

Spring 2021

CS 6465 - Robots & Humans

Improving Rhythm Perception using Rock Paper Scissors

Group 8

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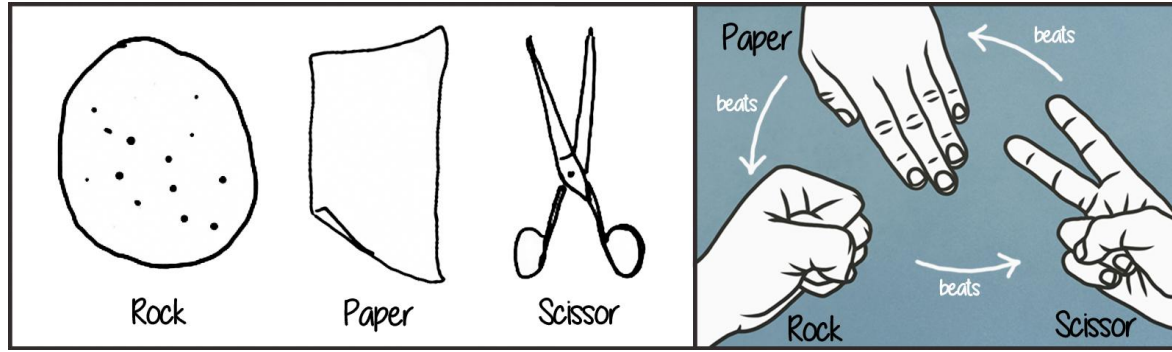
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1.

Introduction

Background



The game Rock Paper Scissors has a unique property of maintaining rhythm between the two players in order for a round to be valid.

Our Plan

We plan to build a human-robot interaction system using the NAO robot capable of playing the **Rock Paper Scissors** at *configurable rhythm settings* with a human player while actively tracking the user's rhythm and giving feedback when the user is not moving *on time*.

