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Project Presentation

# GloveHero

## Arduino-based System for Hand Rehabilitation

Designing Mechatronic Systems for Rehabilitation

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Part 1

# Rehabilitation Devices: Scenario

02



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# What are we going after?

**What?** .....

Stroke, spinal cord injury, neuromuscular disease, ligaments reconstruction

**Why?** .....

Quality of life, independency

**How?** .....

Interactive game: involve the patient and autonomous rehabilitation



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# Where does GloveHero come in handy?



Repetitive gestures:

- 4 pinches
- Hand opening-closing (punch)
- Pronosupination



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Part 2

# Hardware and Programming Interfaces

05



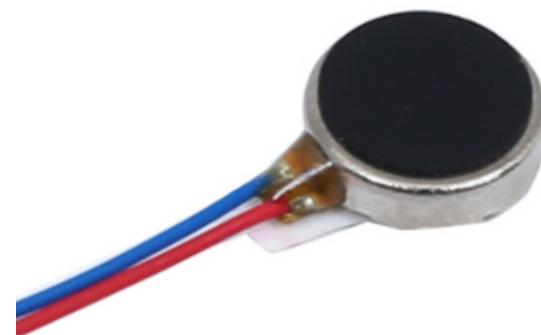
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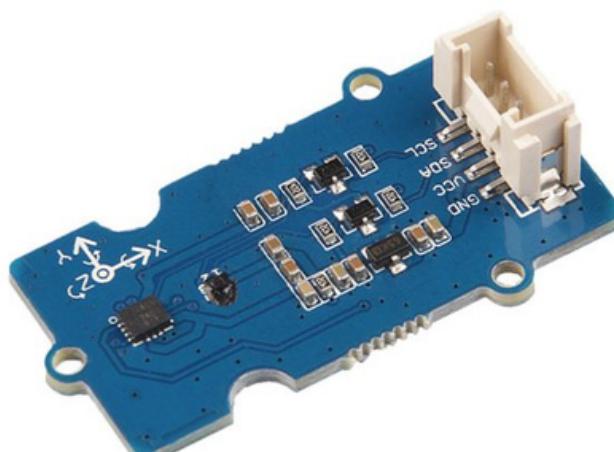
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2 - HARDWARE AND PROGRAMMING INTERFACES

