Live Demonstration: Towards an Ultra Low Power On-board Processor for Tongue Drive System

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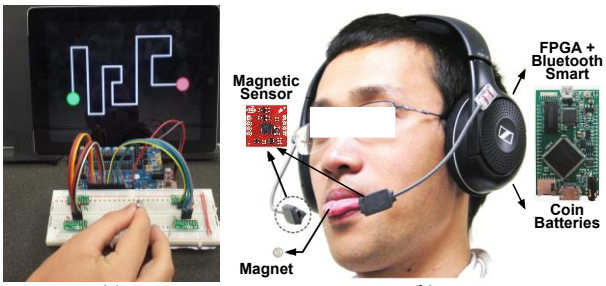
I. Introduction

Tongue Drive System (TDS) is a new unobtrusive, wireless, and wearable assistive device that allows for real time tracking of the voluntary tongue motion in the oral space for communication, control, and navigation applications. The latest TDS prototype appears as a wireless headphone and has been tested in several human subject trials. Producing a smaller and more stable version of the TDS requires placing a considerable restraint on the battery size, and consequently requiring a considerable reduction in its power consumption to operate over an extended period of two days on a single charge. To reduce this power consumption, we have implemented an ultra low power local processor for the TDS that performs all signal processing on the transmitter side, following the sensors. Assuming the TDS user is on average issuing one command/second, implementing the computational engine reduces the data volume that needs to be wirelessly transmitted to a PC or smartphone by a factor of 1500x, from 12 kbit/s to 8 bit/s [1-2]. The design is implemented on an ultra low power IGLOO nano FPGA and is tested on an AGLN250 prototype board using four external LSM303D 3-axis magnetometers and a Texas Instruments CC2540 Bluetooth transceiver, as seen in Fig. 1-a. According to our post place-and-route results, implementing the processor on the FPGA drops the power consumption by 27%. This work presents the demonstration of first implementation of the proposed onboard FPGA-based processor for TDS. This demonstration is based on our earlier published work in the special edition of Biomedical Circuits in the IEEE Transactions on Circuits and Systems II [1].

II. Demonstration Setup

The TDS operates by completing four main tasks; reading the sensor data, performing a noise reduction operation, processing the data to classify which command was selected, and finally wirelessly transmitting the command to the receiver. In order to use TDS, the user must first attach a magnetic tracer to their tongue, which is then tracked using data from four magnetometers. Once the FPGA has read the magnetometers' data it performs an earth's magnetic field (EMF) attenuation by using two of the sensors as reference points. The data is then classified using a single-stage KNN Euclidean algorithm and the result is wirelessly transmitted to the receiver. The working prototype setup is shown in Fig. 1-a. The prototype that will be used for the demonstration will consist of the same components, but will be integrated into a wearable headset, as seen in Fig 1-b. The demonstration will consist of a wireless headset, as seen in Fig. 1-b, a radio receiver, a laptop, and a poster. No special accommodations will be necessary.



(a) (b)

Fig. 1. (a) The FPGA test setup (b) Complete external TDS on headset with FPGA and sensors intgeration.

III. Visitor Experience

The visitor will have the opportunity to see a live demonstration of the external Tongue Drive System (eTDS) as a presenter demonstrates using the headset and tongue movement to control a computer program on the laptop. Since the system requires attaching a magnetic tracer to the users' tongue, we provide them an option to use a small magnet attached to a stick to control the system instead by moving it to designated positions in a 3D space. The poster will illustrate to the visitor both the methodology of how the eTDS system works as well as how using an FPGA for onboard data processing can greatly reduce the power consumption of the system compared to previous eTDS devices that transmitted raw data for external processing. The live demonstration would reveal the essence of our work by showing the visitor that capturing tongue movement is a viable method of communicating with today's technology and that using an onboard FPGA to process the magnetometers' data is a reliable and much more power efficient alternative to transmitting the raw data to the laptop for processing.

References

[1] Sina Viseh, Maysam Ghovanloo, and Tinoosh Mohsenin. "Toward an Ultralow-Power Onboard Processor for Tongue Drive System." *Circuits and Systems II: Express Briefs, IEEE Transactions on* 62.2 (2015): 174-178.

[2] S.Viseh, A.Acevedo, M.Ghovanloo and T.Mohsenin, "Towards a low power FPGA implementation for a stand-alone intraoral tongue drive system" 39th Annual GOMACTech Conference, April 2014.

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