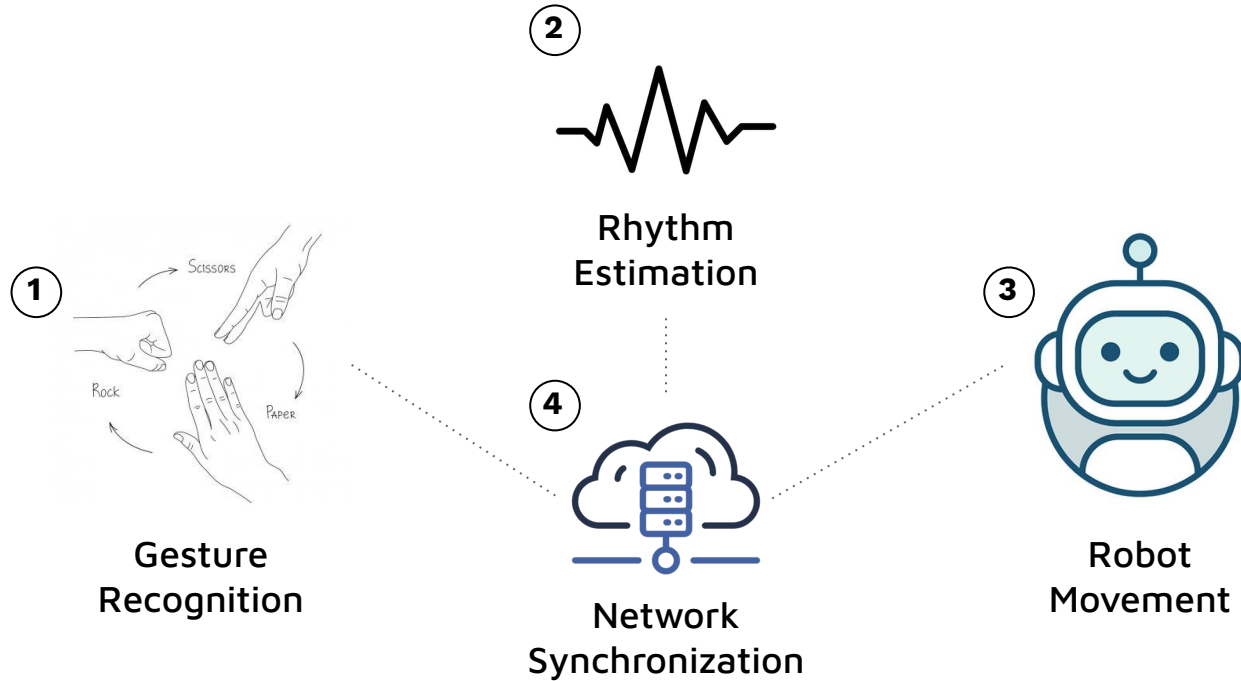
Our Hypothesis

1. We hypothesize that people with deficient rhythm perception will find it difficult to accurately play **Rock Paper Scissors** since it requires move synchronization.
2. We also hypothesize that the **Rock Paper Scissors** game can effectively help improve rhythm perception.

2.

**System
Implementation**

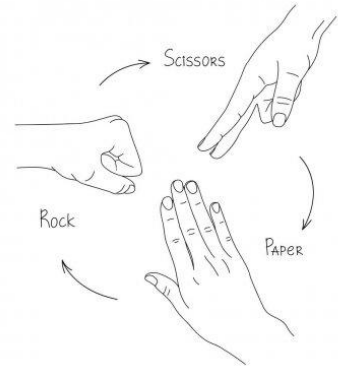
System Components



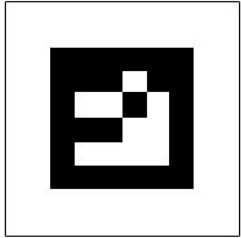
2a.

Implementation: **Gesture Recognition**

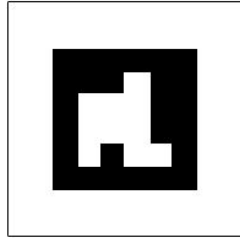
ArUco Marker Based Gesture Recognizer



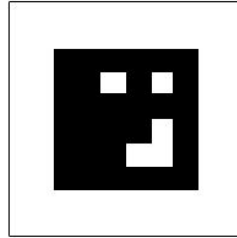
Gesture Recognition Setup



Ring Finger Tip



Index Finger Tip



Middle Finger Base

+



ArUco Markers

Finger-Worn

1.5cm x 1.5cm

OpenCV

Tracking ArUco Markers

Gesture Recognition Results



Rock



Paper



Scissor

Implementation:

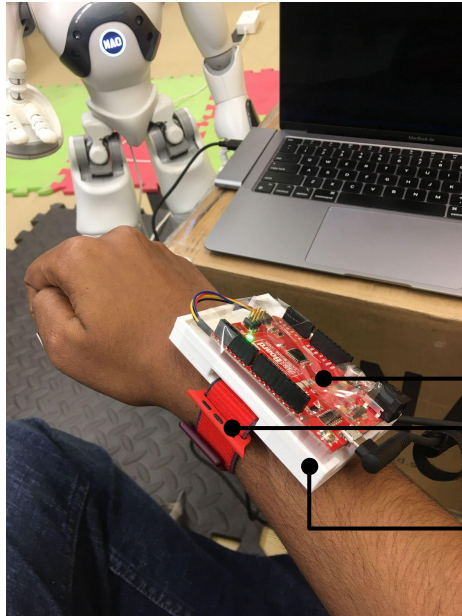
Rhythm Estimation

Thresholding Based Signal Processing

2b.



