SensorTile Game Controller in Unity

Final Project Presentation

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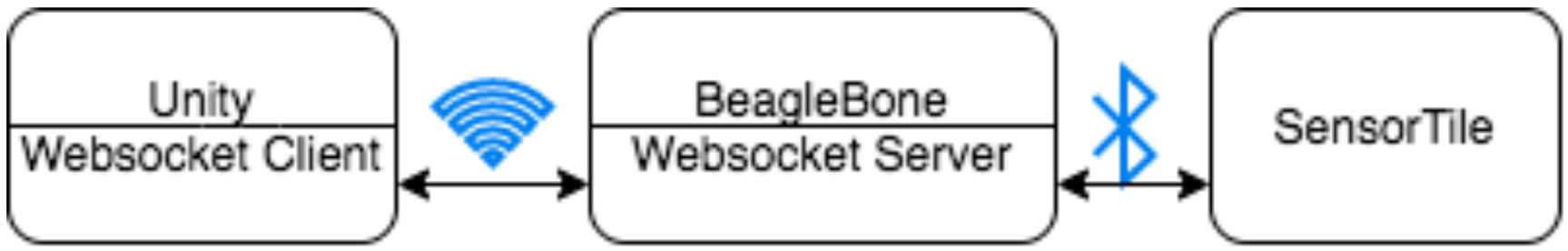
Introduction

- Hand-free game controller using SensorTile: play
  - User's motions simulating control input from a gamepad/ joystick
- Motion Pattern Recognition with Embedded ML:
  - Fast, lightweight, and independent to the integrated game engine (e.g. can work with Unity, HTML5 game)
- Utilize wireless communication: BLE and Wifi
  - Hand-free game controller is cordless, indeed.

Components



- A BeagleBone is used to receive SensorTile’s data, process, and forward to Unity.

- BeagleBone communicates with SensorTile via BLE connection.

- Unity (or may any other program) communicates with BeagleBone using WebSocket protocol.

Basic Game Controller

- D-Pad Buttons [1][2][3][4]
- Button A [5]
- Button B [6]

- Train an ANN to detect and classify 6 motions
- Features are extracted from Gyroscope sensor
- Embedded ML (1) running on SensorTile's processor

[1] Charles Zaloom - EmbeddedML - https://github.com/merrick7/EmbeddedML

Contributions

- SensorTile Firmware: deploys a ML model to classify 6 motion patterns and BLE communication
- A server program running on BeagleBone:
  - connect to SensorTile’s BLE using gatttool
  - Host a web socket server
- A demo game scene implemented in Unity:
  - Connect to BeagleBone (via WS) to send train request and receive detected motions

Motion Pattern Recognition

- Base on STMicroelectronics SensorTile Tutorial 13 - Rotation Angle Classification with Machine Learning

- Modify the program of Tutorial 13 to update the program flow and add BLE communication with a connected device, e.g. BeagleBone:

  - Receive command to for training step.

  - Send detected motion in running step

- Experiment with the ANN for detecting 6 different motions based on changing in rotation angle.

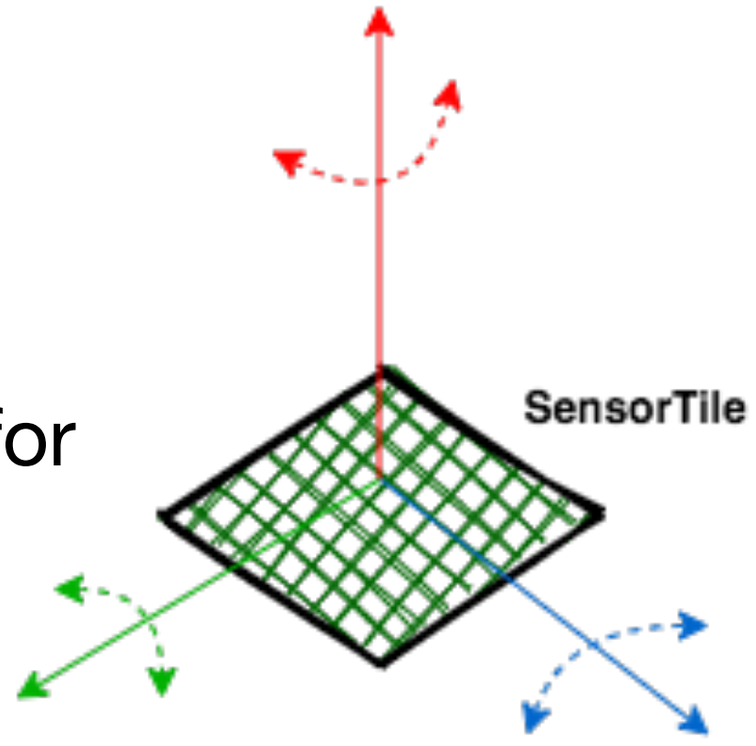
Proposed Motion Gestures

- Based on changing in rotation angle in relative to the starting position of the SensorTile.

- 6 motion gestures for 6 buttons:

  - Tilt the SensorTile about X or Y axis for D-pad buttons

  - Rotate the SensorTile about Z-axis clockwise and counter-clockwise for Button A and B.



