**1. Latency Analysis Visualization**

The following table provides the ideal latency range for each component of the controller’s operations, offering an overview of the estimated time each step takes in the response loop.

| **Operation** | **Description** | **Estimated Latency (ms)** |
| --- | --- | --- |
| **MPU6050 Data Reading** | Reading 6 bytes each for accelerometer and gyroscope data via I²C | 1–3 |
| **Calibration and Filtering** | Applying complementary filter and performing trigonometric calculations for pitch and roll | 2–5 |
| **Mouse and Keyboard Actions** | Triggering commands with delay to ensure registration (delay (50)) | ~50 |
| **Total Estimated Latency per Loop** | Sum of all operations | ~58 |

***Purpose*: This table summarizes the estimated latency for each operation, providing insight into where delays may occur in the system.**

**2. Practical Latency of Controller Actions**

This table compares ideal latency values with observed practical latencies during gameplay. Practical latency accounts for real-world factors like system overhead and user interaction variability.

To determine the real-world latency of the controller system, we conducted tests based on two consecutive timestamp readings from the sensor outputs. The latency for each action was estimated by recording the start and end timestamps for each sensor-triggered action. **A total of 100 such readings per sensor were taken, and the average timestamp values were calculated** to obtain an accurate estimate of the latency for each action.

|  |  |  |  |
| --- | --- | --- | --- |
| **Action** | **Ideal Latency (ms)** | **Real-World Latency(ms)** | **Description** |
| Key Press (Forward) | ~58 | ~72 | Triggered by foot sensor to move forward |
| Key Press (Jump) | ~58 | ~71 | Triggered by foot sensor to perform jump action |
| Key Press (Left Turn) | ~58 | ~69 | Triggered by foot sensor to turn left |
| Key Press (Right Turn) | ~58 | ~69 | Triggered by foot sensor to turn right |
| Key Press (Break) | ~62 | ~78 | Triggered by foot sensor to perform break action |
| Key Press (Pick) | ~62 | ~76 | Triggered by foot sensor to pick an item |
| Key Press (Fly Up) | ~62 | ~80 | Triggered by foot sensor to fly up |
| Key Press (Fly Down) | ~62 | ~80 | Triggered by foot sensor to fly down |
| Gyroscope (Camera Movement) | ~8 | ~13 | Head gyroscope movement to adjust camera |

Practical latency values are slightly higher than ideal due to the addition of real-world delays. Complex actions like **Break** and **Fly** require more processing, resulting in marginally higher latencies.

**3. Gameplay Time Comparison**

Players were given 15 minutes to practice with the controller before gameplay times were recorded. The table below compares the average gameplay times using a keyboard and mouse versus the controller.

The gameplay took place on a **basic flat map**, which included various movement actions such as **forward, left, right**, as well as **jumping** and **breaking a wall** at the end of the course. This setup allowed players to use the controller to execute different in-game movements that simulate typical controls in a simplified environment.

|  |  |  |
| --- | --- | --- |
| **Player** | **Keyboard & Mouse (Time)** | **Controller (Time)** |
| Player 1 | 2 min 20 s | 3 min 10 s |
| Player 2 | 3 min 23 s | 5 min 03 s |
| Player 3 | 4 min 19 s | 5 min 46 s |
| Player 4 | 1 min 58 s | 2 min 59 s |
| Player 5 | 2 min 32 s | 3 min 13 s |
| Player 6 | 2 min 48 s | 3 min 22 s |
| **Average** | **2 min 53 s** | **3 min 55 s** |

**A graph of orange and yellow bars

Description automatically generated**

**4. Learning Curve: Initial vs. Post-Practice Times**

The following table illustrates the improvement in gameplay times after players had 15 minutes to get accustomed to the controller.

|  |  |  |
| --- | --- | --- |
| **Player** | **Initial Time with Controller** | **Time After 15 Minutes of Practice** |
| Player 1 | 6 min 09 s | 3 min 10 s |
| Player 2 | 9 min 45 s | 5 min 03 s |
| Player 3 | 9 min 46 s | 5 min 46 s |
| Player 4 | 5 min 32s | 2 min 59 s |
| Player 5 | 8 min 22 s | 3 min 13 s |
| Player 6 | 7 min 34 s | 3 min 22 s |
| **Average** | **7 min 51 s** | **3 min 55 s** |

There is a significant reduction in gameplay time after players practiced with the controller, demonstrating an improvement in familiarity and response time.

A graph of orange and yellow bars

Description automatically generated

**5. Command Execution Accuracy**

The following table summarizes each player’s accuracy in executing a specific sequence of commands with the controller. Players were asked to follow a set sequence of moves, and each command’s accuracy was recorded.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Player** | **Left (1)** | **Left (2)** | **Right** | **Forward** | **Jump (1)** | **Break** | **Jump (2)** | **Back** | **Left (3)** | **Forward (2)** | **Correct Commands** |
| Player 1 | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | ✔️ | 10 |
| Player 2 | ✔️ | ❌ | ✔️ | ✔️ | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | ✔️ | 8 |
| Player 3 | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | ❌ | ✔️ | 7 |
| Player 4 | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | 8 |
| Player 5 | ✔️ | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | ✔️ | ✔️ | ❌ | ✔️ | 8 |
| Player 6 | ✔️ | ✔️ | ✔️ | ✔️ | ❌ | ✔️ | ✔️ | ✔️ | ✔️ | ❌ | 8 |
| **Average** |  |  |  |  |  |  |  |  |  |  | ~8 |

The average accuracy across players was approximately 80%, with some variability in specific actions, indicating areas for possible improvement in controller responsiveness or usability.