Rhythm Estimation Setup

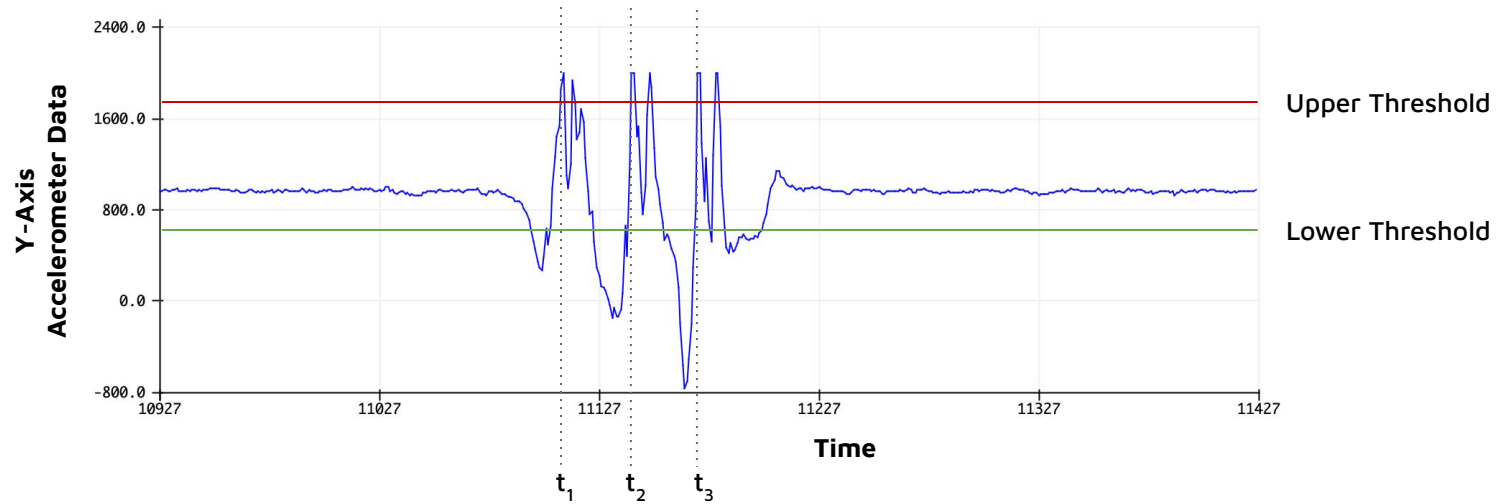


Arduino Uno +
Sparkfun 9-DoF IMU

3D Printed
Wrist-Mount

Apple Watch
Wrist-Strap

Rhythm Estimation Methodology



Rhythm Estimation Results

The rhythm estimation module generates two outputs:

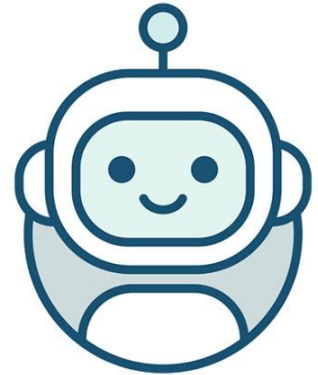
1. **Rhythm** of the hand movement (in BPM).
2. **Time** at which the last beat was dropped.

2c.

Implementation:

