Using Keepon with a brain-machine interface

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***Abstract*— My Keepon, a simple and low-cost version of Keepon robot, is a black box with two buttons. For human-robot interaction studies, it needs to be controlled by a PC. The goal is to control the movements and sound of the robot independently with the built-in programs via PC serial communication (UART), and PlayStation 2 (PS2) controller. Furthermore, by using Emotiv brain-machine interface, My Keepon can be controlled by thoughts as an innovation. This system is used for the brain-robot experiment of Prof. Rudi De Raedt, psychology professor of Ghent University, Belgium to create a real-life experience that one can control the environment with his mind.**

I. BACKGROUND

Keepon, an interactive robotic toy for kids of all ages, is a small yellow creature-like robot designed for simple, natural, nonverbal interaction with children [1] to study social development. It was developed by Hideki Kozima while at the National Institute of Information and Communications Technology in Kyoto, Japan. The research model of Keepon has four motors, a rubber skin, two cameras in its eyes, and a microphone in its nose [2]. Hidden buttons are used to wake it up and detect touches at each side of the robot. There is a speaker in the base which generates sounds corresponding to specific actions. In our project, a low-cost version of Keepon called My Keepon is used with limited capabilities e.g. no camera and not possible to control by PC.

Based on the latest developments in neuro-technology, Emotiv has developed a revolutionary new personal interface for human computer interaction. In Emotiv system, the Emotiv EPOC is a high resolution, neurosignal acquisition and processing wireless neuroheadset with 14 electrodes [3]. By implementing Emotiv SDK on PC software, user's thoughts, feelings and expressions produced by the brain can be read wirelessly from this EPOC via EPOC USB Receiver.

Using My Keepon, we access its hardware and software in order to manage the movements and sound independently to the built-in programs. In addition, connection with Emotiv system allows us to create a brain-machine interface to control this robot for various applications.

II. CURRENT RESULTS

My Keepon uses two microprocessors to control the movements and sound, which talk to each other via I^2C protocol [4]. The PS232 (address 0x52) deals with sound and encoders while the PS234 (address 0x55) handles driving the H-bridges, main processing (including handling button presses) [4]. These microprocessors are the slave and master node of the I^2C bus respectively. In order to control My Keepon, we need to access this bus, turn the robot to Manual mode and send commands to get our desired movements or sound. Specifically, two I^2C pins of an Arduino Uno are connected to the corresponding ones of the hardware of My Keepon with a logic voltage converter (5V to 3.3V). An easy way to control My Keepon by the I^2C commands is using a software on PC, written in Microsoft Visual C#, and a PS2 controller. The task of Arduino is to convert user commands from graphical user interface (GUI) components via UART or PS2 commands to I^2C ones. Since single movements can be controlled, it is possible to generate flexible actions by combining them together. Besides the built-in sounds, our software can play other recorded audio files depending on requirements of specific applications. Demonstration video is available at *http://youtu.be/RV49kw9CDp8*.

A connection with Emotiv headset is established to receive brainwaves (EEG) for mind control purpose by implementing Emotiv SDK. The Emotiv API is exposed as an ANSI C interface that is declared in three header files ($edk.h$, $EmoStateDLL.h$, $edkErrorCode.h$) and implemented in two Windows DLLs ($edk.dll$ and $edk\_utils.dll$)[3]. Our software called EmoKeepon includes the above files to receive data from neuroheadset which are translated into an easy-to-use structure called an EmoState [3]. User's thoughts data in EmoState e.g. forward, backward, rotate left, rotate right, etc. are transmitted to Arduino Uno and then converted to I^2C commands of Keepon. The performance of user's thoughts detection significantly depends on the training process.

Currently, Prof. Rudi De Raedt of Ghent University is testing our system for his experiment. With this system, we create a real-life experience that one can control the environment with his mind [5]. In this case, participants learn to move My Keepon forward, backward, rotate left, rotate right, etc. This experiment allows to test whether this experience might positively influence the way people deal with stressful situations [5]. For more information, visit our website at *http://www.vikeepon.tk*.

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