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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



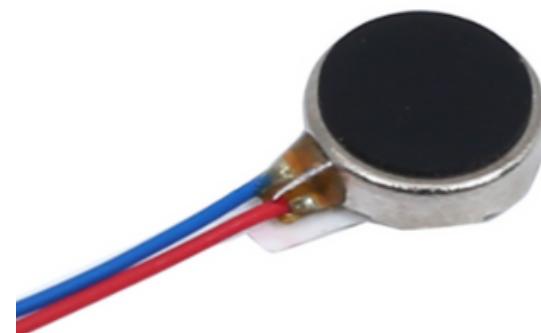
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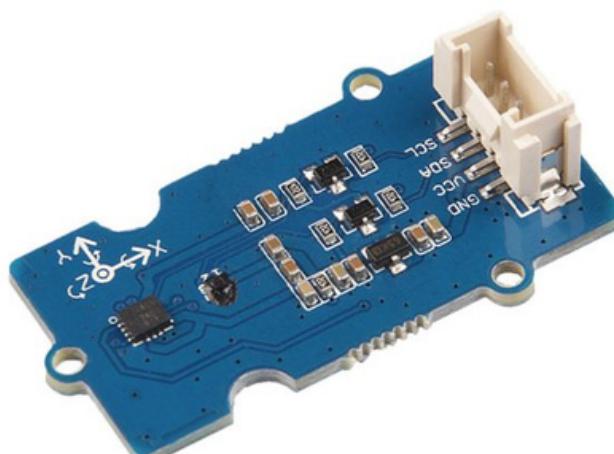
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2 - HARDWARE AND PROGRAMMING INTERFACES

