University of Zurich[UZH]
Department of Informatics

ai lab

Apparent moving sensation recognition in prosthetic applications

Alejandro Hernandez-Arieta
Maresa Afthinos
Konstantinos Dermitzakis

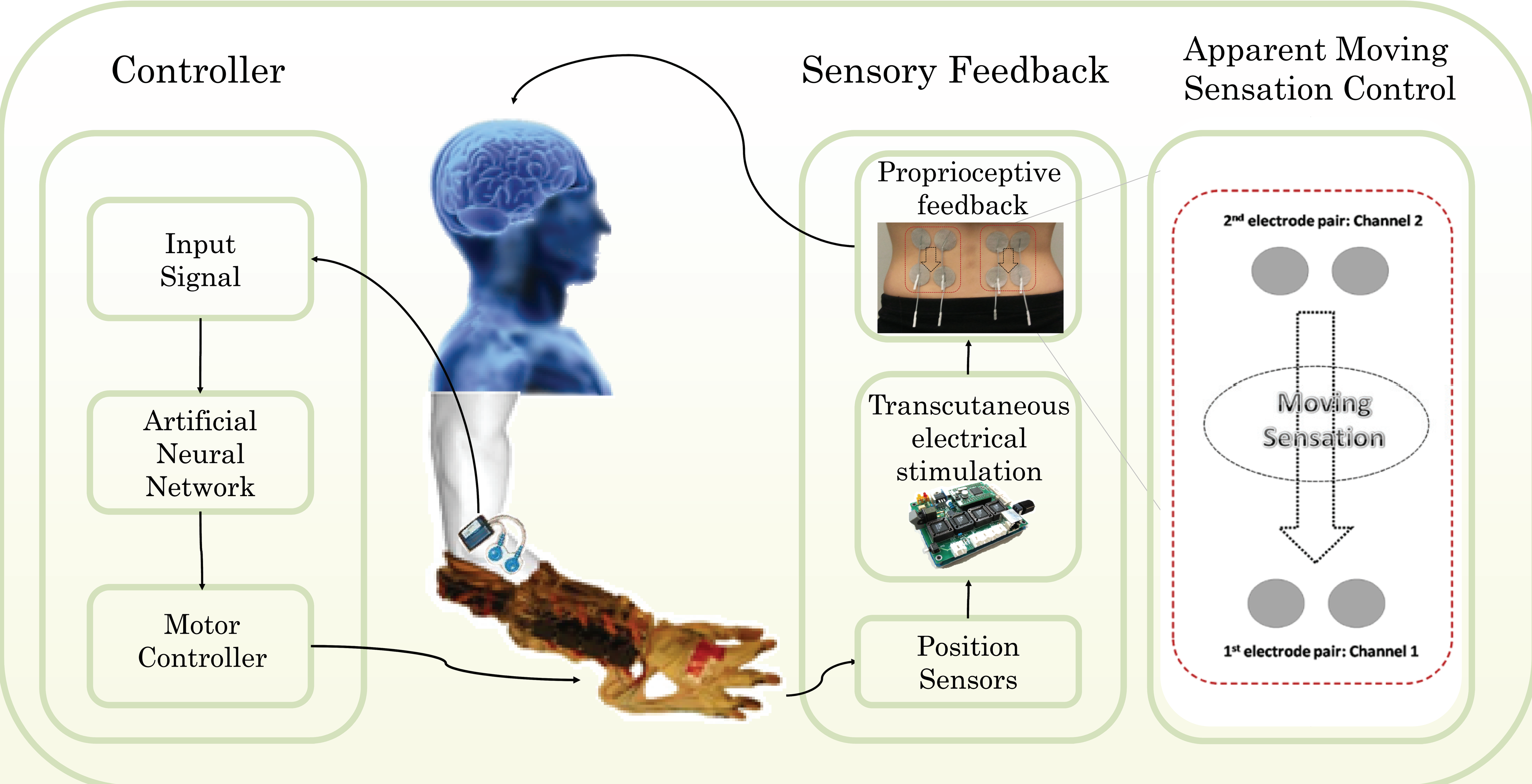
In collaboration with:
Dr. Daniel Kiper
Neuroinformatics Department,
ETHZ/UZH Zurich,
Switzerland

