Sign Language Translator System

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Abstract. This paper presents a low-cost wireless sign language translator for interpreting and having a conversation between deft and non-deft persons. The system is a glove-like one with sensors embedded in every finger of the glove as to fusion the information from multiple sources and accurately providing an output of the sign language. The paper presents the hardware modules and the software workflows that were used to implement the system and it shows a first prototype of the system. The achieved accuracy, in terms of sign detection, is around 85%.

Keywords: Sign language · Wireless systems · Sensors · IoT

1 Introduction

All around world we can find women and men unable to speak through their mouth or which are deaf or even worse, both, ever since they were born and due to something that happened during their life. They do not represent a majority, indeed, and some people might never have this type of person amongst their friends or in their entourage or they might not even meet one in their life, but they do exist and they do need our help.

There are research attempts to close de gap between the deft group and others. In [1] the authors presented a a sign language apparatus built using a glove with movement sensors on fingers, used to produce time series of data. The editing apparatus, as it was called, was using a sign language word dictionary for storing the processed data, a sentence data editing divider for reading out the time series data and adding predetermined additional information to produce time series data and an animation synthesizer to create an animation movement for the present sign. Also, in [2] the authors design a case with a touch screen display located on its face, a microprocessor for word, letters and number translation into videos with a real person performing the translation. The device consisted into a memory for words database and the complementary video. The purpose of the project was to translate a user input data selected from the screen and to display the corresponding returned video output.

The purpose and motivation of this paper is to try to fill the gap of communication between the deft and others, giving them a way in which they could have a normal conversation. This gap should be filled using a low-cost and robust solution. Hence, the paper presents a sign language translator, sign language being a dialect where the communication is possible without the means of acoustic sounds. All the letters are based on sign patterns, movements and orientations of the hand, so that the device is presented in the form of a glove.

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This paper is organized as follows. Section 2 describes the implemented system, Sect. 3 presents the results and Sect. 4 concludes this paper.

2 The Implemented System

2.1 The Hardware Modules

The hardware modules connections are based on the microcontroller which is the heart of the project, meaning it connects and gives life to everything. The Flex sensors are used on every finger of the hand to measure how bend a finger is and by fusioning the data with the accelerometer and the Contact sensor to determine what is the letter that the user is showing at a given time. Then, the microcontroller, gathers data from all flex sensors, from contact sensors and from accelerometer, processes data and passes it further, remotely, to another microcontroller which communicates with a LCD (Fig. 1).

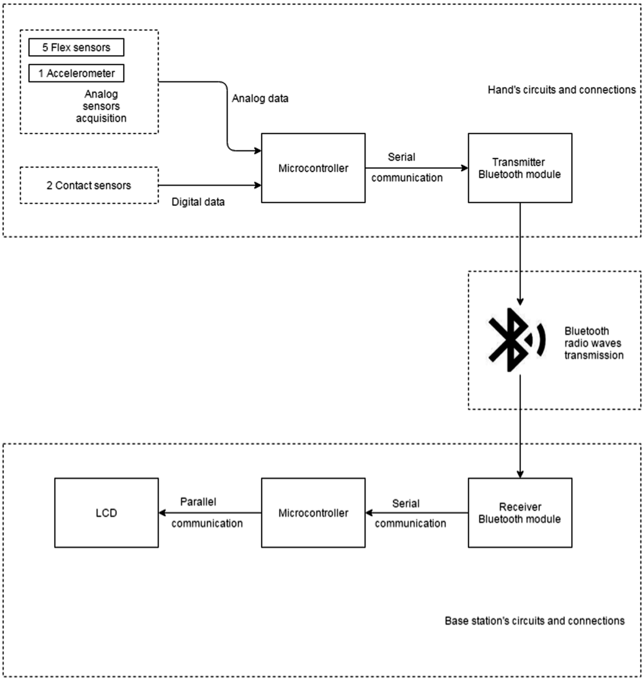

Fig. 1. The hardware modules

2.2 The Software Applications

Based on the modules shown in Fig. 1 it can be easily understood that we have 2 main blocks. The hand block and the base station block. Both these blocks have separate workflows that should follow and that are programmed in the microcontroller. The hand software application is divided into two main areas, one for initializations and the other one for ongoing processes.