Robot Movement

Parameterized Movements Using Python



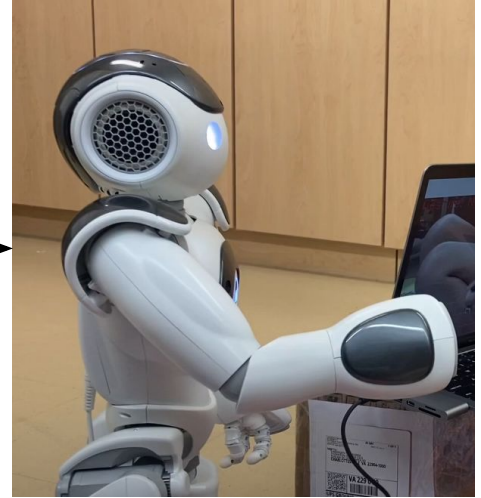
Robot Beat Serve



Initial Position

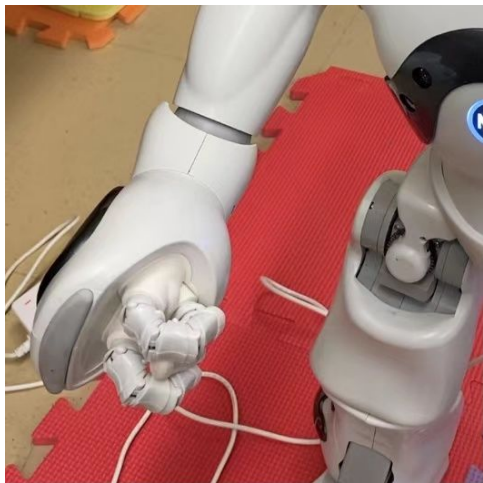


Hand Up



Hand Down

Robot Gesture Representation



Rock



Paper



Scissor

Robot Movement Modes

Sample Rhythm Mode

Plays sample beats.

Parameter

1. **Speed:** **Slow (60 BPM)** | **Medium (90 BPM)** | **Fast (120 BPM)**
(set by user)
2. **Sample Beat Count:** 5
(fixed)

Gaming Mode

Plays one set of the game.

Parameters

1. **Gesture:** Rock | Paper | Scissor
(chosen at random each round)
2. **Speed:** **Slow (60 BPM)** | **Medium (90 BPM)** | **Fast (120 BPM)**
(set by user, fixed for a set)
3. **Rounds in a set:** 5
(fixed)

2d.

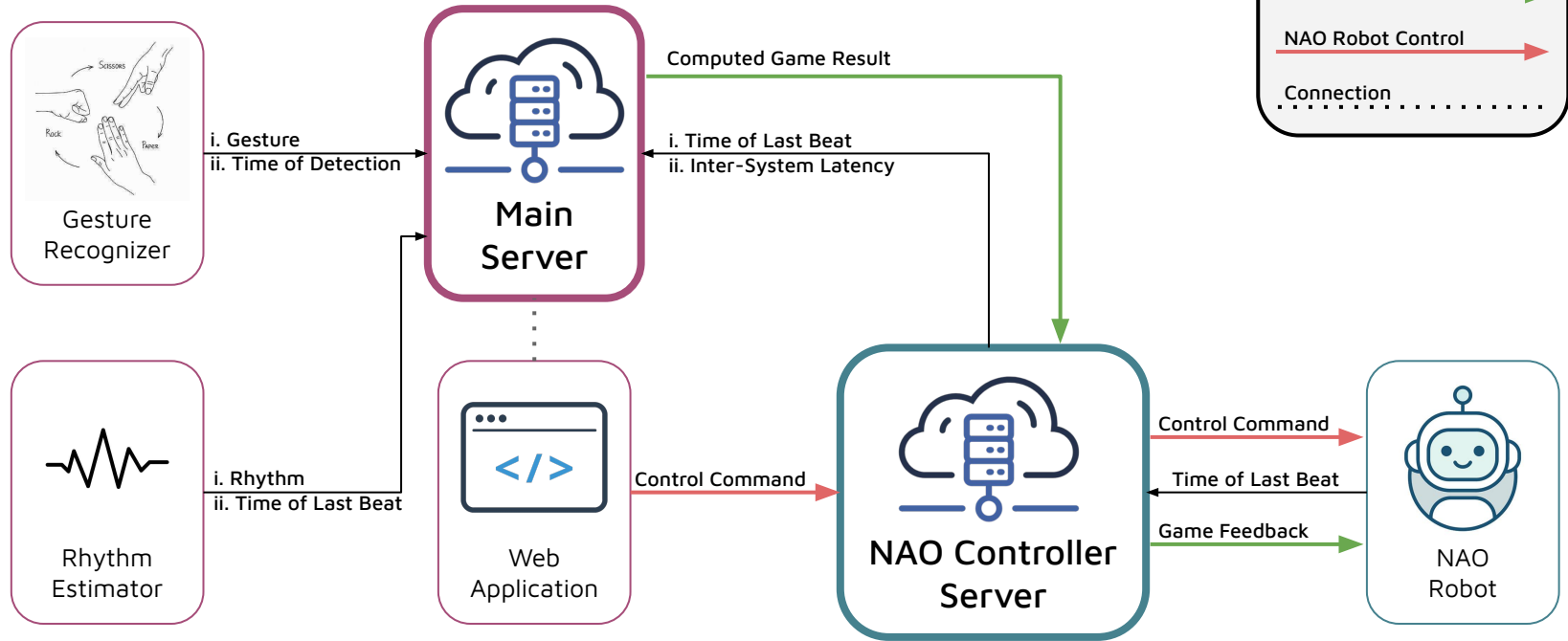
Implementation:

Network Synchronization

Synchronizing All The Components Over A Server



System Data Flow



3.