Recent years have seen considerable improvements in state-of-the-art prosthetic devices. Research has recently shifted towards providing sensory information feedback to users of such prostheses. Sensory information is necessary for the seamless integration of these devices with the human body. In this study we look at the possibility to use the "apparent moving sensation" illusion[1,2] as a means of transmitting proprioceptive information, using transcutaneous electrical stimulation[3,4]. We applied 5 incremental steps (20%, 40%, 60%, 80%, 100%) on both sides of the spine, in two directions (up, down).

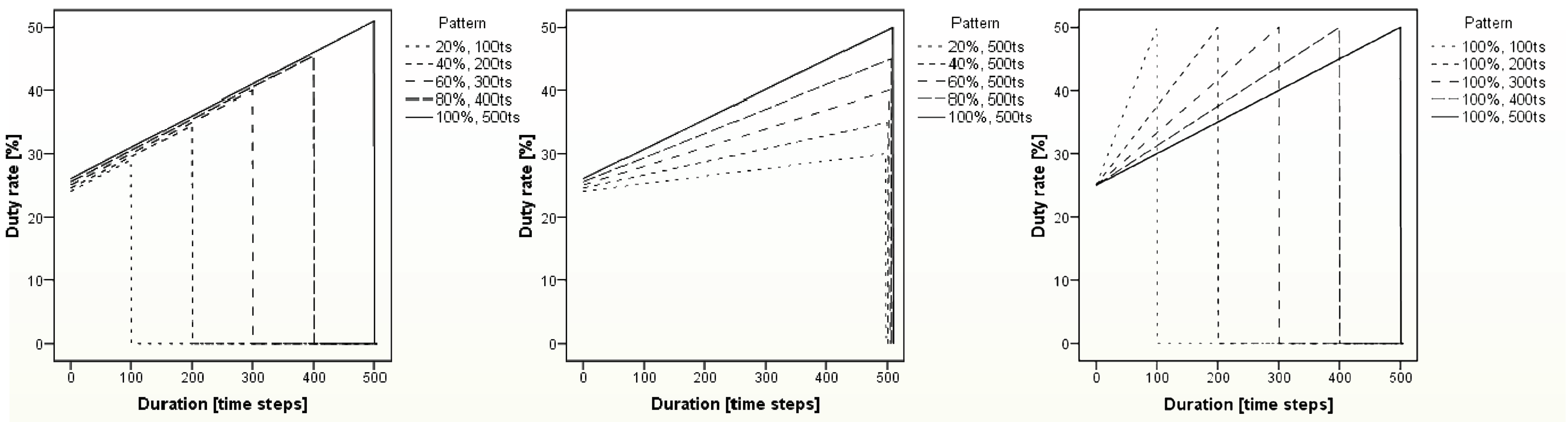
Application Concept

The intention of the user is detected using machine learning techniques over EMG data (electrical activity of the muscles while contracting). The recognized intention is translated into movement of the robot hand.

Through position sensors, we detect the movement of the fingers, which is translated into the apparent moving sensation, divided in degrees of traveled distance[4]. We use transcutaneous electrical stimulation to control the position of the illusory sensation in the body.



