Gesture Recognition Empowered by Ambient Light and Embedded AI

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1 DEFINITIONS

Ambient Light: Unmodulated light from the surrounding environment.

Photodiode: "A semiconductor diode which, when exposed to light, changes its electrical resistance".[1]

2 BACKGROUND

The COVID-19 pandemic highlighted how much interactions with public technology require physical touch, which increases the **transmission of diseases**. [2]

Gesture Recognition reduces reliance on physical touch.
Using ambient light as a medium reduces the energy required and is more **privacy friendly** than using cameras.

The project uses **three photodiodes** and an Arduino Nano 33BLE to recognize the **shadows** of the gestures people perform.

One of the major steps to focus on is the **data collection** for this kind of gesture recognition because no existing dataset exists for this scope.

3 RESEARCH QUESTION

> What kind of gesture dataset should be constructed for the purpose of training a machine learning model?

4 CHALLENGES

1. Selecting the hand gestures to use that can be identified by the photodiodes.
2. Making the dataset diverse.
3. Controlling the experiment when collecting the data.

5 SYSTEM OVERVIEW

The pipeline for the development of the main project has 4 sections.

1. Deciding on the optimal setup of the hardware [3].
2. Process the signals from the photodiodes effectively [4].
3. Deciding on the hand gestures and collecting the training data.
4. Selecting the best ML model to use and training based on the data [5,6].

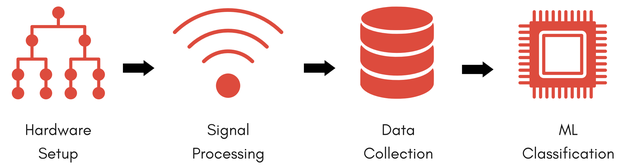

Figure 1: The pipeline for development.

6 DESIGN AND IMPLEMENTATION

The **10 hand gestures** that were classified have been defined as the following:

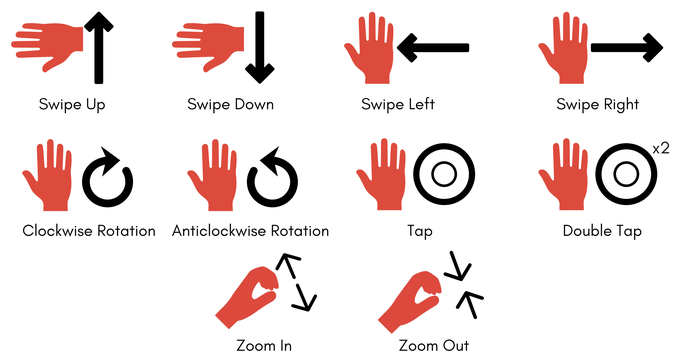

Figure 2: The set of hand gestures that were collected.

These hand gestures were selected using shadow analysis to see if they are distinguishable.

Each hand gesture was performed by a total of **50 people** 5 times on each hand, creating **5000 instances**.

The 50 candidates ranged from **19 to 38 years old** and the gestures were performed under **different light intensity ranges** (from poorly-lit rooms to outdoors in peak sunlight).

There were **33 male** and **17 female** candidates with only 5 left-handed people. Hand widths ranged from 8.5-12cm and lengths from 15.6-21.4cm

7 RESULTS

Training the model resulted in an **81.0% validation accuracy** with the processed dataset and an **86.8% validation accuracy** with the raw dataset.

Reasons the accuracy is lower than expected:

- The processing pipeline not being able to cut off buffers in raw data.
- Varying ways candidates performed the gestures.
- Various environments caused edge cases.

The adaptability of the system to new environments:

- The system showed to work best in well-lit indoor environments between 100-1000 lux.
- The light source at an angle causes the shadow to be offset and sometimes not cross the photodiodes.
- Two light sources (lamp and sunlight) cause two shadows to be cast, creating unrecognizable patterns.
- Light intensity outdoors changes drastically due to cloud movements.

A tradeoff between data that produces high accuracy and data that reflects real-world environments.

8 CONCLUSION

A dataset for gesture recognition using ambient light has been designed and built.

The building of the dataset has given insight into the limitations of gesture recognition using ambient light when used in different environments. It also shed more light on the intuitiveness of the gestures.

9 REFERENCES

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