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Sign to Text Language Conversion Using Arduino Nano

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Abstract
Sign language is a vital communication tool for individuals who are deaf or hard of hearing. However, the lack of understanding by individuals who do not know sign language creates communication barriers. This paper presents an innovative system that addresses this issue by converting sign language gestures into text using Arduino Nano, Flex Sensors, and an I2C LCD Display. The flex sensors detect the bending of the user's fingers, which is interpreted by the Arduino to display the corresponding American Sign Language (ASL) letters on an LCD in real-time. The system provides a low-cost, efficient, and easily implementable solution to facilitate communication between sign language users and non-sign language users.

Keywords: Sign to text, Arduino nano, Flex sensor, LCD, LCD (I2C Interface).

1. Introduction

Communication is a vital part of human interaction, and for people with hearing impairments, sign language is a crucial mode of communication. However, a significant challenge arises when deaf individuals need to interact with those who do not understand sign language. There is a growing need for assistive technologies that can bridge this communication gap. This paper discusses the development of a real-time sign language to text translation system using a flex sensor for hand gesture detection and an Arduino Nano for processing the input and controlling an I2C LCD display. The primary aim of this project is to provide a cost-effective solution to enable real-time sign language communication for people who may not be familiar with the language.

2. Literature Review

The goal of numerous research projects has been to use various technologies to translate sign language into speech or text. To decipher hand gestures, these systems frequently use sensors and machine learning algorithms. Among the noteworthy pieces are:

Accelerometer and Gyroscope-Based Sign Language Recognition [3]. This system used sensors to identify hand movements and orientation changes. But it needs a lot of sensors, which makes it more complicated and expensive.

Flex Sensors and Arduino for Gesture Recognition [2, 4]: In this study, flex sensors were used to identify hand movements and translate them into text. Although it was less expensive, its accuracy in recognizing intricate gestures was constrained.

Real-time Gesture to Text Conversion: Machine learning-based systems [1] have been created that use cameras to identify gestures and translate them into text. However, these systems are often too costly and complicated for regular users, and they require powerful processors.

Despite their usefulness, the majority of current systems have drawbacks like high cost, complicated setup, and trouble recognizing a variety of gestures. By using flex sensors for hand gesture recognition and emphasizing affordability [4], simplicity, and real-time output, our system seeks to address these problems.

3. System Design and Methodology

System Overview

The Arduino Nano, flex sensor, and I2C LCD display are the three main parts of the system.

Flex Sensor: The main input device is the flex sensor. When a user bends their finger, it recognizes the movement and transforms it into an analog voltage. To determine the hand gesture that corresponds to a letter in the American Sign Language alphabet, the Arduino reads this analog signal.

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Arduino Nano: The Arduino Nano uses an I2C LCD display to display the corresponding ASL letter after processing the data from the flex sensor. It reads the voltage from the flex sensor using the analog-to-digital conversion and converts it to an ASL letter.
I2C LCD Display: The recognized letter is output via the LCD. With just two data lines (SDA and SCL) needed to display the text, it connects to the Arduino via the I2C protocol.

Flow of System Design
When a finger bends, the flex sensor senses it and produces an analog voltage.
This analog voltage is read by the Arduino Nano.
The value is contrasted with preset cut-off points that represent various ASL letters.
The I2C LCD shows the recognized letter.

Methodology
Calibration of Flex Sensors
The minimum and maximum bend (angle) of the corresponding finger are detected by each calibrated flex sensor. Flex sensor values are mapped to a corresponding bending angle by the Arduino after it has received analog inputs from the sensors.

Algorithm for Gesture Recognition
For gesture recognition, the system makes use of thresholding. The sensor values are compared by the system to preset thresholds that correspond to various gestures, such as the letters A through Z in the American Sign Language (ASL) alphabet. The matching letter appears when a gesture fits a pattern.

Presenting the Identified Letter
The system recognizes the gesture and then displays the matching letter on the LCD screen using the LCD. print() function. Users can see the result as soon as they make the gesture thanks to real-time feedback as shown in Fig.1.

