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Implementation of embedded assistive device for disabled people

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Abstract. In this paper we present an embedded assistive device for disabled people that is intended to be used as both keyboard and mouse replacement. Assistive device consists of two main parts: an Arduino compatible board, preferably an Arduino UNO R3 as used in this paper, or an Arduino Leonardo, and a simple analog thumb-stick joystick. Presented device is connected to a computer trough a USB port trough which it sends its input data. Special software collects the received input data and triggers various events in order to execute various actions. Primary goal of presented assistive device is to simulate mouse movements and a single mouse click and in that manner replace majority of moue functions thus enabling users to perform various mouse based tasks such as navigating through menus, drag and drop actions etc., as well as to enable an input and control over a virtual onscreen keyboard thus enabling users to type.

Keywords: embedded, assistive, device, arduino, disabled people

1. Introduction

With growth of technology, and in recent years Open source electronic devices, programmable micro controller boards such as Arduino, NodeMCU, BeagleBone etc. and microcomputers such as Raspberry Pi, Intel Edison and Intel Galileo, a whole new world has opened up towards both experts and enthusiasts to work on various projects that could be classified as Embedded systems. Ease of access and low cost of aforementioned components also contributed towards an increase of general interest towards custom embedded devices.

It is in human nature to help one another. A lot of actions and activities that we take for granted great number of people can only dream of. For example a simple task of communicating one with another, weightier that be trough a verbal or visual communication a lot of people with disabilities find rather difficult. Disabilities can be various ranging from light to severe and focusing on both physical and mental ones. In this project we made and attempt towards building and assistive device that would enable disabled people with various kinds of disabilities to use a computer in order to communicate and work. Basic idea is to control a computer via a simple thumb-stick joystick that can be found on various game console controllers such as Sony PlayStation 4 or Microsoft XBOX.

This would enable people with limited or slim hand movement and coordination to interact with a computer, express emotions, communicate with other people etc. There are various devices that are designed to act as assistive devices, however their price range is somewhat expensive. Our goal is to create and embedded low cost assistive device and push developed software on services such as GitHub in order to be used by an Open Source community in order to help disabled people that do not have resource to obtain other more expensive assistive devices. The hardware itself, both micro controller board and analog hat joystick, cost approximately around 20 dollars or it could be even cheaper if some sort of Arduino clone or counterfeits that are available on the market are obtained, while the source code of a software and the software itself is intended to be released free of charge as an Open Source software that can be extended towards specific needs of a disabled person that will be using the device. This way a great level of freedom is given towards the extensibility and development of a presented device.

As mentioned before, there are various other assistive devices for disabled people and various researchers are already working on various assistive devices that would help disabled people. With this in mind we can say a field of study has already been formed that focuses on making assistive devices for disabled people. With this attempt we are trying to make our small contribution in the aforementioned field by introducing Open Source low cost components and concepts of Open Source software in order to produce cheap non profitable assistive devices.

There are examples of other Arduino board based assistive and monitoring devices such as a microcontroller that is placed on a wheelchair and tracks users movement and notifies his or hers caretaker if something goes wrong. E.g. An epileptic seizure. This is presented in work of Jesús Cabal-Aragón et. Al. [1]. Work of Geonea et. Al [2] describes an Arduino based wheelchair prototype while Leite et. Al. [3] present a device for electromechanical braille reading digital text that is also Arduino based with usage of servo motors. In work of Abd Wahab et. Al [4] a Smart Cane that helps visually impaired by alerting them of certain obstructions trough voice alerts and vibrations is presented while Gangopadhyay et. Al [5] present a similar Arduino based system as Leite et. Al. [3].

2. Device implementation

Hardware implementation of presented device is rather simple. As mentioned before, it consists of two key parts: an Arduino compatible board in this case Arduino UNO R3 and a simple analog thumb-stick joystick that can be found in most Arduino starter kits. Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button [6]. Wiring is quite simple, as shown in Fig 1. and relies on supplying power to the analog thumb-stick joystick trough 5V pin, ground trough GND pin, and reading analog values from X Axis and Y Axis on Analog 0 and Analog 1 pins. Switch is connected via digital pin 2 and essentially presents a left mouse click button.

