

DEVELOPMENT OF AN FPGA-BASED REAL-TIME P300 SPELLER

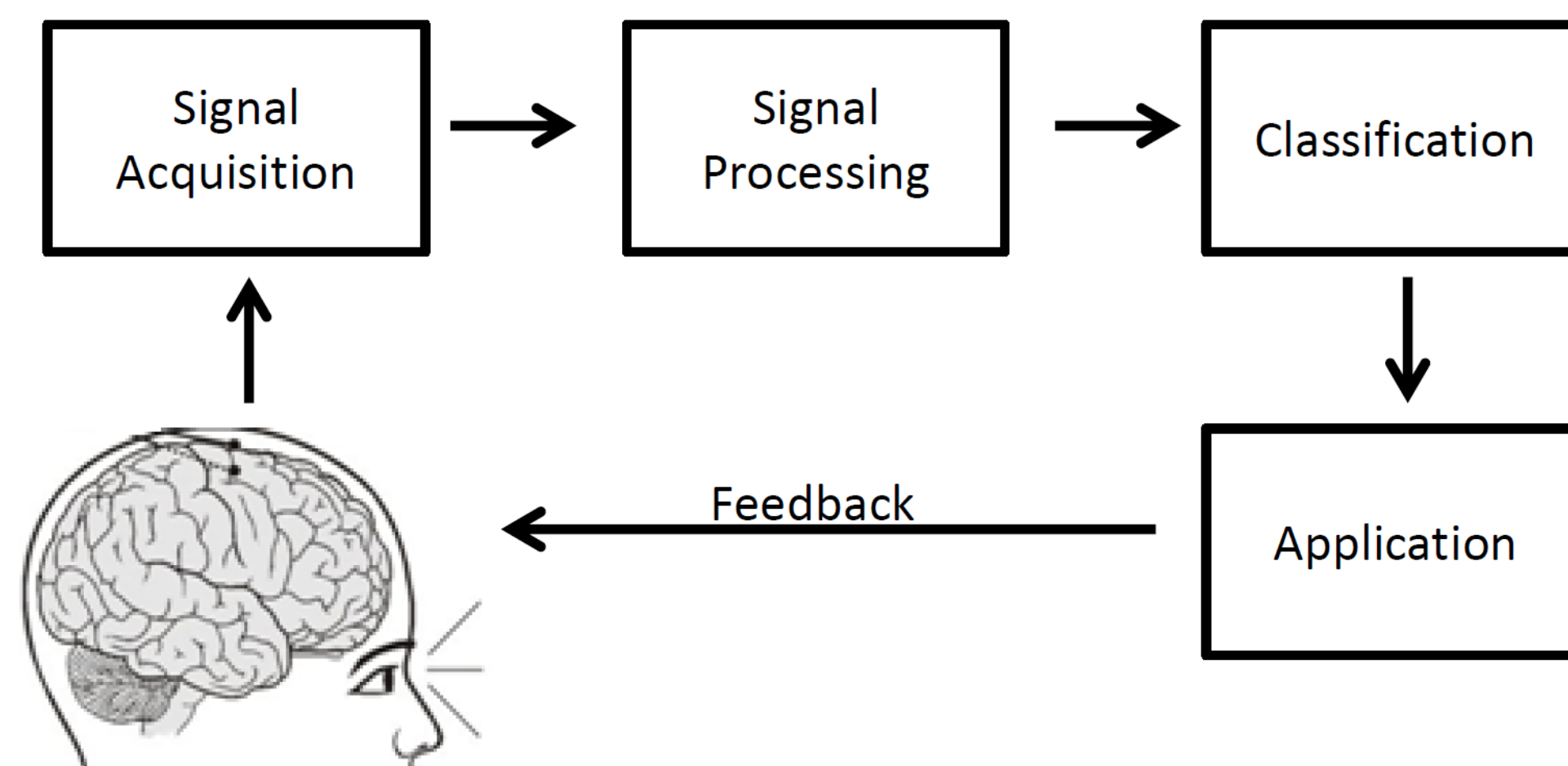
Kanav Khurana, Pooja Gupta, Rajesh C. Panicker and Akash Kumar



Introduction

- A Brain Computer Interface (BCI) facilitates direct communication between a computer and the human brain.
- A P300 Speller Application designed using FPGA's for processing.
- FPGA's benefits over PC's
 - Low cost
 - Low power consumption
 - Portability