# Hand-sensing glove



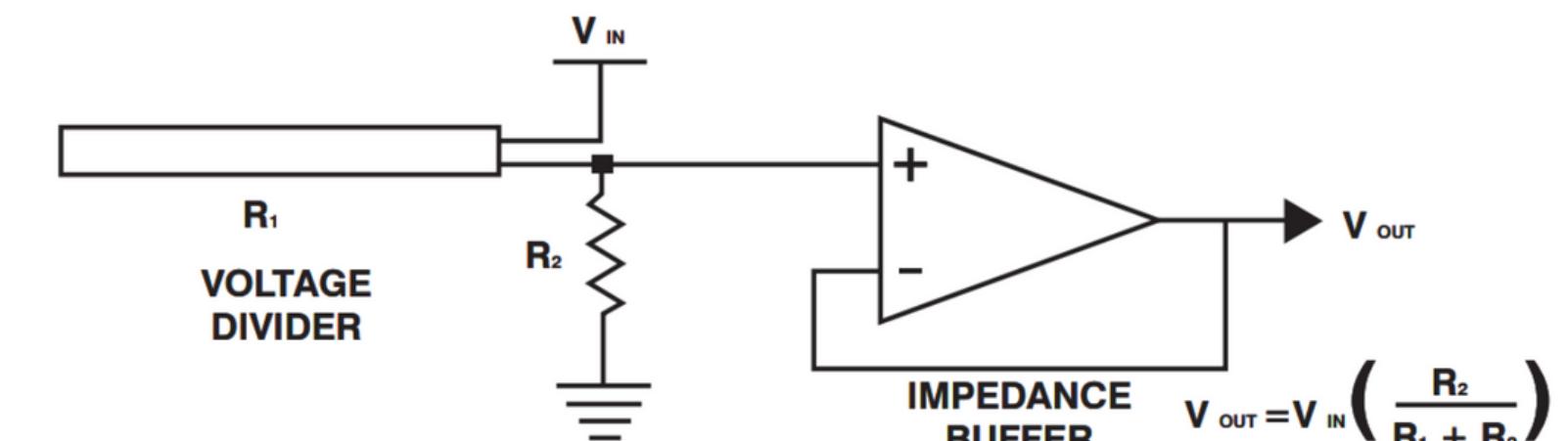
Haptic motor



Grove - IMU 9DOF



Strain Gauges FS2L055



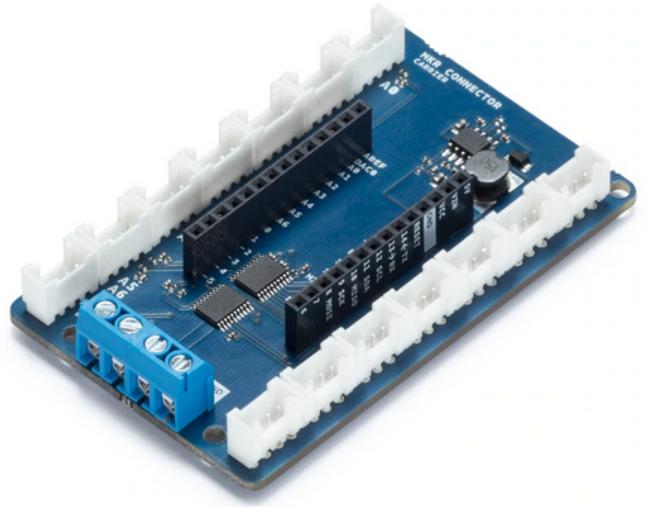


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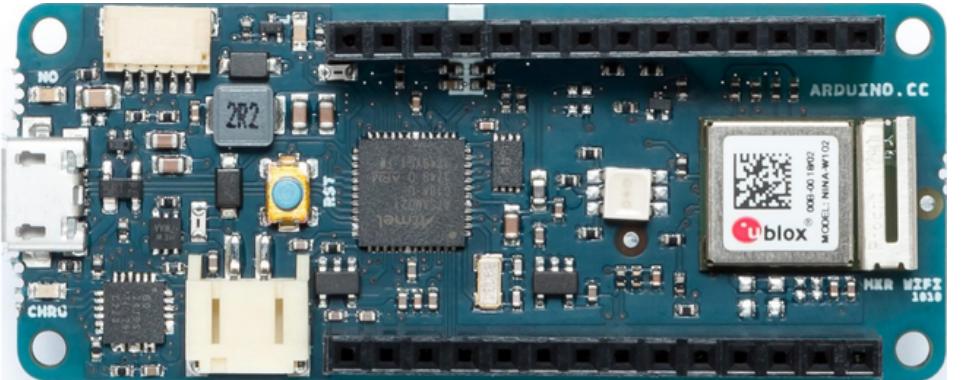
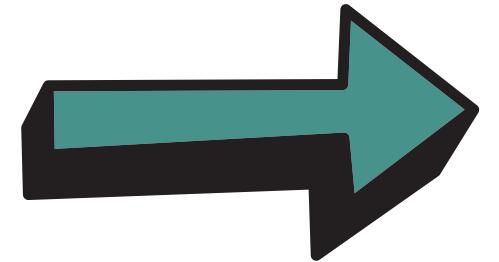


2 - HARDWARE AND PROGRAMMING INTERFACES

# Data analysis



Arduino MK3 Connector Carrier



Arduino MKR 1010 WiFi3



Data acquisition

Preprocessing

Labeling

Features extraction

Thresholds identification

Machine Learning

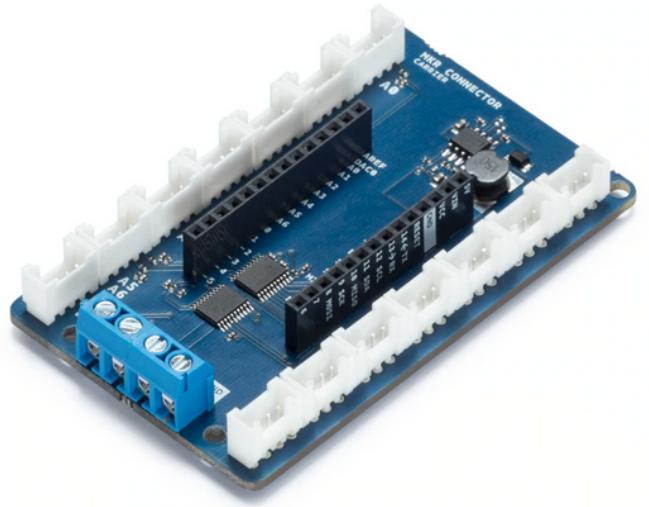


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2 - HARDWARE AND PROGRAMMING INTERFACES