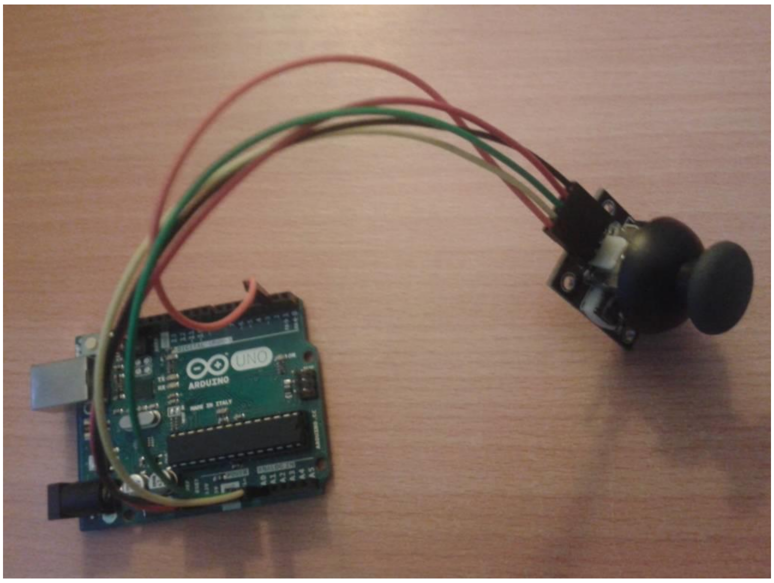

Fig.1. Arduino UNO R3 and analog thumb-stick joystick

A simple piece of code is written to read both analog and digital inputs and write them to serial port formatted as shown in Fig. 2. Frequency of sampling and sending input data is 100ms meaning that in 1 second we get 10 analog readings from analog thumb-stick joystick. A sample of input data that is being sent is also shown in Fig. 2, while composed device itself is shown in Fig. 1.

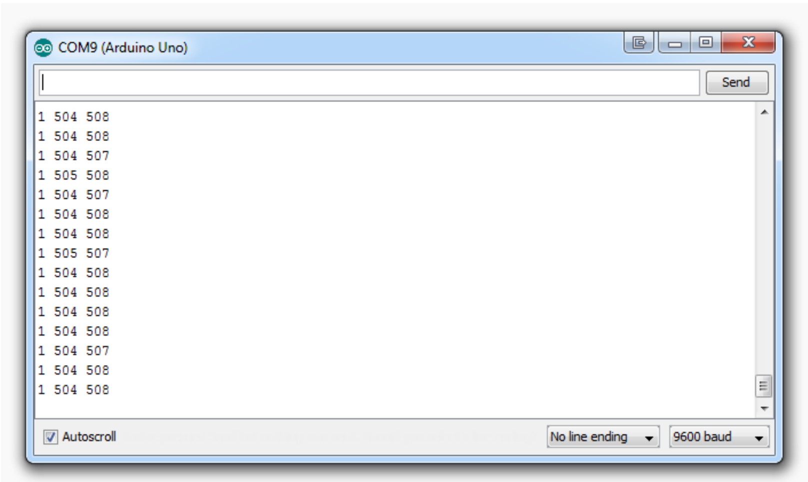

Fig.2. Format and sample of input data

Software implementation of a presented device relies on interpreting data that described device sends via USB port on a baud rate of 9600 bits per second. A simple windows forms .NET application is made using Visual Studio 2015 Edition that listens to a USB port that device is connected to, and based on sent values invokes WINAPI functions that are located within user32.dll file. Aforementioned application is shown in Fig 3. To control a mouse pointer values from X and Y axis of a thumb-stick joystick are converted to appropriate offsets for mouse input and sent via SendInput function [7] as input instructions. The same goes for left mouse click simulation. Based on all of the previously stated facts it can be concluded that, for now, devised device is supported by a software that runs only on Windows operating systems and requires a .NET Framework.

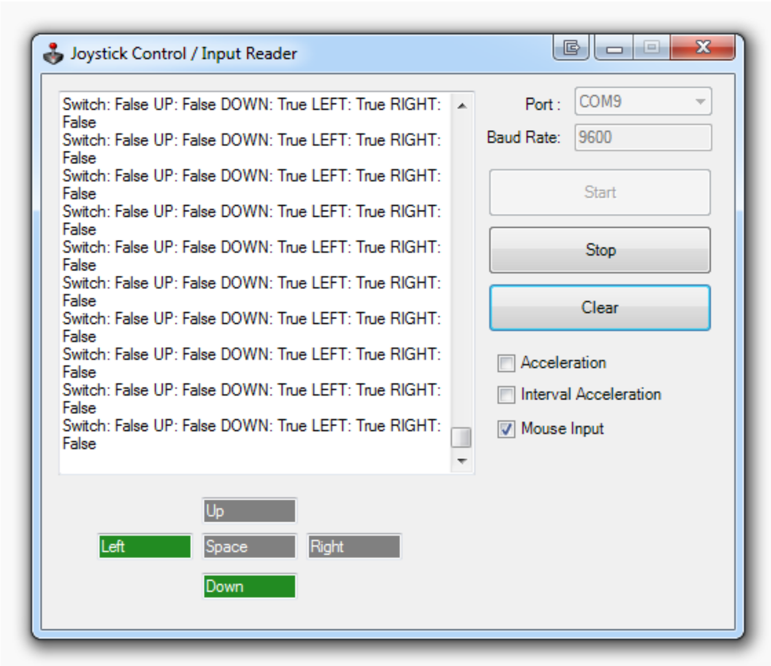

Fig. 3. Joystick control application

It is important to emphasize that device and software itself is treated as an additional input device so it can be used as an input in any full screen application such as various games while keyboard and mouse remain completely functional. Developed application itself could be configured to emulate various keys in order to potentially simulate movement trough virtual environments such as museums and various well know architectural sites.