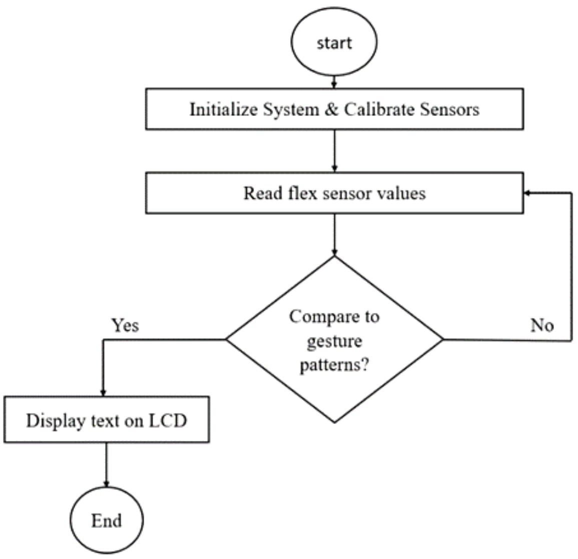

Fig 1: Flow chart of system design

4. Implementation
Hardware Setup
Five flex sensors one for each finger are connected to the Arduino Nano's analog pins as part of the hardware configuration. The recognized text is shown on an LCD that supports I2C. A 5V USB connection [4] is used to power the Arduino [2].

i). Arduino Nano
The ATmega328P chip serves as the foundation for the tiny, portable Arduino Nano as shown in Fig.2 microcontroller board. Because of its portability, affordability, and simplicity of use, it is perfect for projects like the sign language recognition system.

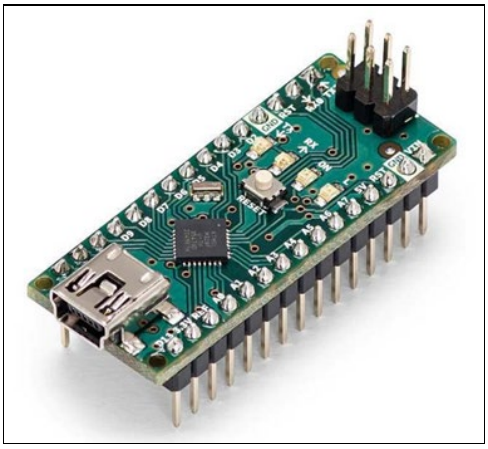

Fig 2: Arduino Nano

Functions and Role in the System:
Microcontroller: The Arduino Nano serves as the system's brain. After processing the analog input values from the flex sensors, it displays the recognized sign language gesture as text on the LCD.
Analog-to-Digital Conversion: The voltage output from the flex sensors, which is correlated with the bending of the fingers, is read using the analog pins (A0 to A5) on the Arduino Nano. After that, the analog signals are transformed into digital signals that the Arduino can understand.
LCD Control: To show the identified letters in real time, the Arduino Nano connects to the I2C LCD.

Specifications:
- ATmega328P processor
- 5V is the operating voltage.
- Eight analog input pins (A0 to A7) • Fourteen digital I/O pins, six of which are PWM pins
- Memory: 2 KB SRAM, 32 KB Flash Memory
- USB Interface: Used for power supply and programming; clock speed: 16 MHz.

ii). Flex Sensors
Flex sensors as shown in Fig.3 are variable resistors that alter their resistance in response to the degree of bending that is applied to them. These sensors are essential for determining the degree of finger bending, which is the primary characteristic of sign language hand gesture recognition.

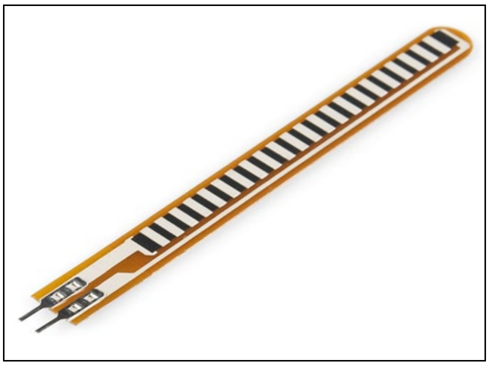

Fig 3: Flex Sensor

Functions and Role in the System

- **Finger Bending Measurement:** Each finger's degree of bend is determined by placing a flex sensor on it. The sensor's resistance varies as the finger bends. This change is read as an analog value by the Arduino.
- **Arduino Data Input:** The Arduino Nano's analog pins are linked to the flex sensors. The position of the finger determines the resistance of each sensor, which is subsequently read as an analog input by the Arduino.
- **Gestures:** These resistance values are mapped to particular gestures by the Arduino. For instance, a bent finger might indicate a higher sensor value, whereas a fully straight finger might indicate a lower value.