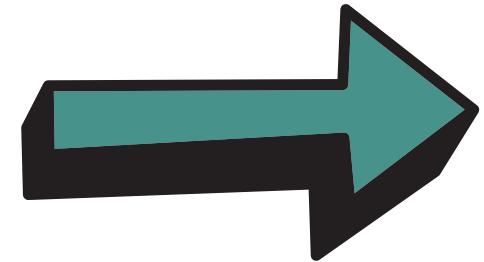
# Real-time system



Arduino MK3 Connector Carrier



Arduino MKR 1010 WiFi3



Game and HMI  
Calibration (WIP)  
Gestures classification



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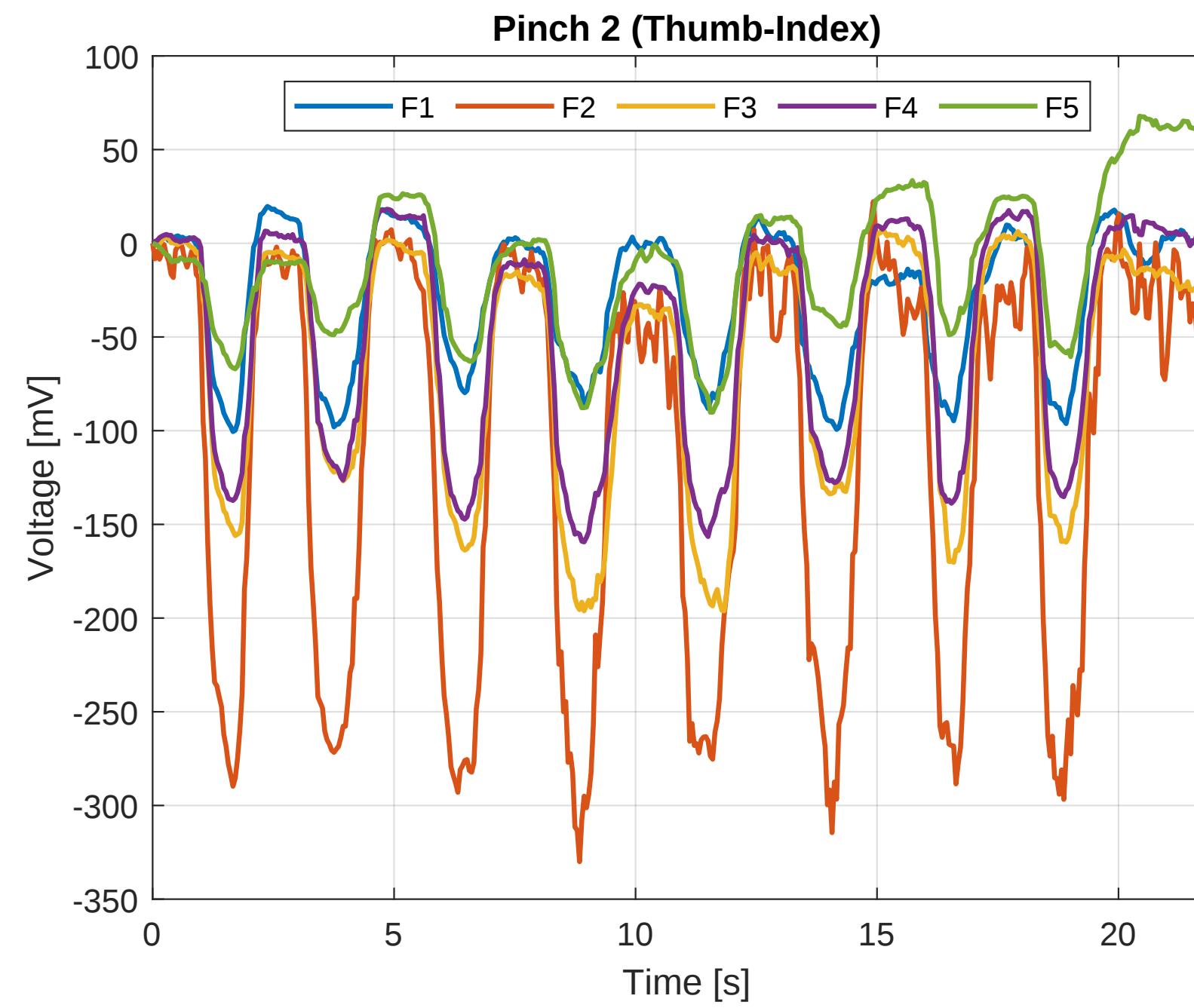


