EMBS, which took place in Lyon, France.

It is common knowledge in neuroscience that the movement of the arms or legs results in activation around the pyramidal area of the central nervous system (CNS). Tsubone's group at the Nagaoka University have successfully estimated the start and end timing of a person's tapping movement by utilizing the NIRS signal around the pyramidal area.

Using NIRS, this group of researchers measured the hemoglobin (Hb) signals during an individual's movement. The analysis of these signals suggested that that movement of the subjects' arms or legs resulted in an increase of oxy-hemoglobin (oxy-Hb) and total hemoglobin (total Hb); however, a decrease in deoxy-hemoglobin (deoxy-Hb) levels were found within the motor cortex of the brain.

Interestingly, the Hb signals in the motor cortex depended less on the frequency of the movement, and instead relied more heavily on the intensity of the muscle activity, thereby signifying that maximum tapping effort would result in a larger activation of the Hb signals.

By collecting data from several subjects that were performing motor activity, which involved tapping their right hand on the desk, and analyzing the cerebral blood flow and Hb levels at different times, movement amplitudes and speeds, Tsubone's team tried to estimate the start and end timing of the tapping movement throughout the neural network.

An OMM-3000 NIRS system was also used in this study. After the probes are arranged at specific regions, near IR light was focused on the scalp from incident probes, whereas detector probes were used to measure the light as it passed through the cerebral cortex in order to estimate the Hb levels.

The start and end timing of the movement of the arms by the human subjects were estimated by classifying the states into three types, of which included an increase in Hb, a decrease in Hb and no variation of Hb.

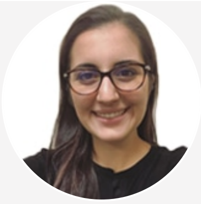
Each of these types of responses were used to design a learned network based on the data acquired throughout the study. Using this method, the researchers were able to estimate the 'on' or 'off' control of the BCI with a success rate of more than 70%.

Conclusion

The research discussed here demonstrated that learned networks can be used to estimate both the start and end timing of muscle movement by individuals. With this information, researchers can design effective BCIs capable of detecting simple human movements which can ultimately be applied to a wide range of biomedical purposes.

Reference and Further Reading

1. Tsubone, T., Muroga, T., & Wada, Y. (2007). Application to robot control using brain function measurement by near-infared spectroscopy. *Iee Xplore.* DOI: 10.1109/IEMBS.2007.435348.



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After completing her Bachelor of Science in Toxicology with two minors in Spanish and Chemistry in 2016, Benedette continued her studies to complete her Master of Science in Toxicology in May of 2018. During graduate school, Benedette investigated the dermatotoxicity of mechlorethamine and bendamustine, which are two nitrogen mustard alkylating agents that are currently used in anticancer therapy.