Hand-sensing glove



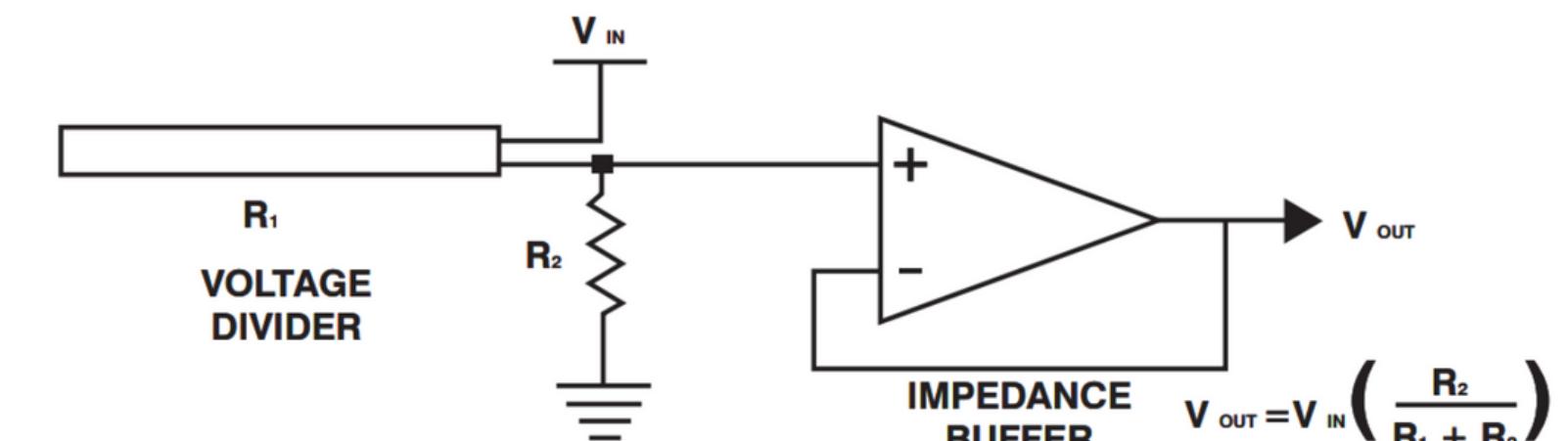
Haptic motor



Grove - IMU 9DOF



Strain Gauges FS2L055



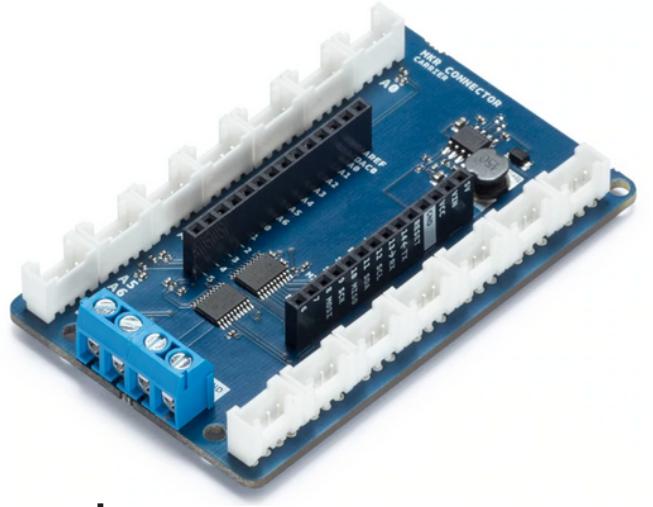


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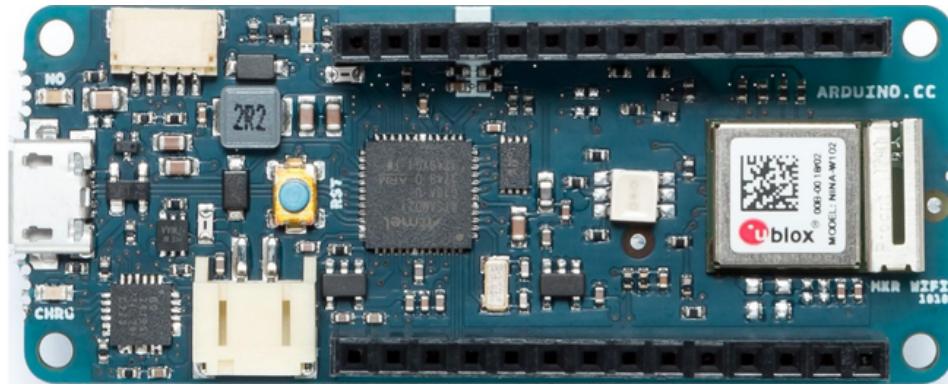
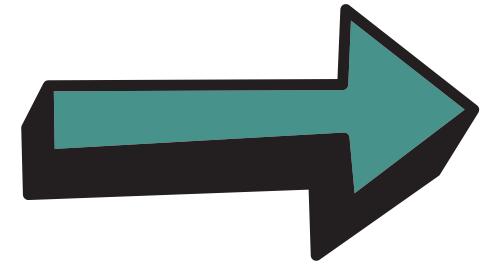