Part 3

# Classification Algorithms



# Thresholds Classification



## SIGNAL WINDOWS

Duration  
Overlapping  
Features extraction

## FEATURES

XYZ accelerations values  
Strain gauges minimum values



# Machine Learning

|                |                | Confusion Matrix |                |                |                |                |              |              |                |
|----------------|----------------|------------------|----------------|----------------|----------------|----------------|--------------|--------------|----------------|
|                |                | P <sup>2</sup>   | P <sup>3</sup> | P <sup>4</sup> | P <sup>5</sup> | N              | F            | S            |                |
| Output Class   | P <sup>2</sup> | 100<br>14.3%     | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%      | 5<br>0.7%      | 0<br>0.0%    | 0<br>0.0%    | 95.2%<br>4.8%  |
|                | P <sup>3</sup> | 0<br>0.0%        | 100<br>14.3%   | 0<br>0.0%      | 0<br>0.0%      | 5<br>0.7%      | 0<br>0.0%    | 0<br>0.0%    | 95.2%<br>4.8%  |
| P <sup>4</sup> | 0<br>0.0%      | 0<br>0.0%        | 88<br>12.6%    | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%    | 0<br>0.0%    | 100%<br>0.0%   |
|                | P <sup>5</sup> | 0<br>0.0%        | 0<br>0.0%      | 2<br>0.3%      | 95<br>13.6%    | 2<br>0.3%      | 0<br>0.0%    | 0<br>0.0%    | 96.0%<br>4.0%  |
| N              | 0<br>0.0%      | 0<br>0.0%        | 10<br>1.4%     | 5<br>0.7%      | 88<br>12.6%    | 0<br>0.0%      | 0<br>0.0%    | 0<br>0.0%    | 85.4%<br>14.6% |
|                | F              | 0<br>0.0%        | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%      | 100<br>14.3% | 0<br>0.0%    | 100%<br>0.0%   |
| S              | 0<br>0.0%      | 0<br>0.0%        | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%      | 0<br>0.0%      | 100<br>14.3% | 100%<br>0.0% |                |
|                |                | 100%<br>0.0%     | 100%<br>0.0%   | 88.0%<br>12.0% | 95.0%<br>5.0%  | 88.0%<br>12.0% | 100%<br>0.0% | 100%<br>0.0% | 95.9%<br>4.1%  |

## ALGORITHMS

K-nearest neighbors (KNN)

Support Vector Machine (SVM)

Decision Trees

## OBSERVATIONS

Without Calibration: accuracy 75:90%

With Calibration: accuracy >93%

Useful for more complex gestures

Arduino memory limit: compression and TCPIP



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Part 4

# Calibration

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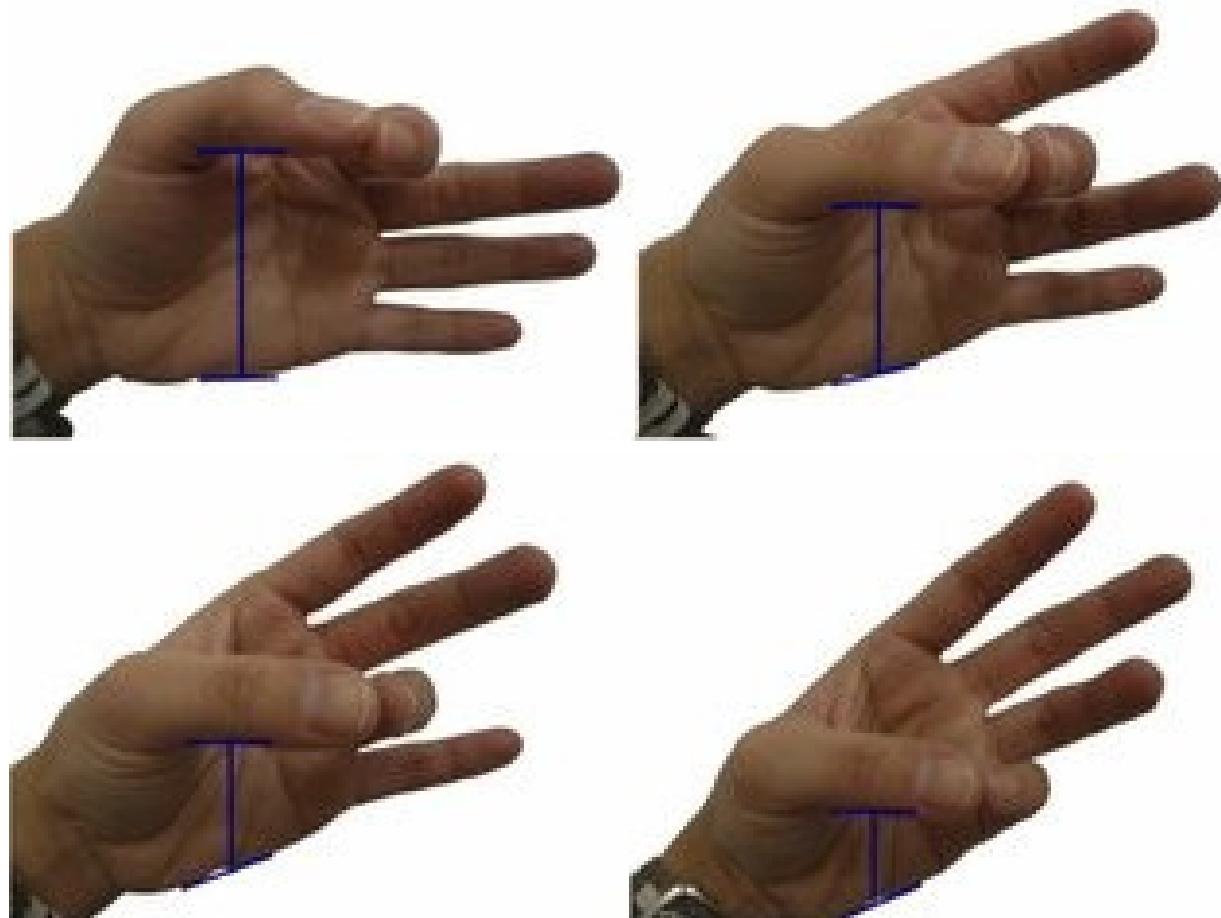