Feature Data Acquisition: Rotation Angle

- Collect SensorTile's rotation rate sensor microgyroscope with sampling period of 0.01 seconds to measure rotation angle (for X, Y and Z axises)
    - Up to 1 second (maximum 100 data acquisition cycles).
    - Or the rotation angle magnitude exceed the threshold of 30 degrees
- Normalize feature values

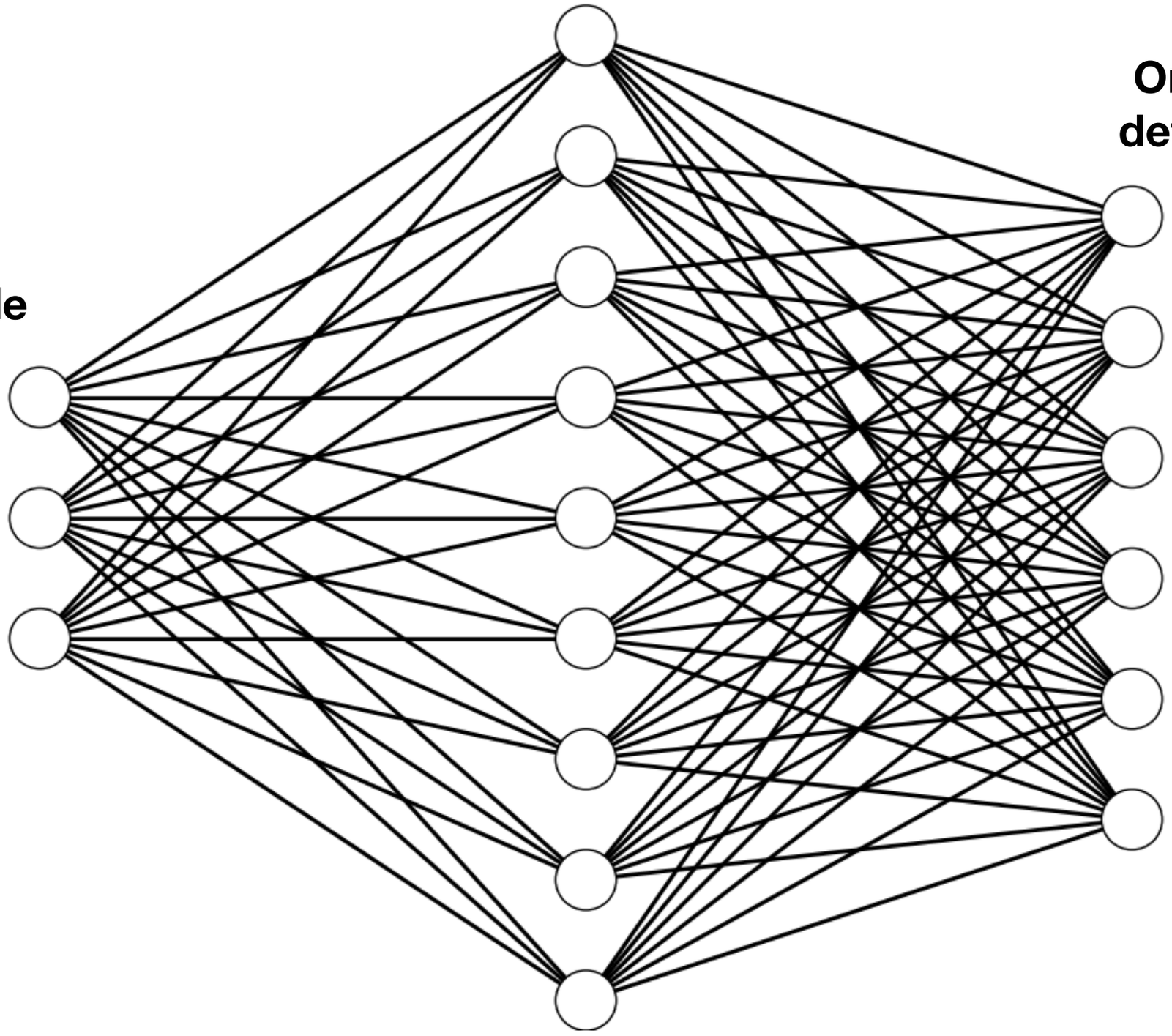
Neural Network Topology

Normalized Rotation Angle

X

Y

Z



One output per detected motion

Performance Assessment

- The ANN was successfully trained in 60-80 epochs with z-score threshold of 1.

- The ANN successfully detected 6 motions as shown in the demo video.

- However, the motion pattern depends on the initial position of the SensorTile - Require user to return to the starting position to perform next motion.

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Training Epochs: 60

State 0 Max 57  Mean 16         Z-score 128     Outputs 57      -40     18      22      18      23
State 1 Max 55  Mean 12         Z-score 170     Outputs -19     55      21      -1      9       9
State 2 Max 41  Mean 17         Z-score 134     Outputs 16      20      41      -13     19      20
State 3 Max 36  Mean 10         Z-score 154     Outputs 21      -8      -4      36      9       10
State 4 Max 53  Mean 15         Z-score 141     Outputs 25      8       23      7       53      -27
State 5 Max 61  Mean 13         Z-score 171     Outputs 14      3       16      12      -23     61
Index 0 Error State: 0
```

Questions