2 - HARDWARE AND PROGRAMMING INTERFACES

Data analysis



Arduino MKR 1010 WiFi3



Arduino MKR 1010 WiFi3



Data acquisition

Preprocessing

Labeling

Features extraction

Thresholds identification

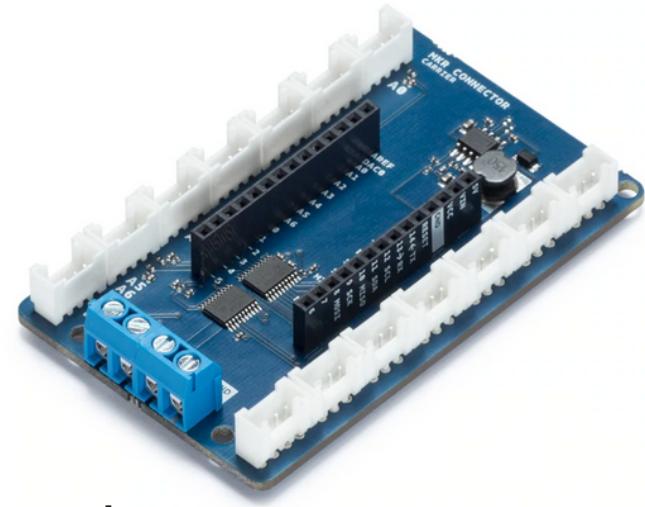
Machine Learning



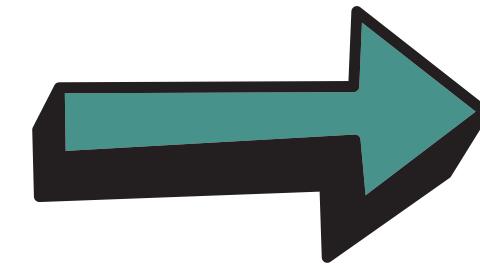
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Real-time system



Arduino MKR 1010 WiFi3



Arduino MKR 1010 WiFi3



Game and HMI
Calibration (WIP)
Gestures classification



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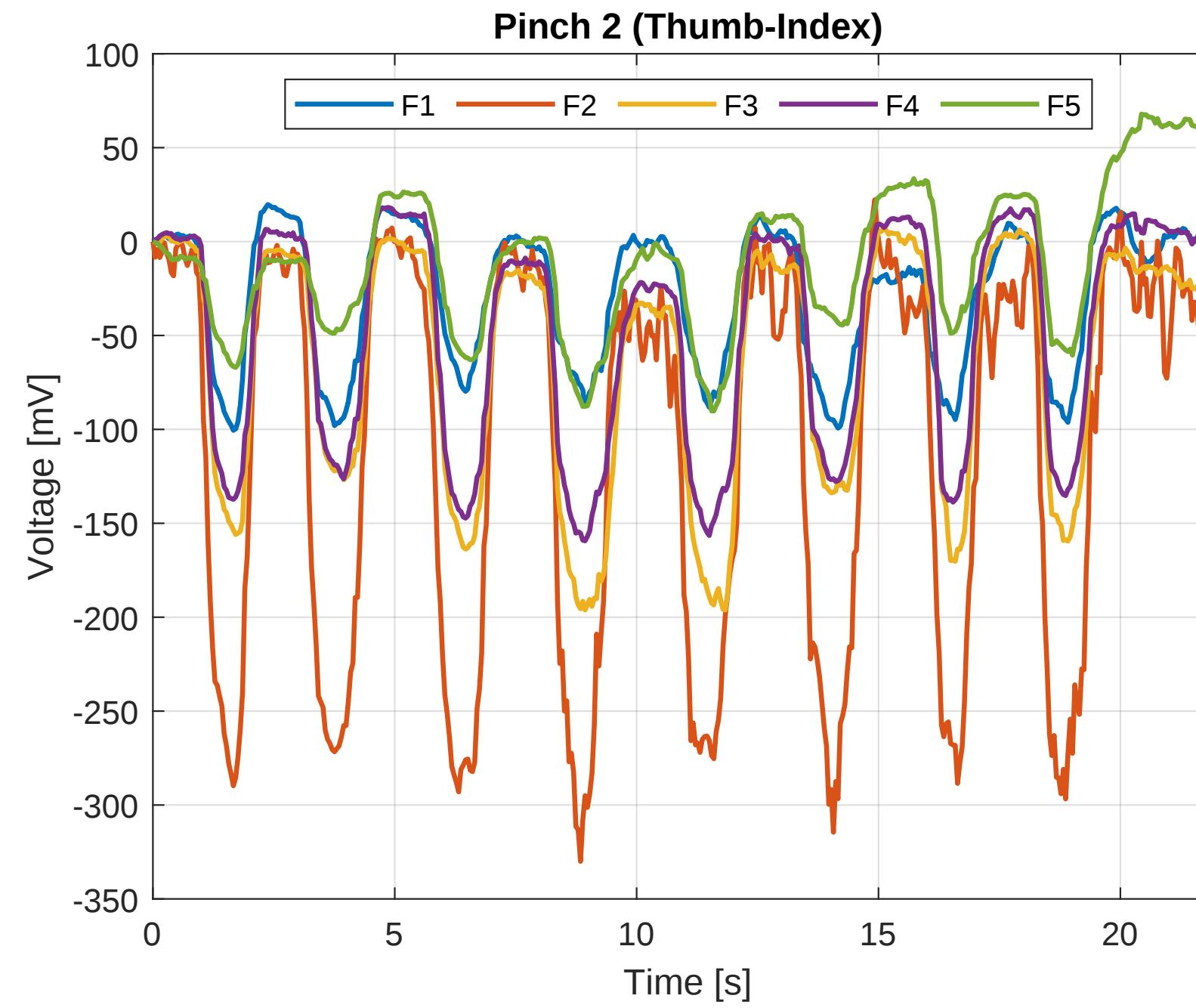