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4 - CALIBRATION

# Threshold calibration



1. Each pinch repeated N times
2. Extract features
3. Mean of the features
4. Thresholds: 10% tolerance

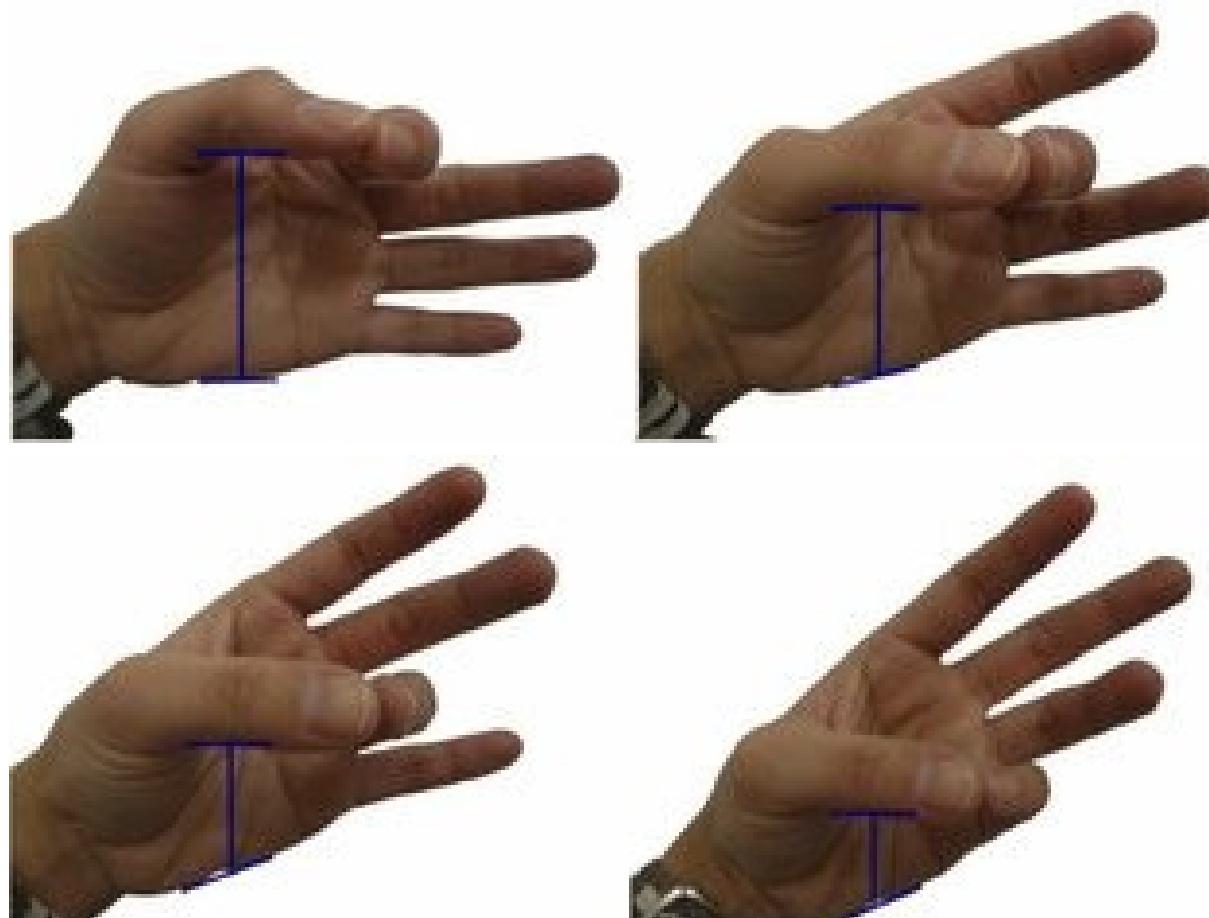


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4 - CALIBRATION

# ML calibration



For each gesture:

1. 3 acquisitions at a different velocity
2. During each acquisition, the gesture is repeated 8 times
3. Preprocessing and labelization
4. Features extraction and normalization
5. Training dataset saved



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Part 5

# GloveBeats

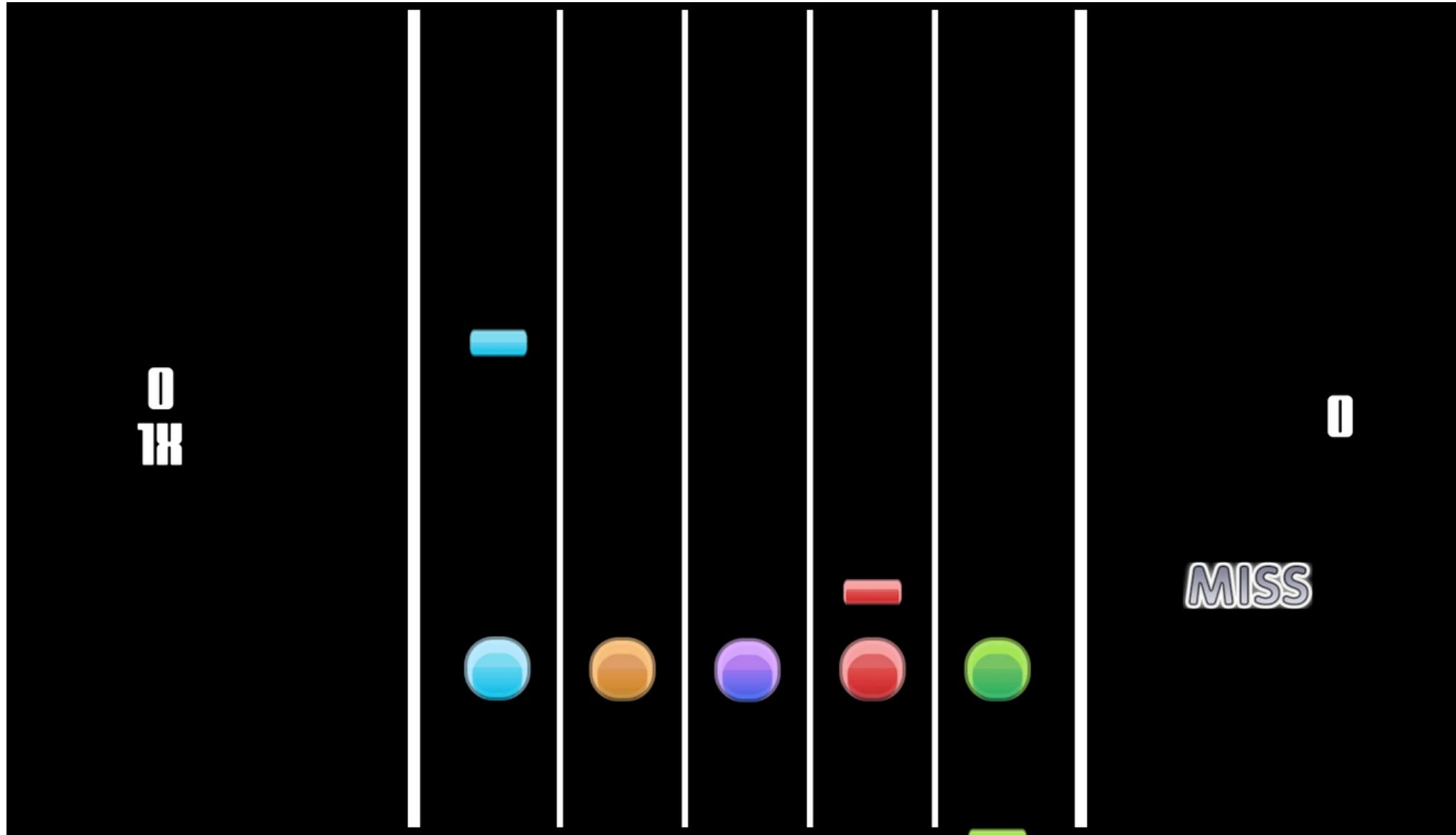
## Let's play!



