Gesture-enabled Remote Control for Healthcare

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Background

- Gesture recognition is widely used in healthcare
  - Manipulate healthcare device
  - Physical rehabilitation
  - Fall detection

Limitation of Current Gesture Recognition Platform

- □ Not comfortable to wear

- □ No open API

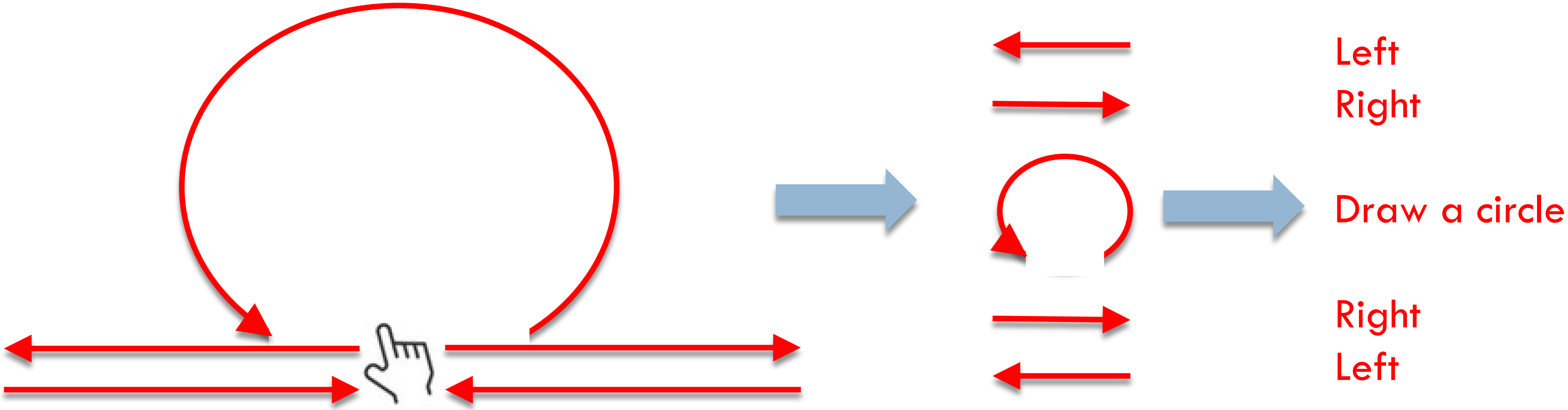
- □ Too expensive

Shimmer3 ($445)

Lack of reliable platform for gesture recognition and motion sensing study in healthcare

Limited work in continuous gesture recognition

- Continuous gesture recognition
  - Retrieve and recognize gesture from a sequence of hand movement



Left

Right

Draw a circle

Right

Left

- Current work
  - Not accurate
  - Huge computational effort

Lack of effective continuous gesture recognition mechanism for resource-limit device.

Outline

- □ Wristband hardware platform
- □ Continuous hand gesture segmentation and recognition framework
- □ Introduction to APIs

Gemote Hardware Components

Various sensors

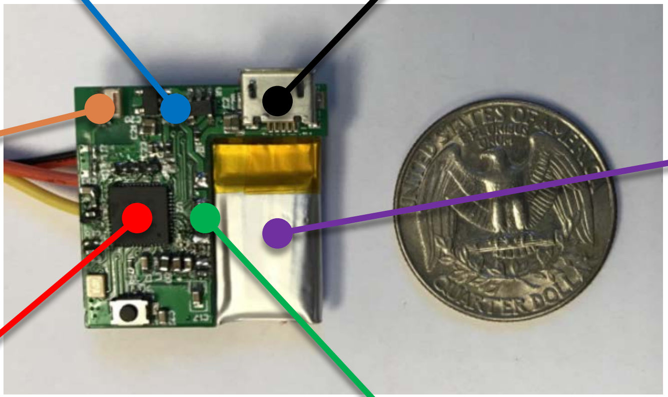
- Accelerometer
- Gyroscope
- Compass

BLE supported

- Rage: 40m

Strong computational capability

- nRF 52832 (ARM M4)