Experimental Setup

Game Feedback Parameters

(a) Timing-Based Threshold

Based on the user's input timing, the following thresholds are used to generate feedback:

- Move Delay < -0.3 s → **Human Timing is Early**
- **abs**(Move Delay) ≤ 0.3 s → **Perfect Timing**
- Move Delay > 0.3 s → **Human Timing is Late**

- **abs**(Move Delay) > 0.5 s → **Round is Invalidated**

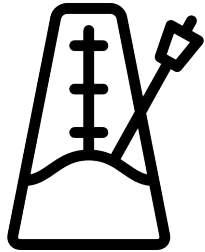
Game Feedback Parameters

(b) Rhythm-Based Threshold

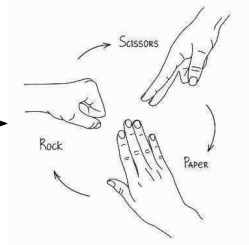
Based on the user's input rhythm, the following thresholds are used to generate feedback:

- Rhythm Difference < -5 BPM → **Human Rhythm is Slow**
- **abs**(Rhythm Difference) ≤ 5 BPM → **Perfect Rhythm**
- Rhythm Difference > 5 BPM → **Human Rhythm is Fast**
- **abs**(Rhythm Difference) > 10 BPM → **Round is Invalidated**

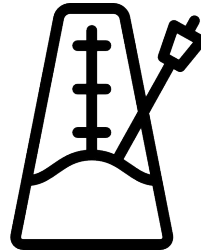
Experiment Flow



**Rhythm
Assessment Test**
(Pre-Game Score)



Rock Paper Scissor



**Rhythm
Assessment Test**
(Post-Game Score)



Exit Survey
(Qualitative Feedback)

Experiment Session Breakdown

3 Game Speeds

Slow | Medium | Fast

x

3 Blocks

(Each block contains a *slow*,
medium, and *fast* game)

x

5 Rounds

(Each game consists
of 5 rounds)

=45 Total Rounds/Participant

(+ 5 Test Rounds)

4.

Experimentation

Pilot Study

Participant

2 Participants, Both Female, Age Mean: 24Y

Demography

Findings

- Network latency constant needs to be updated regularly.
- Negative messages such as “Discard/Invalidated Round” makes the user nervous and more conscious of their movement.
- Users want a trial run before the main game.

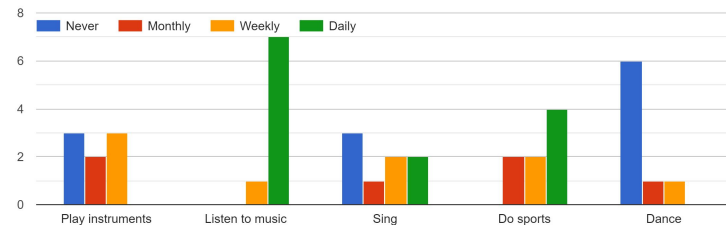
User Study

Participant

8 Participants, 4 Female 4 Male, Age Mean: 23.5Y

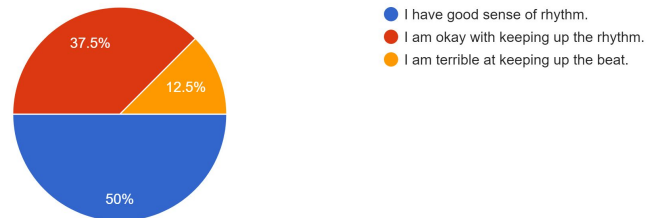
Demography

How often do you do the following activities?