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5 - GLOVE BEATS



Base on GUITAR HERO game

RHYTHM Game

Correct gesture and timing

Scoring system: increasing the engagement\*\*

\*\* Goršič, M., Cikajlo, I. & Novak, D. Competitive and cooperative arm rehabilitation games played by a patient and unimpaired person: effects on motivation and exercise intensity.

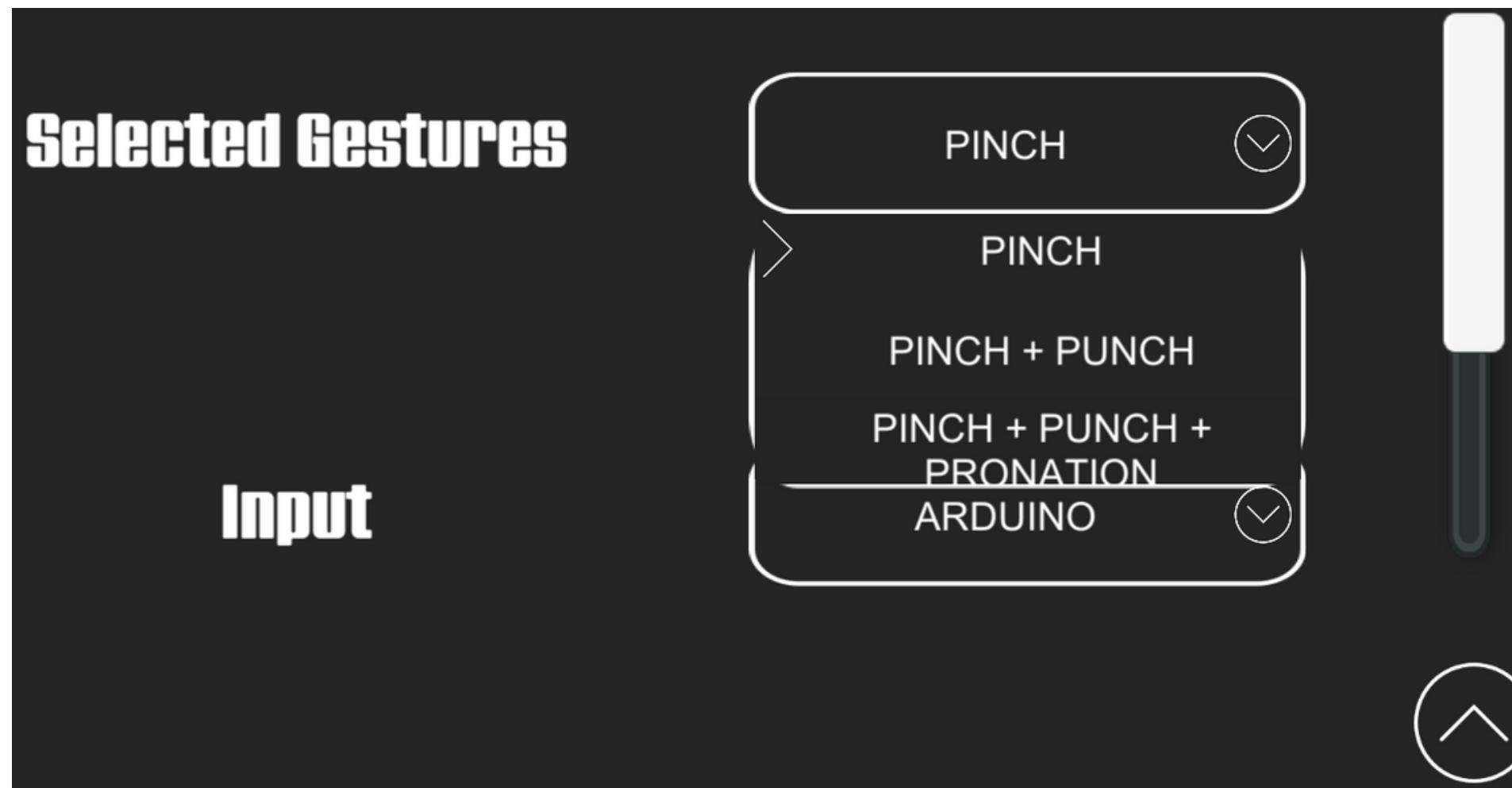


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5 - GLOVE BEATS



Input

Scoring system: increasing the engagement\*\*

Different modalities:

