Human Computer Interaction: Hand Gesture recognition Using Tiny Machine Learning

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Introduction

The traditional input methods such as keyboard, mouse, and controllers, have limitations in terms of flexibility and intuitiveness, which may not cater to all users. This project aims to overcome these limitations by proposing a more natural and intuitive way of interacting with electronic devices. Recognizing hand gestures is a promising approach as it allows users to interact with the devices in a way that mimics their natural body language.

This project utilizes two "***Arduino Nano 33 BLE Sense***" devices to recognize hand gestures and translate them into game controls, which would enable users to perform actions such as jumping, moving left or right, shooting, protecting, and adjusting speed by making hand gestures.

The proposed solution has the potential to enhance user experience, especially in interactive environments such as gaming or smart homes, where intuitive and natural interaction is highly desirable.

The Arduino Nano 33 BLE Sense

Data collection:

In order to train the machine learning model for hand gesture recognition, data collection plays a crucial role. The data collection process involves recording multiple repetitions of each gesture. In this project, four basic gestures are considered: **up**, **down**, **right**, and **left**.

During the data collection process, each repetition of a gesture generates 119 samples, which include 3 values of acceleration (aX, aY, aZ) and 3 values of gyroscope (gX, gY, gZ). These values are recorded from the sensors on the "Arduino Nano 33 BLE Sense" devices, which capture the hand movements associated with each gesture. The combination of acceleration and gyroscope values provides a detailed representation of the hand gesture, which is crucial for accurate recognition.

The collected samples are then saved in a CSV file, which is used in the training process of the machine learning model.

Arduino Nano Arduino held by hand for data acquisition

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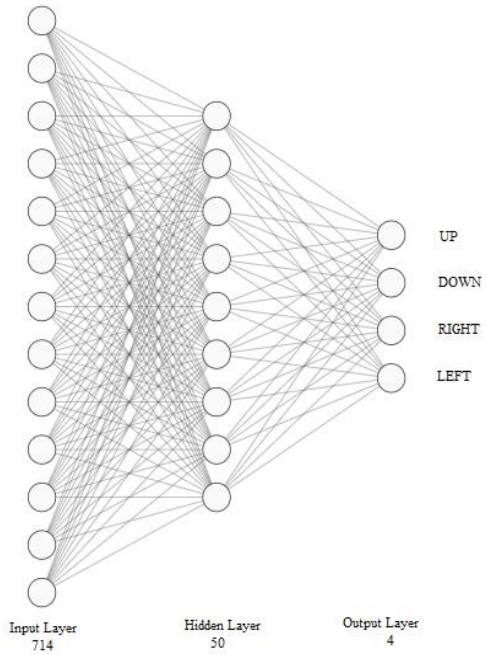
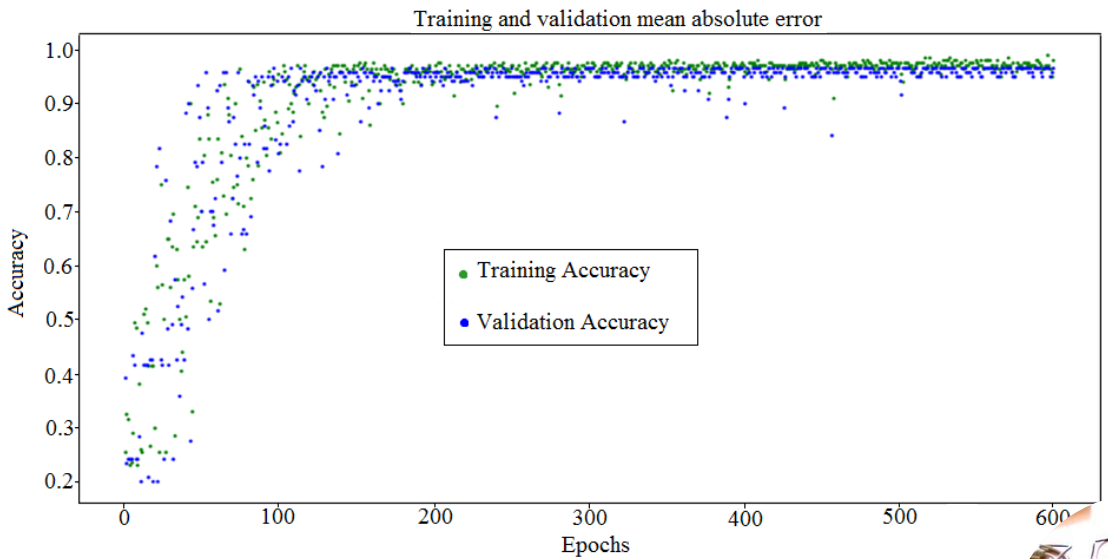
Machine learning model architecture:

The machine learning model architecture utilized in this project includes an input layer with 714 nodes, a hidden layer with 50 nodes, and an output layer with four nodes representing the movements: Up, Down, Right, and Left. The input layer receives 714 samples, generated during the data collection process, consisting of acceleration and gyroscope values for each gesture (119*6=714). The output layer is responsible for classifying each gesture based on its corresponding movement.

During the training process of the machine learning model, 100 samples are used for each gesture. This ensures that the model is trained with a sufficient amount of data for each gesture, enabling it to recognize and classify hand movements with greater accuracy.
It is also important to note that the model is trained using 600 iterations. This allows it to fine-tune its predictive capabilities over time and make accurate predictions even in complex and dynamic scenarios where hand gestures may vary in speed or trajectory.



The used Shallow Neural Network



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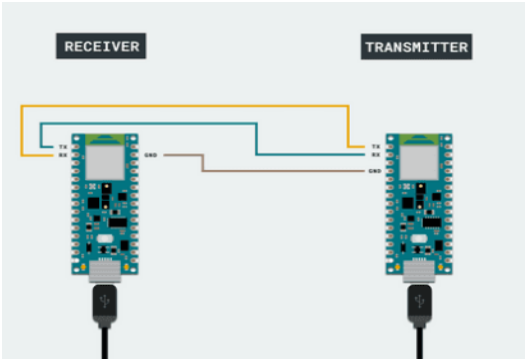
Communication protocol

Accurate recognition of hand gestures requires the communication between the two "Arduino Nano 33 BLE Sense" devices. To achieve this, the project uses the Universal Asynchronous Receiver-Transmitter (UART) communication protocol. This protocol enables the transmission of data between the devices asynchronously, allowing for configurable data format and transmission speed.
Specifically, when the right-hand Arduino device makes a prediction, it sends this information to the left-hand receiver Arduino using the UART communication protocol. This process ensures that both devices are synchronized and work together to accurately predict the final gesture.



Hand gesture recognition and classification process

The process involves using a trained machine learning model to classify hand gestures on individual Arduino devices.
This enables each device to independently predict hand gestures for the right and left hand.
Once the right-hand Arduino makes a prediction, it transmits the prediction to the left-hand Arduino using the UART communication protocol. The left-hand Arduino then combines the predictions from both hands to accurately predict the final gesture.
Using a machine learning model facilitates accurate and efficient recognition of hand gestures. Furthermore, the seamless communication protocol between the Arduinos enhances the user experience.