Stimulation Methods



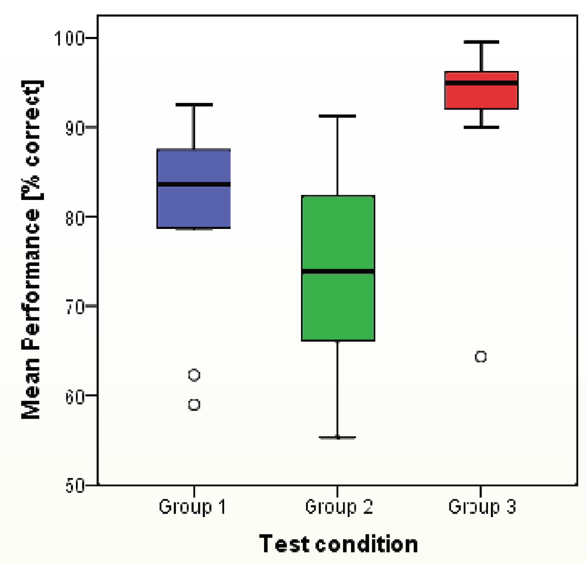
a) b) c)

Relation between duty rate change and stimulation time.

Duty rate change plotted against the stimulation time for the three experimental groups. The plot shown presents the duty rate applied for only one of the two electrode pairs, the duty rate of the other electrode pair changes complementary. (a) Group 1: Duty rate change as well as the stimulation duration change from pattern to pattern, meaning the duty rate change has a stable frequency over all patterns. (b) Group 2: All patterns have the same duration, but differ in their duty rate change. (c) Group 3: The patterns differ only in their stimulation time, the duty rate always changes by 100%.

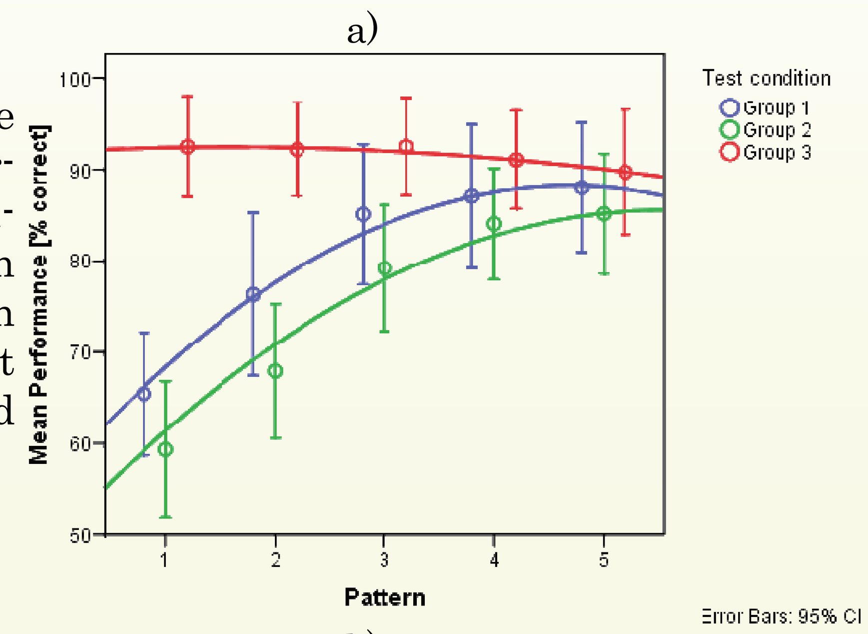
Performance Results

a) Mean Performance. The method used in group 3 shows the best performance over the other stimulation methods with a mean of 95% recognition rate.



a)

b) Pattern performance. The graph shows the performance of the stimulation patterns depending on stimulation method. It can be appreciated the best performance due to method used in Group 3.



b)

Conclusions

Our experimental results show how the apparent moving sensation illusion can be controlled to provide incremental steps in the position of the distance traveled by the illusory sensation. Three methods were applied to optimize the control of the sensation. Constant intensity rates with changing time, constant time rates with changing intensity rates, and variable time with a intensity rate change of 100%. Our results show how the third method presents a mean recognition rate of 95%, making the best solution for the application. As future work, we will apply the results from these studies in more complex interaction tasks to measure its reliability as a source of proprioceptive information.

References

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