Part 3

Classification Algorithms



Thresholds Classification



SIGNAL WINDOWS

Duration
Overlapping
Features mean

FEATURES

XYZ accelerations values
Strain gauges minimum values



Machine Learning

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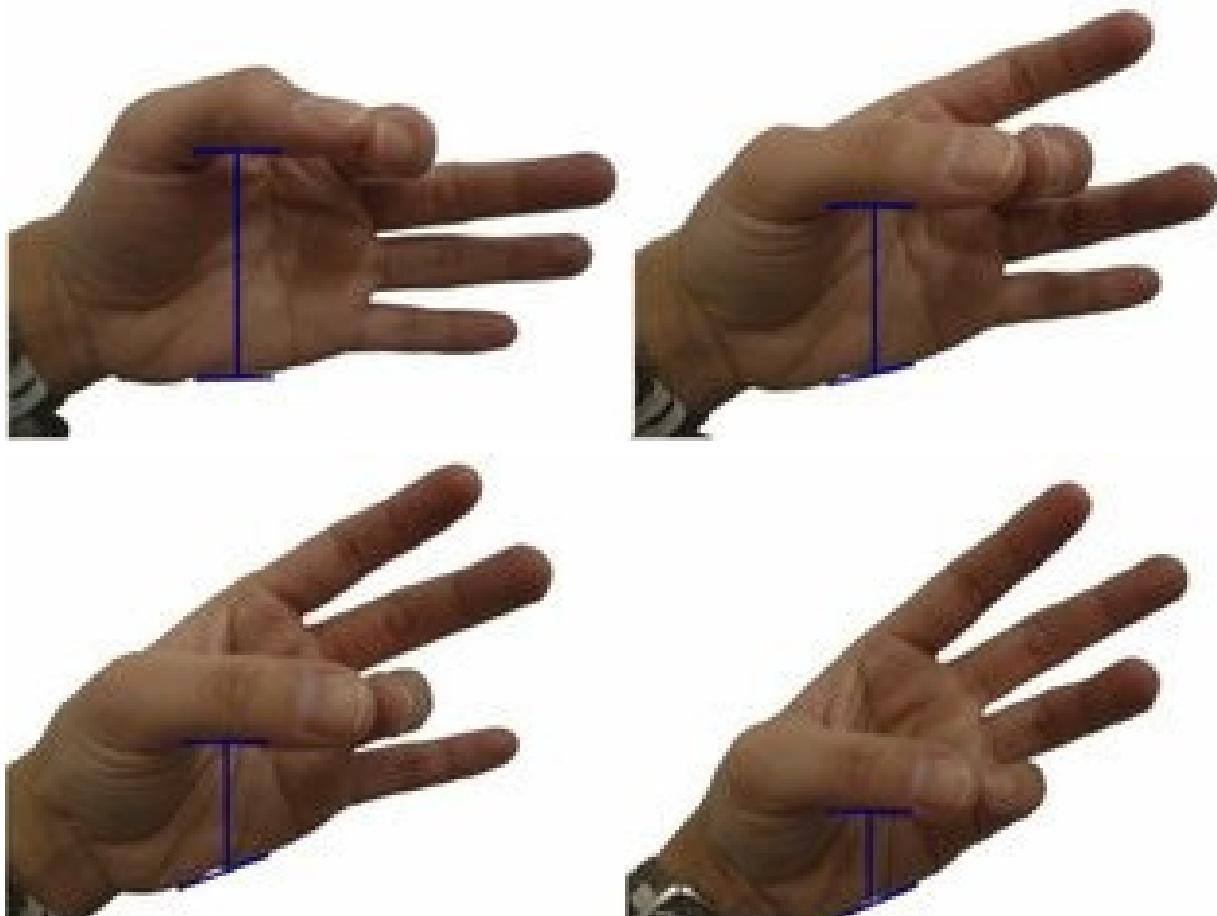


