Concept for an EEG-based Gaming-Controller with Embedded Machine Learning Support

Chao Qian, Intelligent Embedded Systems Lab, University of Duisburg-Essen, Germany
Andreas Erbslöh, Intelligent Embedded Systems Lab, University of Duisburg-Essen, Germany
Patrique Fiedler, Data analysis in life sciences, Technische Universität Ilmenau, Germany
Elsa Kirchner, Medical Technology Systems, University of Duisburg-Essen, Germany & Intelligent Health Care Systems, DFKI, Germany
Gregor Schiele, Intelligent Embedded Systems Lab, University of Duisburg-Essen, Germany

Introduction

Modern brain-computer interfaces (BCI) allow precise and reproducible user-environment interactions using electroencephalography (EEG) recordings. In gaming applications, Perri Karyal uses the EMOTIV EPOC X EEG-headset (14-channel, wireless) to control game avatars. The online data stream processing takes place on computer. Our research is concerned with achieving a high level of user comfort with real-time processing on a mobile solution. This requires local signal processing and machine learning on an embedded platform.

Methods

Our objective is to achieve an end-to-end signal processing for controlling games with EEG recordings using comfortable dry Flower electrodes. Data acquisition is conducted using MentaLab Explore+ (12 channels, 1 kHz, wireless). The online data processing includes digital filtering and action recognition using AI accelerators on a Field Programmable Gate Array (FPGA) within the ElasticAI ecosystem. Therefore, AI models are trained using PyTorch, and transferred to the FPGA. To improve the robustness of our algorithm in gaming scenarios, we provide an extended dataset by combining EEG recordings and 9-axis acceleration data for artifact detection.

Results

We successfully acquired our first datasets using EEG recordings with dry Flower electrodes and MentaLab device. This dataset includes eight recording sessions from six candidates to imagine the movement of the left or right hand. We assessed data quality by employing EEG-Net to classify the two classes, which achieves an accuracy of 97%. It is worth noting that the impact of pre-processing (digital filtering, pruning channels, reducing sampling rate) has been explored and shown to maintain the same level of accuracy.

Conclusion

Our first approach of building an EEG-based gaming controller allows to generate first datasets and to perform online data processing and ML inference on a workstation. In future, the dataset is extended to enable motion detection for gaming scenarios like 'Pac-Man'. Moreover, the AI models used are trained and transferred to the local hardware for controlling more complex video games.