The Big Picture

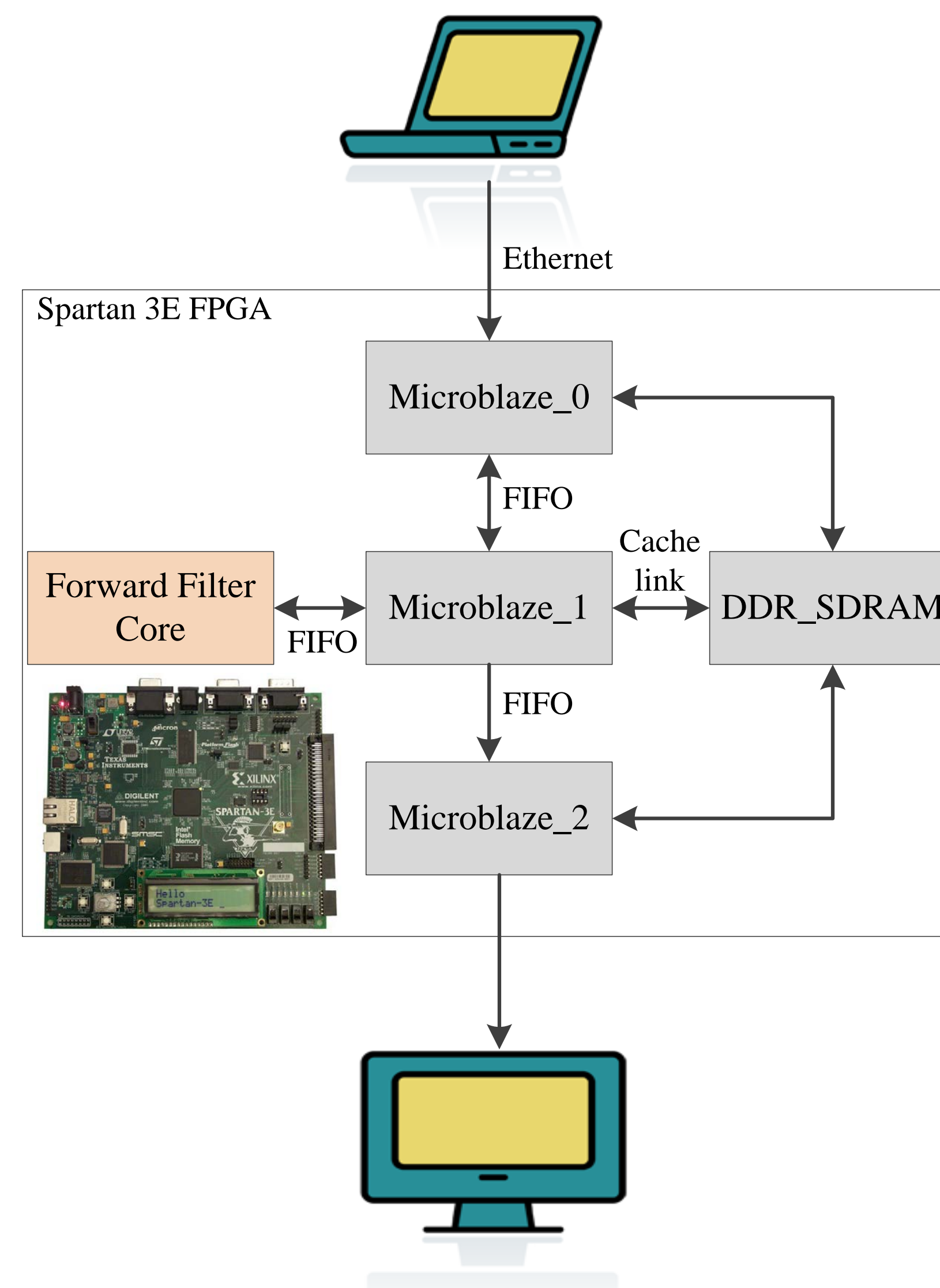


The P300 mental strategy

- 6 X6 grid of characters with rows/columns being highlighted.
- Peak appears in the EEG pattern 300 ms after row/column containing the target character is highlighted.

	7	8	9	10	11	12
1	A	B	C	D	E	F
2	G	H	I	J	K	L
3	M	N	O	P	Q	R
4	S	T	U	V	W	X
5	Y	Z	0	1	2	3
6	4	5	6	7	8	9

System Overview



- EEG data streamed from PC in real-time.
- MB_0: data input and forwarding it to MB_1.
- MB_1: forward filter core, data classification
- MB_2: display the stimulus and classification output

Algorithm

- Each row and column is highlighted once in each *round*
- Data sampled at 256 Hz, from 7 EEG channels.
- Data is time-stamped and co-related with stimulus
- Fisher's Linear Discriminant Analysis (LDA) used for pattern recognition.

Experiments

- 720 rounds of data are recorded.
- First 100 rounds are used to form the LDA classifier.
- The remaining are used for classification.
- Rounds to identify each character are varied from 2/4/5/10/20.

Results

- FPGA online – C/VHDL implementation with real-time processing on FPGA

Table 1: Resource utilization on Spartan 3E 1600E

Resources	MB_0	MB_1	MB_2	Filter
Slices	953	1169	852	4019
LUTs	1823	2268	1565	5377

Table 2: Classification results

Matlab	Round/Char	2	4	5	10	20
Offline	Accuracy	65%	84%	94%	98%	100%
Matlab	Round/Char	2	4	5	10	20
Online	Accuracy	58%	69%	73%	82%	87%
FPGA	Round/Char	2	4	5	10	20
Online	Accuracy	58%	69%	73%	82%	87%

Conclusions

- Integrated stimulus generation, signal acquisition and signal processing on an FPGA.
- Design allows online real-time processing of the P300 signal without a bulky personal computer.
- Accuracy at par with a PC.