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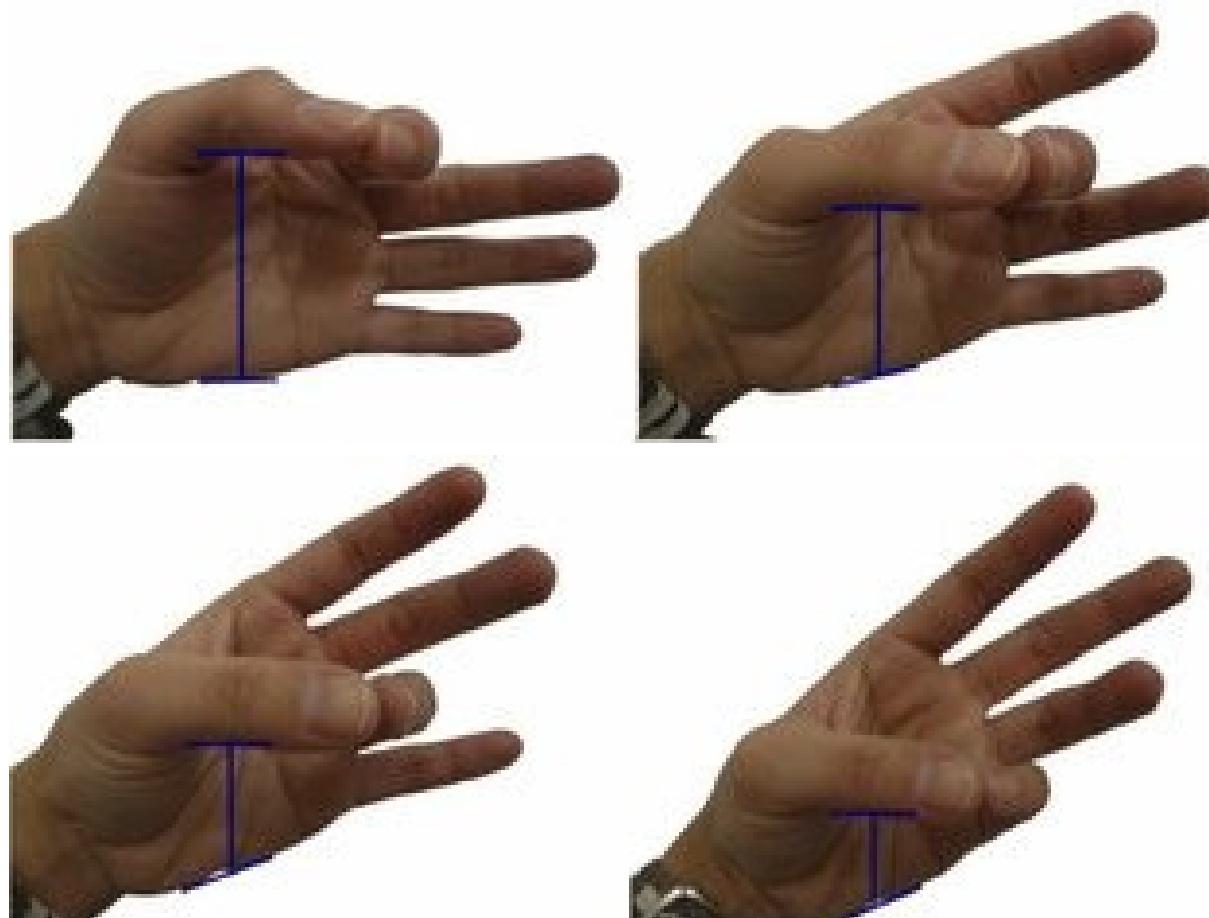
4 - CALIBRATION