Specifications

- **Sensor Type:** Resistive
- **Range:** 0 to 180 degrees (depending on the sensor and the application)
- **Output:** Resistance changes as the sensor bends, which is read as an analog signal (e.g., 0-1023 in Arduino's analog Read function).
- **Size:** Typically 2.5 to 4.5 inches long.
- **Sensitivity:** The sensitivity is the change in resistance per degree of bending, and this varies depending on the flex sensor model.

iii). LCD Display with I2C Interface

This system displays the recognized text that corresponds to the sign language gestures using an LCD (Liquid Crystal Display) as shown in Fig.4 With just two wires—SDA (data) and SCL (clock)—multiple devices (such as sensors and displays) can communicate thanks to the Inter-Integrated Circuit (I2C) communication protocol.

Fig 4: LCD Display with I2C Interface

Functions and Role in the System

- **Text Display:** The LCD's main job is to display the translated sign language gesture as text. The Arduino signals the LCD to display the matching letter or word when it detects and recognizes a gesture.
- **I2C Interface:** This interface uses just two pins (SDA and SCL) to enable communication between the LCD and the Arduino. This is particularly helpful for small-scale projects like this one because it minimizes the number of wires needed for communication.
- **Real-Time Display:** For interactive applications like sign language translation, the LCD gives the user immediate feedback.

Specifications:

- **Display Type:** 16x2 character LCD (16 characters, 2 lines)
- **Interface:** I2C (using SDA and SCL pins)
- **Voltage:** Typically operates at 5V (same as Arduino Nano)
- **Resolution:** 16x2 (16 characters in a line, 2 lines)
- **Current:** Typically 100mA (depends on the model and backlight settings)
- **Library:** The I2C LCD is controlled by the LiquidCrystal_I2C library in the Arduino IDE.

iv). Power Supply

The power supply is in charge of giving the system as a whole the voltage and current it needs. In this configuration, 5V powers both the LCD display and the Arduino Nano.
Functions and Role in the System:

- Arduino The power supply is in charge of giving the system as a whole the voltage and current it needs. In this configuration, 5V powers both the LCD display and the Arduino Nano.
- LCD Power: In order to function, the I2C LCD also needs 5V, which can be obtained from an external power source or directly from the Arduino.
- Powering Flex Sensors: The Arduino's 5V pin powers the flex sensors, and the analog pins detect changes in resistance.

v). Wires and Connections

To create the required electrical connections between each component, wires and connectors are required.

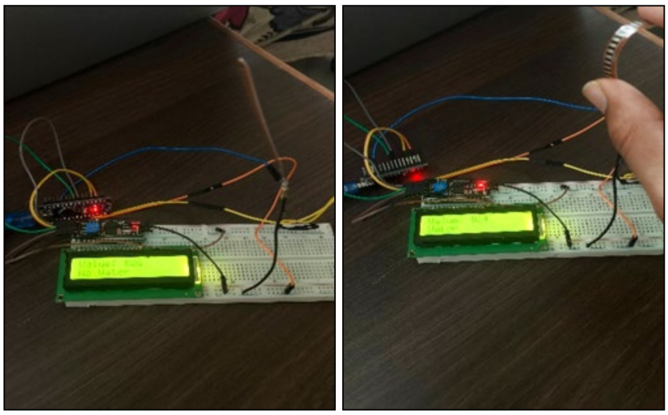

Fig 5: Connection

Functions and Role in the System

- Connecting Flex Sensors: The Arduino Nano's analog input pins are linked to the flex sensors. Every sensor must be connected to a single analog pin (A0 to A4) and be a component of a basic circuit that uses a voltage divider.
- I2C LCD Connection: The SDA (A4) and SCL (A5) pins on the Arduino are used to connect the I2C LCD. The

Arduino's 5V pin powers the LCD.
- PPowering the System: The system is also powered by wires. The Arduino Nano can be powered via a USB connection, and the Arduino's 5V pin powers the LCD and sensors.

Software Components
The following essential components make up the software:
- **Arduino IDE:** The programming environment for creating and uploading code to the Arduino Nano.
- **Arduino Code:** C++ code that processes sensor data, recognizes particular gestures, and connects to an I2C LCD to display text.

5. Result
- The LCD stays blank when the flex sensor is not bent.
- The LCD shows "Water" in real time when the flex sensor is bent.
- During testing, the system operated as anticipated, rapidly updating the message in response to the bend or release of the sensor [4].

6. Conclusion
This project effectively illustrates a basic system that uses a flex sensor to detect bending and an I2C LCD to display the relevant message ("Water") (Fig.5). The system offers an affordable and simple solution through the use of the Arduino Nano [3]. Additional sensors for more complicated inputs, dynamic threshold adjustments, or wireless communication to transmit the data to a distant device are possible future improvements [1].

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