To enable keyboard interaction a user must hold switch on thumb-stick joystick for 3 second and then a dialog pops out asking a user to choose an input type. Aforementioned dialog is shown in Fig. 4. Since Mouse Input is default and preferred method of input, alternative input method is Keyboard Input.

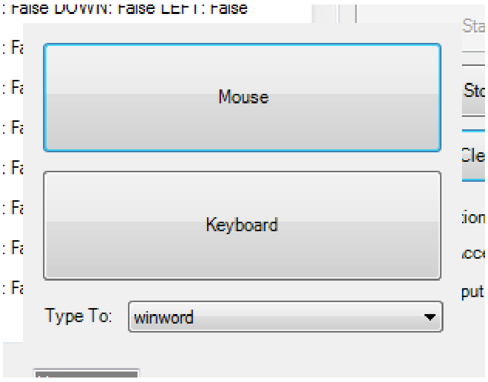

Fig. 4. Input methods

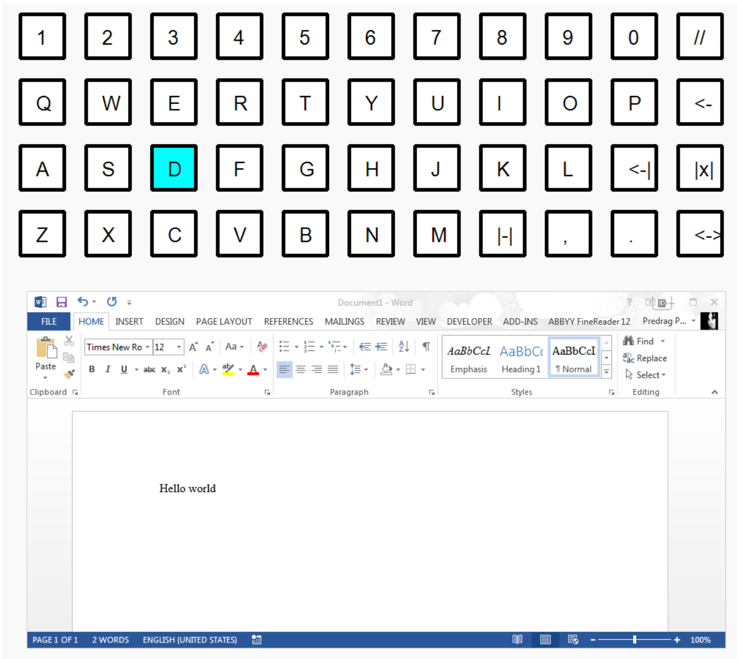

Fig. 5. Onscreen keyboard and typing in Microsoft Word

If Keyboard Input is selected a custom virtual onscreen keyboard is displayed as shown in Fig. 5. Navigation trough available keys is done via an analog thumb-stick joystick while activation of a key, or a key press, is done via button (switch) press. Currently selected key is indicated with a light blue color as shown in Fig. 5. Before a user starts typing it is required for a user to select an application to which software will send simulated keystrokes. Keystrokes are also send trough WINAPI SendInput function. After every keystroke using Microsoft Speech Synthesis each typed letter and key is spoken out in order to indicate what key has been typed in with an option to read entire typed text.

3. Conclusion

In order to provide usage data, presented device will be tested on a number of disabled people. Presented concept is not new since various efforts have been made towards constructing assistive devices of various kind, and, based on the currently perceived literature, we have found similar solutions that use Infra-Red (IR) sensors and other input methods to simulate mouse input. However, we have not found a solution that combines aforementioned components with software support to obtain described functionality, and therefore consider it to be, so far somewhat unique. Further development will include extensibility towards non Windows operating systems such as various Linux/Unix distributions, Mac OS etc. and implementation of described functionality on a driver level or as an operating system service. As mentioned before, we hope that this will become an Open Source project in order to assist as many disabled people as possible. However whether presented solution will become an Open Source project will be determined by aforementioned tests, and if we get positive feedback development of presented device would take a step from a test / pilot project towards a potential Arduino based assistive device platform.

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