Threshold calibration



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

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

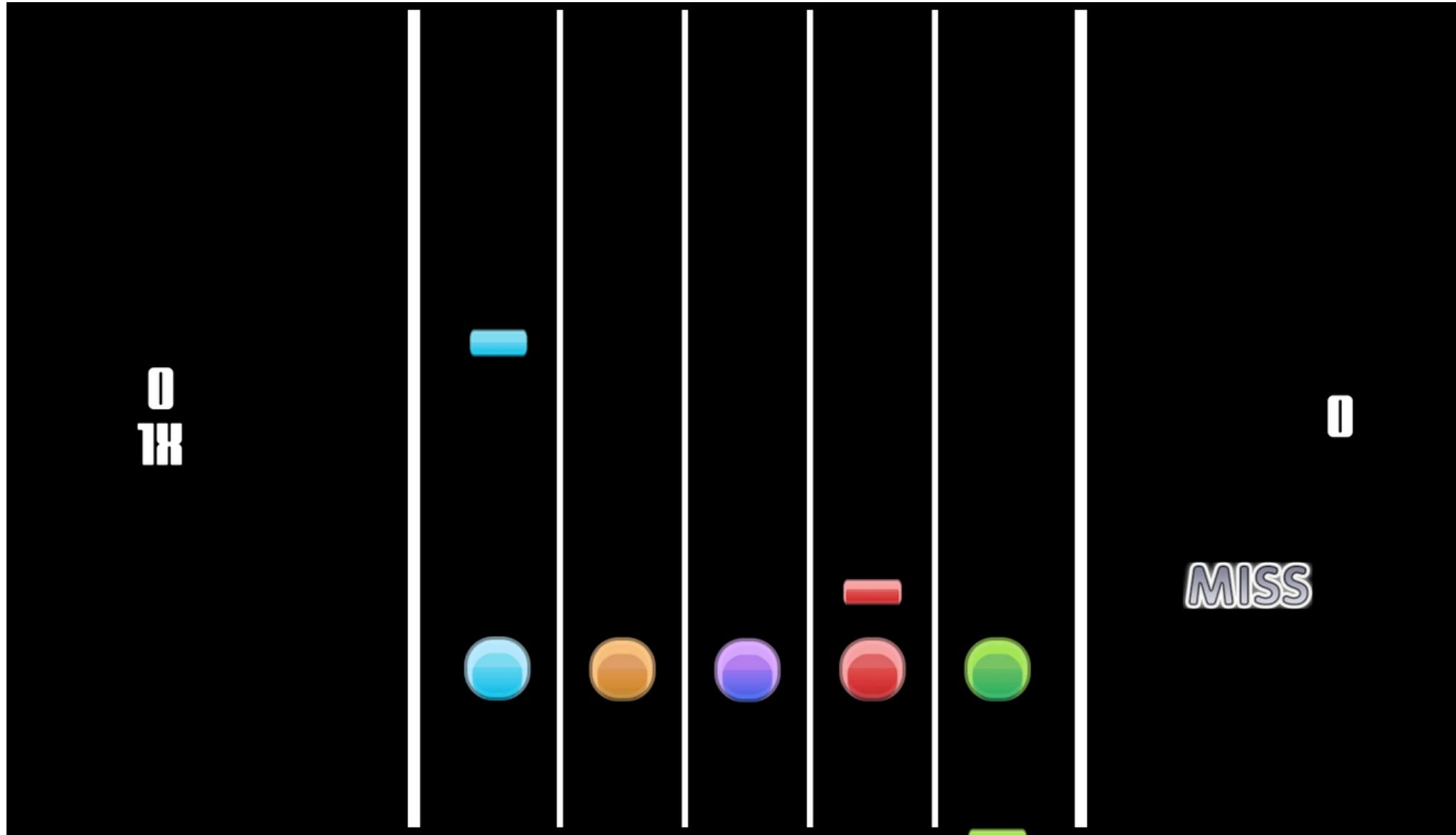
Let's play!