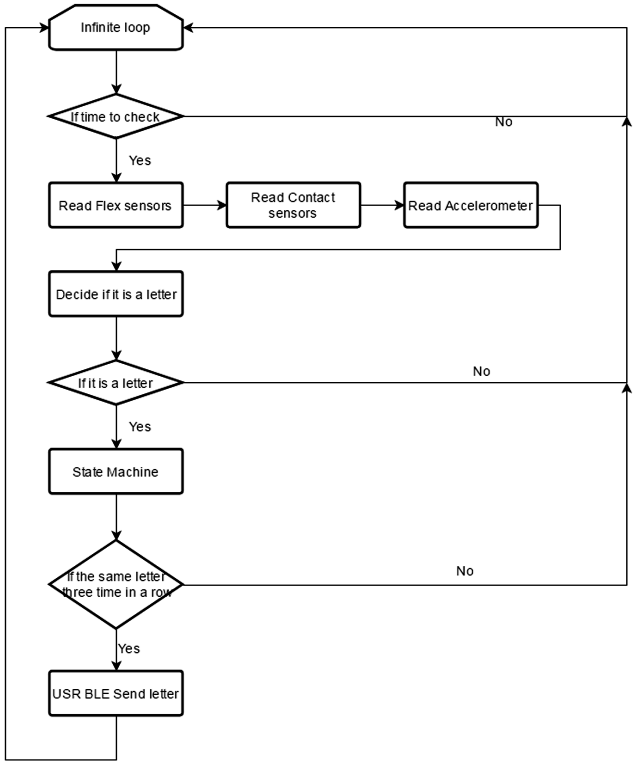

Fig. 2. The glove application

For the initialization part, we should initialize the used PIN's state, the oscillator clock, the ADC, the Interrupts, Enhanced Universal Asynchronous Receiver Transceiver (EUSART), the Bluetooth low energy modules and a Timer. All these initializations are necessary before the main application start and are describing the initial state of the system.

The main application, the one that does the sign translation is presented in Fig. 2. The presented workflow should continuously run, creating a never-ending program with its functionality described below: The code is contained into an infinite loop of a while instruction with the condition to run if the initial condition is true. The time, to check condition, is represented by a flag change by a timer interrupt at each 150 ms. The reading sensors sequence is divided into analog data readings and digital data for contact sensors: Digital data readings are simple, they can be either high value (logic 1) or low value (logic 0), with the actual value of the pin being hold into a register called PORT. To read analog data, several changes are required, beside configuring the module as it was indicated above and placing it in the startup zone: Enable the ADC module; Select the channel corresponding to the PIN where the device is connected; Give time to the module to start and to select a channel by introducing a few microseconds delay; Start the conversion; Wait for the conversion to finish; Disable the

ADC module; Get the result from the ADRESH and ADRESL registers The sign language translator is based on American Sign Language Alphabet (ASL) [3], each letter having its own sign. The differences between the marks being given by the degree of bending of the fingers, the positioning of the hand, the movement or the contact between certain fingers. Based on the data read from the flex sensors, a decision is taken on how much each finger is bent and a certain value is assigned. Based on the data read from accelerometer, the hand's position is determined and a value is also assigned. All the assigned values will be concatenated into a single string and compared with a predefined and previously calculated string for each of the characters. The decision is taken only based on the flex sensors and accelerometer in order to diminish the number of processes, since based on the data received from these sensors, the application is able to distinguish about 85% of the characters. For the rest of the characters, the application is using contact sensors and the same accelerometer, this time used in another approach: Contact sensors are used to decide between "r", "u" and "v", the only difference being the contact between the index finger and the middle finger, while the finger's bend and hand's position is the same; This time, the accelerometer is used to determine the movement which is the only difference between "i" and "j" and between "d" and "z.

Once decided if it is or not an alphabet letter, the letter is either passed to a state machine or the application will wait for the next timer interrupt. The **state machine** is used to check the credibility of the letter, since it could happen for the hand to be in a certain position corresponding to a certain letter in the exact moment of the reading procedure, but in fact it could have just passing by, resulting in erroneous data transmission. The principle of operation is simple, checking the current letter with the previous one and if they are the same, it can move to the next state. The previous letter refers to the decision made based on the sensors readings at the previously timer interrupt, thus the state machine advances to a new state or goes to the first state at each timer interrupt. Once the state machine reaches state 3, meaning that the same letter was found 3 times in a row, the equivalent of 450 ms, it can be decided that a letter has been made and will be sent, using EUSART, towards the Bluetooth module which will further send using radio waves to the base station's Bluetooth module. In the initializing process, the EUSART peripheral was used in a Full-Duplex communication so it can configure the Bluetooth module, sending commands and receiving the confirmation. In the runtime process, a Full-Duplex communication is no longer required, the glove sending data to the base station when a certain letter has been detected, the data exchanging becoming simplex and the Bluetooth device acting as a transmitter.