How do you describe your beat recognition or rhythm recognition ability?

8 responses



5.

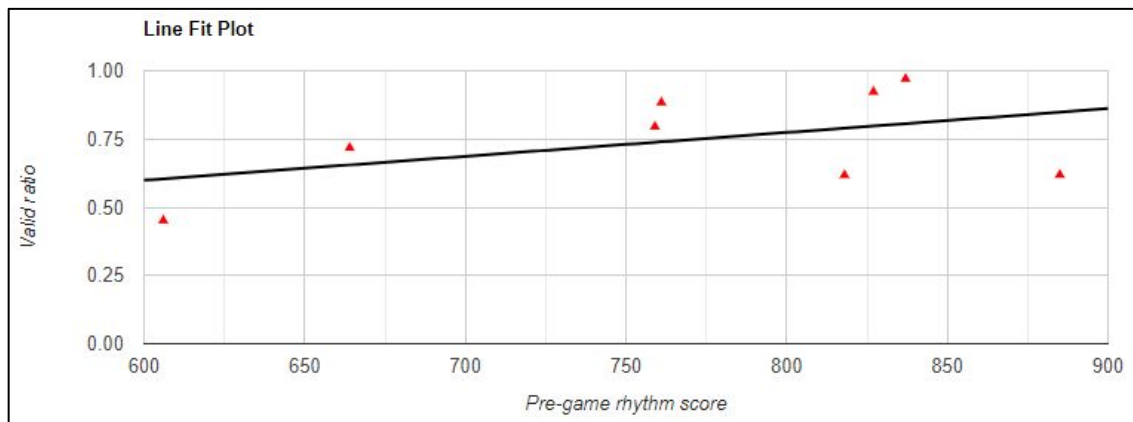
Results & Discussion

Pre-Test Score and Valid Rounds Ratio Correlation

Hypothesis

People with deficient rhythm perception will find it difficult to accurately play Rock Paper Scissors since it requires move synchronization.

1



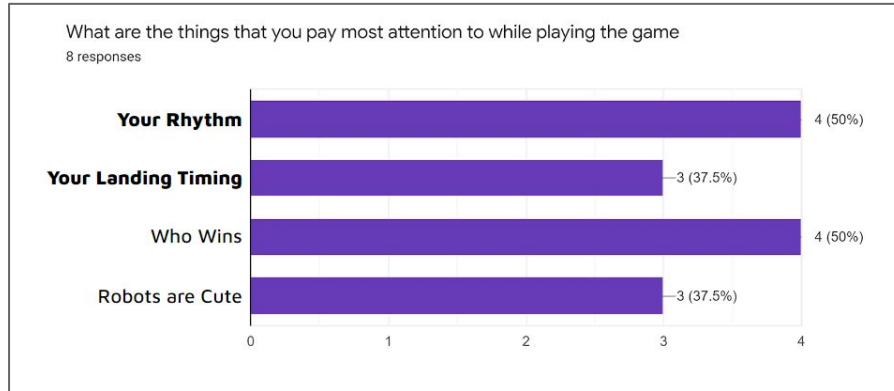
- ❖ Pre-game test score
Mean = 769.6, Min = 606
- ❖ Correlation between
Pre-game test score and
valid rounds ratio:
 - $r(6) = 0.46$
 - $p = 0.252$, $p > 0.05$

Paired T-Test for Rhythm Test Score

Hypothesis

The Rock Paper Scissors game can effectively help improve rhythm perception.

2



One tail paired T-test

- $p = 0.040$, $p < 0.05$
- $d = 0.72$

Effect of Speed on Player Accuracy

Observation

The percentage of invalid rounds increased significantly as game speed was increased.