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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.

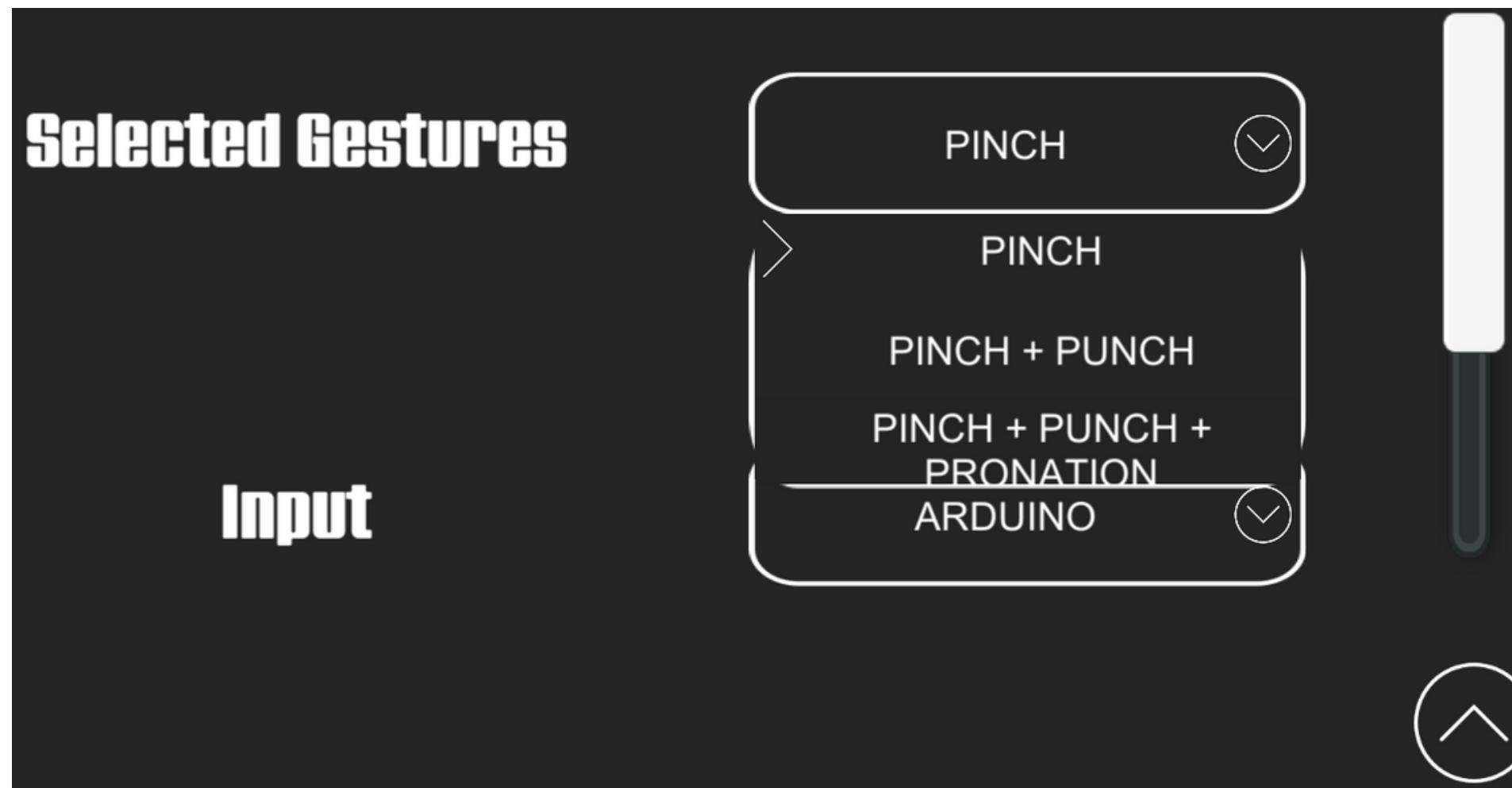


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5 - GLOVE BEATS



Input

Scoring system: increasing the engagement**

Different modalities:

