Picture This!

C6: Joseph Ayala, Anthony Meza, Sophia Zhang
18-500 Capstone Design, Spring 2023
Electrical and Computer Engineering Department
Carnegie Mellon University

Product Pitch

These days, most modern games tend to provide single player experiences that require people to be stationary and by themselves. People are not encouraged to connect socially or be active. To tackle this, our group decided to create a game that would both encourage social interaction and require active movement. We attempted to develop “AR Pictionary”, where players can take turns using a “pen device” to create drawings in a virtual space which can be viewed on an Android phone, allowing other players to view these drawings and guess what is being drawn. Not only is this a novel form of entertainment, but is also a fun way to socialize and get off the couch!

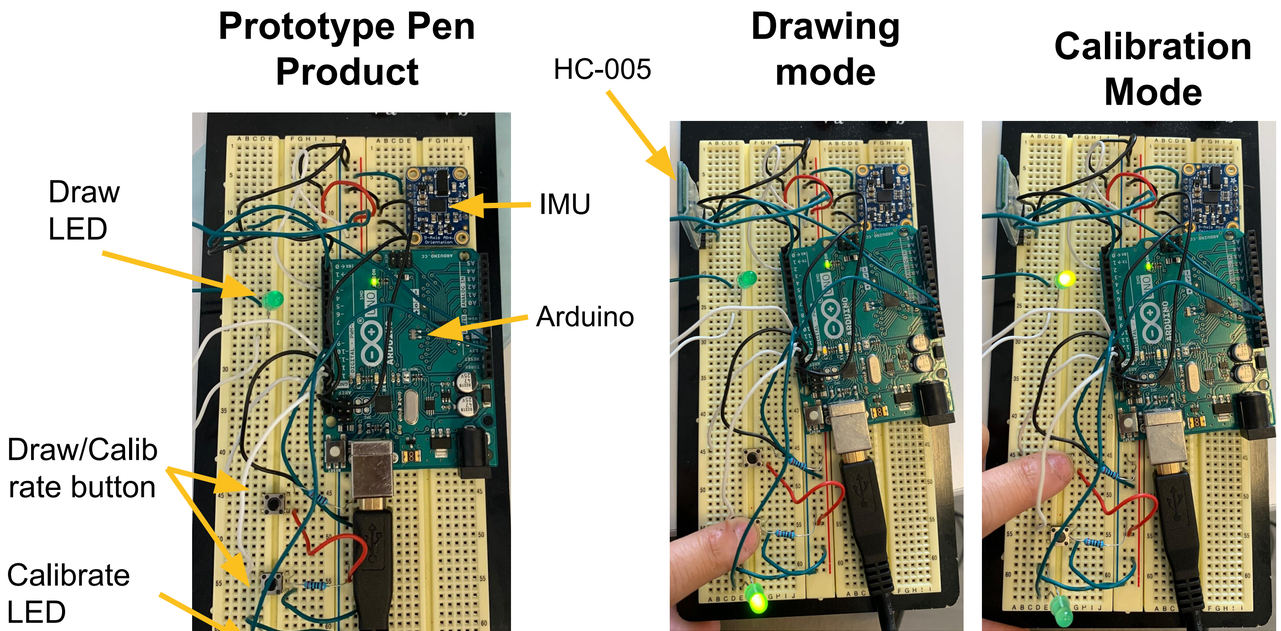
Important key metrics we set to achieve include: less than 1 second of end-to-end latency (time taken for lines to appear on device after pen is gestured in the air), hardware latency of less than 150ms, small and lightweight pen, and highest possible line accuracy.

We achieved an end-to-end latency of **about 10ms**, a hardware latency of **about 8ms,** and our pen is a **little less than 6 oz** in weight. We could not produce accurate lines due to hardware limitations, but our product demonstrates a proof of concept.

System Description

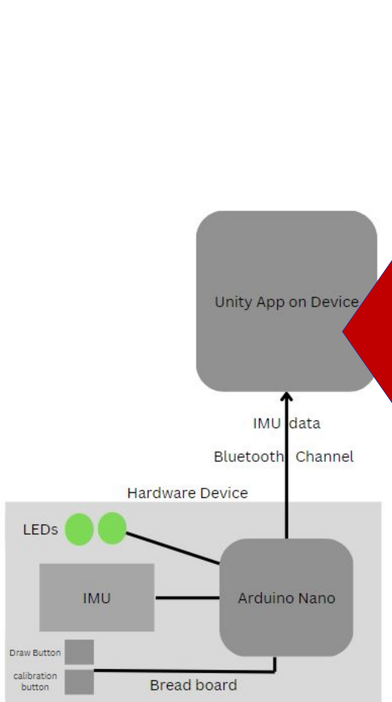
The hardware consists of 2 LEDs, 2 buttons, IMU, Arduino Nano, and a HC-005 bluetooth module. When it is drawing or calibrating, the corresponding LED will light up as a visual cue for the drawer. If it is in draw mode, the IMU will start collecting acceleration and rotational data to calculate its relative position from its starting point and send the data to our app via bluetooth.