Slow
11.63%

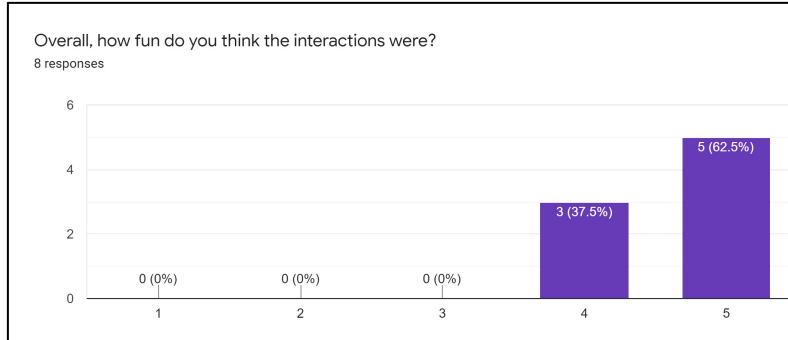
Medium
21.82%

Fast
37.27%

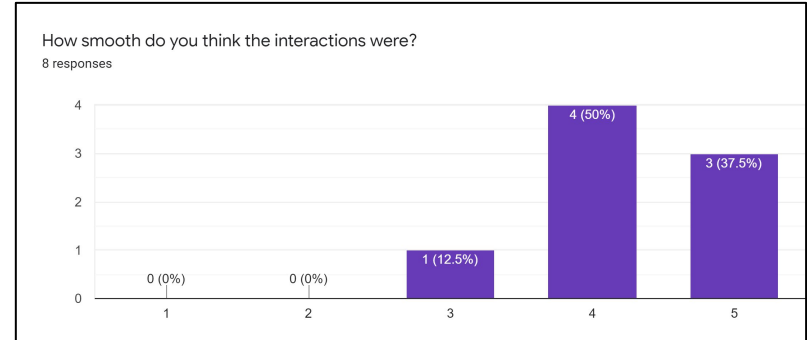
Inference

It is **harder** for participants to maintain rhythm and timing as speed increases.

Performance-Level Metrics



Interaction Enjoyment

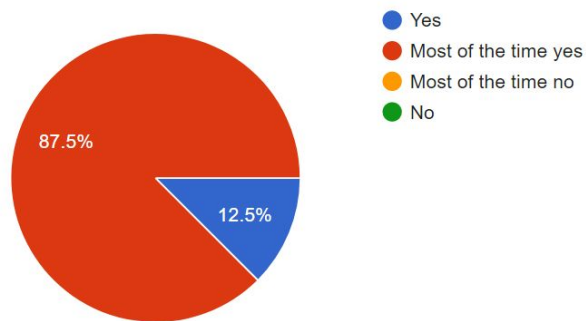


Interaction Smoothness

System-Level Metrics

Do you think the robot's judgements of the game result (i.e. who won the game) were accurate?

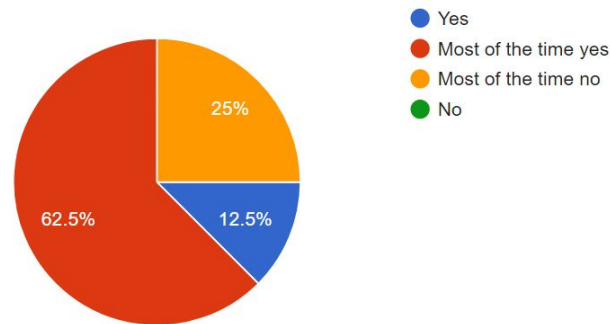
8 responses



Perceived Gesture Recognition Accuracy

Do you think the robot's judgements of the rhythm (i.e. whether you moved faster/slower, or served the move late/early) were accurate?

8 responses



Perceived Rhythm Estimation Accuracy

Limitations

- ❖ Users needed to land their hand within the camera frame, which felt like a constraint to some of the the participant.
- ❖ In order for correct rhythm estimation, users had to move their hands up and down with a jerk motion, failing to do which would result in no data getting recorded.
 - Out of a total of 360 trials, approximately 50 trials were rejected because of not being able to move the hand properly. The data analysis was done using the remaining data.

Future Work

- ❖ Recruit participant with deficient rhythm perception.
- ❖ Control learning effect.
- ❖ Improve gesture recognition and rhythm estimation.

Experimental Setup Demonstration



Thank You!