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

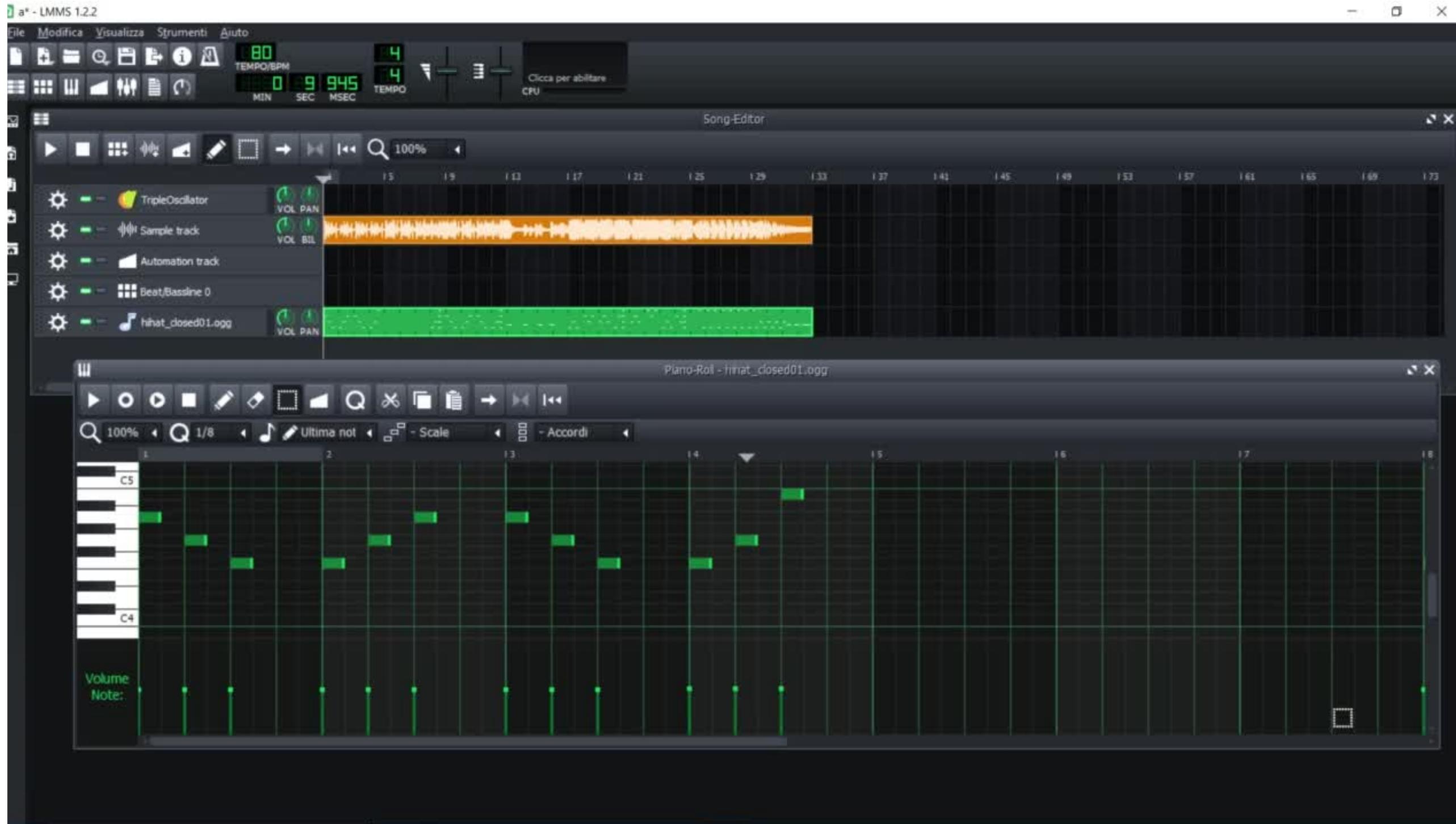


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5 - GLOVE BEATS



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



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Resources

Project GitHub Repository:

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