- 4 pinches
- 4 pinches + punch
- 4 pinches + punch + pronosupination

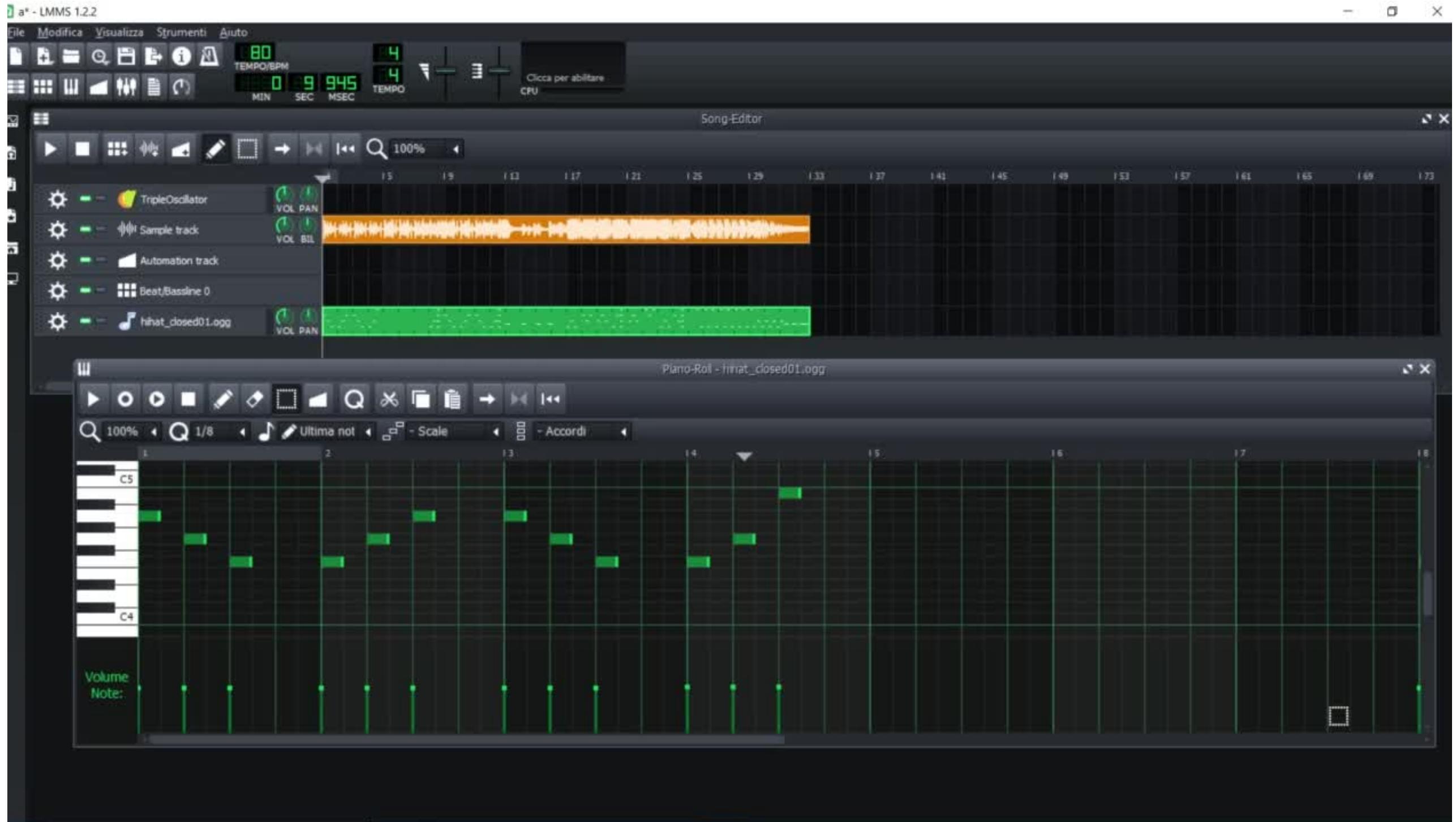


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5 - GLOVE BEATS



Manual music sheet editing

Easy level customization

Adjustable to the patient



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Part 5

# Improvements



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5 - IMPROVEMENTS

## WORK IN PROGRESS

In-game calibration

Haptic-feedback

## IMPROVEMENTS

More complex gestures

3D-printed glove

Longer strain gauges

PCB circuit and arm support

WiFi communication

Postprocessing



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## Resources

Project GitHub Repository:

<https://github.com/MikFerrari/GloveHero.git>