

Supplementary Materials: A Hybrid FPGA-Based System for EEG- and EMG-Based Online Movement Prediction

Hendrik Wöhrle, Marc Tabie, Su Kyoung Kim, Frank Kirchner and Elsa Andrea Kirchner

1. Performance Scores

This supplement contains supplementary performance scores (precision, recall and specificity) for the results shown in the main manuscript.

1.1. Supplementary performance scores for the EMG-based movement prediction

Table S1. Precision, Recall and Specificity for the EMG-based movement prediction, channels 1 to 4.

Channel	1		2		3		4	
System type	CPU	FPGA	CPU	FPGA	CPU	FPGA	CPU	FPGA
Mean Precision	0.278	0.280	0.303	0.303	0.102	0.102	0.132	0.119
Median Precision	0.272	0.272	0.309	0.309	0.106	0.106	0.106	0.099
Mean Recall/TPR	0.808	0.808	0.841	0.841	0.714	0.714	0.847	0.854
Median Recall/TPR	0.879	0.879	0.947	0.947	0.707	0.707	0.882	0.905
Mean Specificity/TNR	0.974	0.974	0.975	0.975	0.921	0.921	0.907	0.895
Median Specificity/TNR	0.973	0.973	0.973	0.973	0.923	0.923	0.926	0.904

Table S2. Precision, Recall and Specificity for the EMG-based movement prediction, channels 5 to 8.

Channel	5		6		7		8	
System type	CPU	FPGA	CPU	FPGA	CPU	FPGA	CPU	FPGA
Mean Precision	0.020	0.021	0.017	0.017	0.016	0.016	0.018	0.018
Median Precision	0.013	0.012	0.015	0.016	0.014	0.014	0.016	0.016
Mean Recall/TPR	0.071	0.070	0.250	0.250	0.237	0.237	0.323	0.323
Median Recall/TPR	0.049	0.041	0.240	0.240	0.195	0.195	0.316	0.316
Mean Specificity/TNR	0.955	0.956	0.854	0.855	0.863	0.863	0.813	0.813
Median Specificity/TNR	0.965	0.966	0.844	0.845	0.862	0.863	0.806	0.805

Table S3. Precision, Recall and Specificity for the EMG-based movement prediction, for channel combinations $1 \in [1, \dots, 8]$ to $2 \in [1, \dots, 4]$.

Channel	$1 \in [1, \dots, 8]$		$2 \in [1, \dots, 8]$		$4 \in [1, \dots, 8]$		$1 \in [1, \dots, 4]$		$2 \in [1, \dots, 4]$	
System type	CPU	FPGA	CPU	FPGA	CPU	FPGA	CPU	FPGA	CPU	FPGA
Mean Precision	0.210	0.206	0.209	0.122	0.198	0.198	0.332	0.303	0.412	0.168
Median Precision	0.195	0.191	0.164	0.112	0.149	0.148	0.319	0.296	0.455	0.163
Mean Recall/TPR	0.931	0.908	0.851	0.946	0.485	0.496	0.937	0.937	0.882	0.964
Median Recall/TPR	0.961	0.929	0.899	0.972	0.398	0.393	0.978	0.978	0.950	0.985
Mean Specificity/TNR	0.947	0.947	0.945	0.898	0.963	0.963	0.971	0.966	0.982	0.928
Median Specificity/TNR	0.946	0.946	0.957	0.900	0.980	0.980	0.973	0.971	0.987	0.933

1.2. Supplementary performance scores for the MRCP-based movement prediction

Table S4. Precision, Recall and Specificity for the MRCP-based movement prediction.

Number of channels	32		64		96		124	
	CPU	FPGA	CPU	FPGA	CPU	FPGA	CPU	FPGA
Mean Precision	0.084	0.081	0.095	0.092	0.108	0.109	0.116	0.111
Median Precision	0.086	0.091	0.101	0.099	0.106	0.109	0.114	0.101
Mean Recall/TPR	0.887	0.856	0.891	0.878	0.896	0.884	0.867	0.866
Median Recall/TPR	0.914	0.894	0.911	0.897	0.925	0.912	0.909	0.877
Mean Specificity/TNR	0.776	0.808	0.821	0.818	0.853	0.858	0.868	0.863
Median Specificity/TNR	0.776	0.808	0.821	0.818	0.853	0.858	0.868	0.863

1.3. Supplementary performance scores for the P300 detection

Table S5. Precision, Recall and Specificity for the P300 detection.

Number of channels	32		64		96		124	
	CPU	FPGA	CPU	FPGA	CPU	FPGA	CPU	FPGA
Mean Precision	0.695	0.710	0.736	0.739	0.750	0.750	0.776	0.776
Median Precision	0.713	0.734	0.744	0.764	0.773	0.779	0.783	0.772
Mean Recall/TPR	0.869	0.871	0.868	0.871	0.858	0.877	0.861	0.860
Median Recall/TPR	0.882	0.872	0.859	0.857	0.860	0.880	0.868	0.869
Mean Specificity/TNR	0.951	0.954	0.961	0.960	0.962	0.962	0.969	0.969
Median Specificity/TNR	0.955	0.962	0.963	0.967	0.967	0.970	0.975	0.971