Mechanical Engineering Thesis Defense

Brain Computer Interfaces for the Control of Robotic Swarms

School for Engineering of Matter, Transport and Energy

Georgios Konstantinos Karavas
Advisor: Panagiotis Artemiadis

abstract

A robotic swarm can be defined as a large group of inexpensive, interchangeable robots with limited sensing and/or actuating capabilities that cooperate (explicitly or implicitly) based on local communications and sensing in order to complete a mission. Its inherent redundancy provides flexibility and robustness to failures and environmental disturbances which guarantee the proper completion of the required task. At the same time, human intuition and cognition can prove very useful in extreme situations where a fast and reliable solution is needed. This idea led to the creation of the field of Human-Swarm Interfaces (HSI) which attempts to incorporate the human element into the control of robotic swarms for increased robustness and reliability. The aim of the present work is to extend the current state-of-the-art in HSI by applying ideas and principles from the field of Brain-Computer Interfaces (BCI), which has proven to be very useful for people with motor disabilities. At first, a preliminary investigation about the connection of brain activity and the observation of swarm collective behaviors is conducted. After showing that such a connection may exist, a hybrid BCI system is presented for the control of a swarm of quadrotors. The system is based on the combination of motor imagery and the input from a game controller, while its feasibility is proven through an extensive experimental process. Finally, speech imagery is proposed as an alternative mental task for BCI applications. This is done through a series of rigorous experiments and appropriate data analysis. This work suggests that the integration of BCI principles in HSI applications can be successful and it can potentially lead to systems that are more intuitive for the users than the current state-of-the-art. At the same time, it motivates further research in the area and sets the stepping stones for the potential development of the field of Brain-Swarm Interfaces (BSI).

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