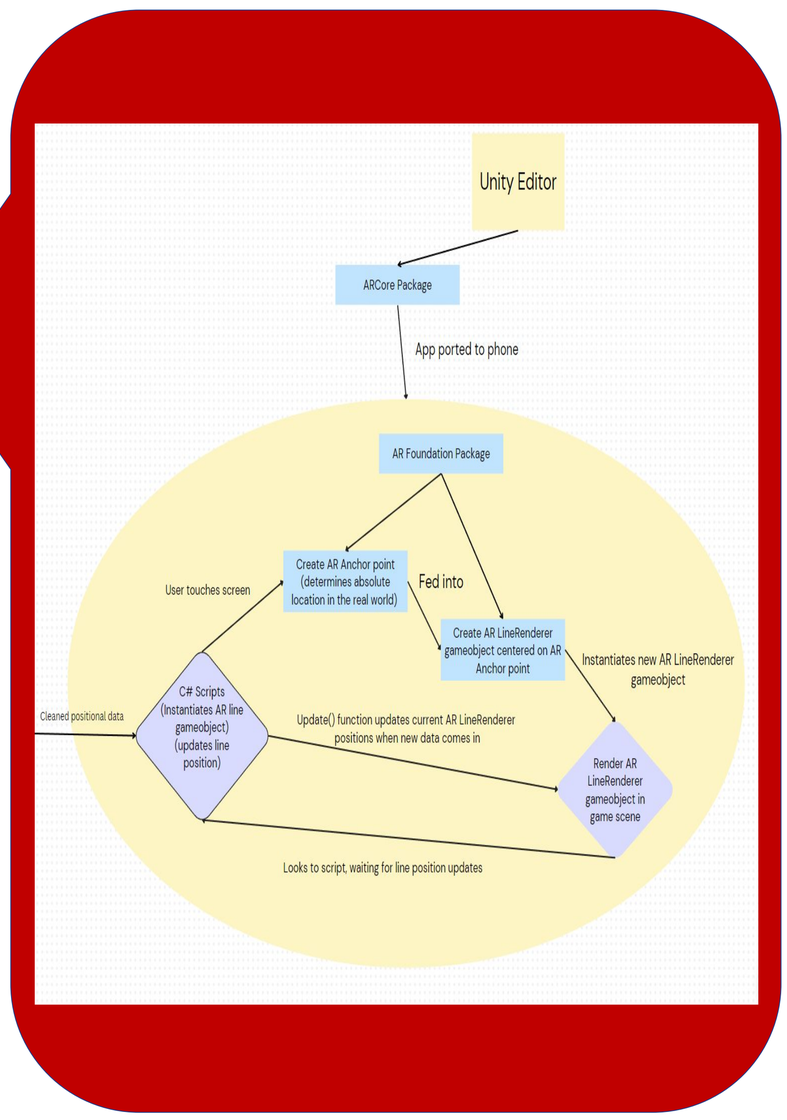
The Software application was created on the Unity game engine and coded on corresponding C# scripts due to its straightforward game making environment. Useful packages that were used to make our project possible include ARCore, ARFoundation and Arduino Bluetooth Plugin. ARCore and ARFoundation in order to create AR objects in virtual space as well as build the AR app to Android, and Arduino Bluetooth Plugin in order to send data between the hardware pen and the Android AR app.



System Architecture

On the bottom left is our hardware architecture. The bottom right is our software architecture. The collected IMU data from the hardware is sent to the Unity App via a bluetooth connection. The data is collected on our Unity App and used in order to create line game objects.





System Evaluation

Hardware-software communication

- Python netsocket
  - too much latency and external equipment
- Wi-Fi with Uduino library
  - not compatible with Android devices
- Bluetooth with Unity library

IMU calibration methods

- Kalman filter + quaternion rotation + error gauging through calibration
  - data not accurate enough
- Sensor fusion
  - more expensive + more space needed
- Alternate methods
  - less intuitive + no guarantees better

Software Trade-offs

- Networking between devices + ARCloud:
  - Challenging to implement and integrate in given time
  - More engaging
- Screen Sharing device
  - Simple implementation
  - Less interactive

Testing Results

Metric	Target	Actual	Met
Pen Size	6”x9”x3”, < 1lb	2.2”x7”x1”, ~6 oz	✓
Pen latency	< 150ms	< 8ms	✓
End-to-end latency	< 1s	~ 10ms	✓
Line accuracy	90%	0%	X
User testing	4 out of 5 users	0 out of 5 users	X
Game functionality	>= 3 players	1 drawer player/personal device, 1 monitor	N/A

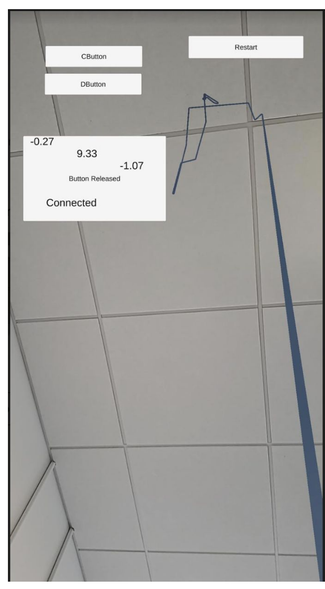


Figure 1: Displays some of the tests we performed and what our results were from the tests

Conclusions & Additional Information

https://course.ece.cmu.edu/~ece500/projects/s23-teamc6/introduction-and-project-proposal/

- Integration is difficult!
- Hardware is noisy and difficult to calibrate
  - any operation on noise will just increase the noise and inaccuracy
- Focus on something the IMU will be able to get more accurate
  - rotation rather than acceleration/position

Electrical & Computer ENGINEERING
Carnegie Mellon