After a letter has been sent, a flag is activated as a safety measure, in order to avoid character's spamming (to transmit the same character forever). From now on, when a timer interrupt occurs, it will be checked whether the new letter is the same as the last one sent: If they are the same and the flag is still active, the program will no longer enter into the state machine; If the characters are different and the flag is still active, the flag will be disabled, the program will reach the state machine's first state and from now on it can follow its normal path shown in Fig. 2.

The base station's application is way simpler, given the fact that it has no sensors, resulting in no need to create a timer and wait for its interrupt or to configure an ADC module. The only thing it does is to process nothing during its run-time until an

EUSART receive interrupt occurs, meaning a letter was transmitted. When a letter was received, his job is to manage the LCD, printing the target slave's MAC address on the first line and checking if there is enough space on the second line for character printing. If it has received a character and there is no empty slot to display it, it will clear the display, reprint the MAC address on the first line, set the cursor on the second line and display the received character. After the initialization process, the EUSART interface is kept in a Simplex transmission with the current Bluetooth device acting as a receiver.

3 Results

From the point of view of flex sensors, these were few important variables which changed the original readings, from a free mode, into something hard to predict and with certain calibrations required. The most important factor was the difference between finger's lengths and their capability to bend and this time not between people, but the same person's fingers. Thus, each finger required its own configuration based on its range of values. The range of values was decided by reading the voltage level given while the hand was acting and making all the sign contained in the American Sign Language.

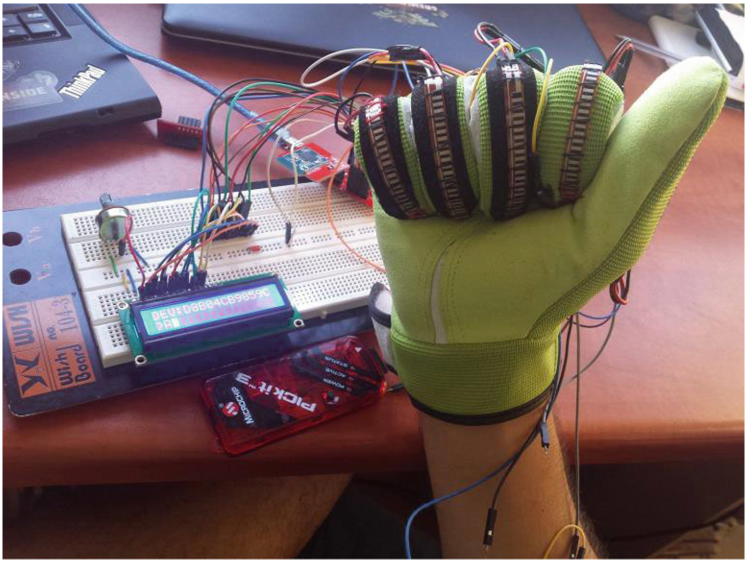

Fig. 3. The prototype of the sign detection system

For all the signaling problems we've could identify the cause using a Logic Analyzer which can measure both digital and analog signals. The device has a computer compatible application that can create a history of the measured signals. The user can also select if he uses a certain protocol and the application will translate the level of voltage into the respective code.

After the calibration process of the accelerometer and the flex sensor's data for the user specifications, the application could distinguish most of the letters, the only problems seem to be to determine the signs that involve movement. In the current configuration, the same accelerometer is used for position and movement detection, sometimes making the decision difficult. The module was used to determine the position of the hand based on the acceleration on each axis and the movement, using the gyroscope as a direction indicator and thus, using some decisional blocks, we can identify the existence of the movement. In Fig. 3 can be seen the glove doing the A letter and the base station printing the slave's device MAC address on the first row and the character on the second, in front of an arrow.

4 Conclusions and Future Work

In this paper, we presented the results of a sign detector system that can be used in understand a basic conversation with a deft person. We plan to extend our work to add other signs that represents a whole world to understand also a fast pace conversation. Also, given the Bluetooth capabilities of the system, the base station module could be implemented inside a smartphone application for easier and more practical usage.

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