USB charge

- Charge Time: 1 hour

Li-Ion battery

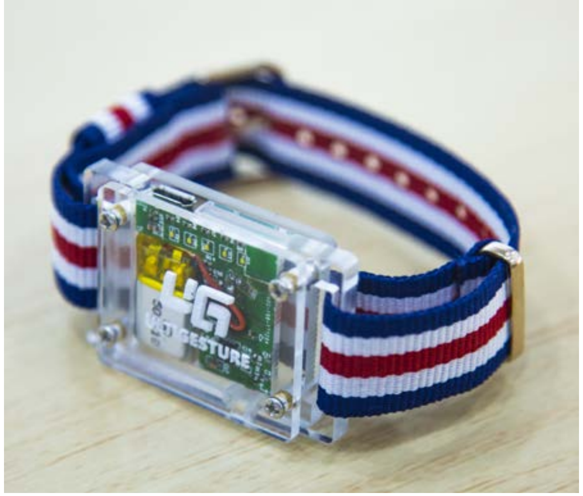
- 3.7V, 75mAH

Energy efficiency

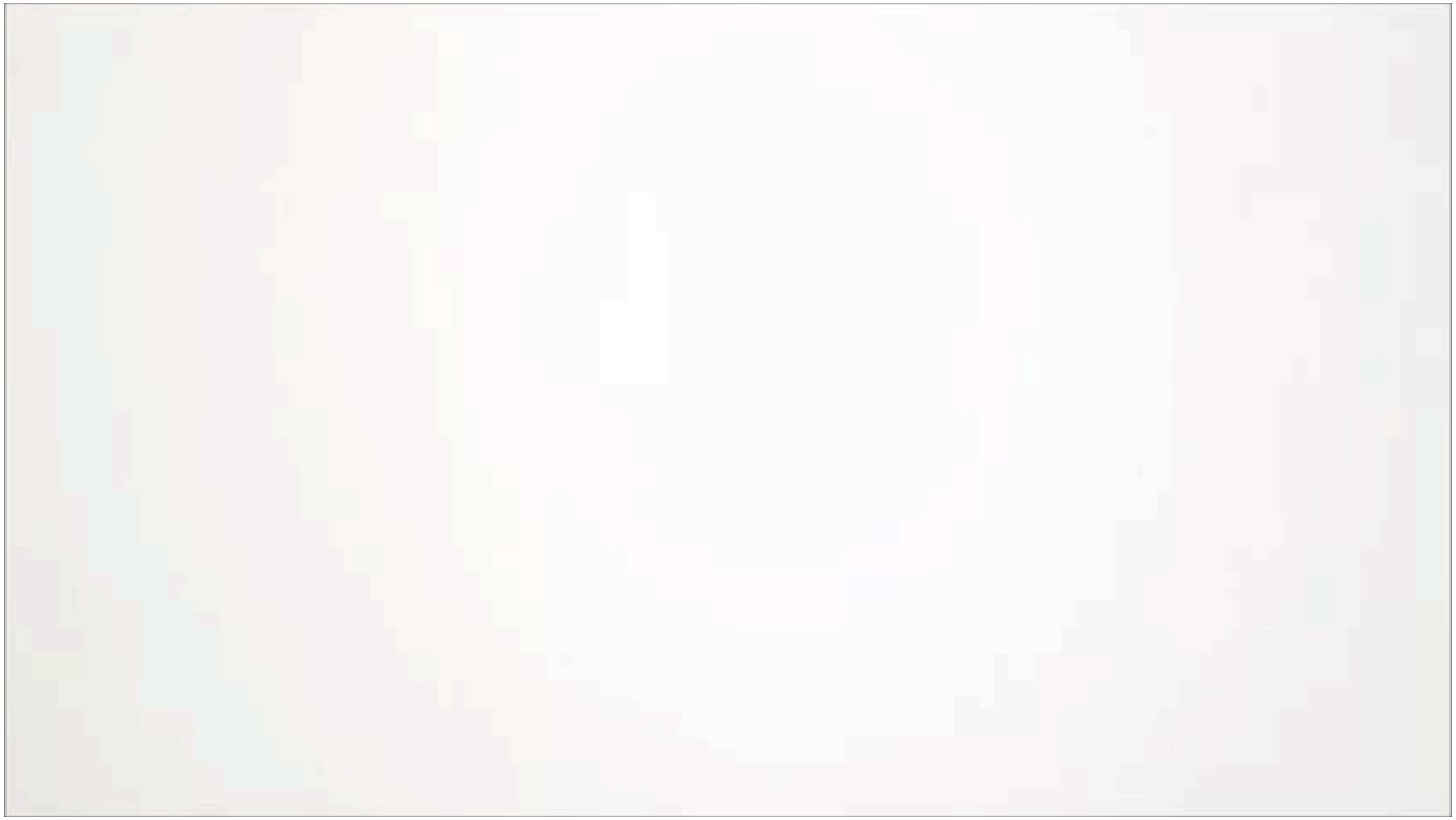
- Work Current: 10~20mAH
- Sleep Current: 1uAH

Gemote Hardware Features

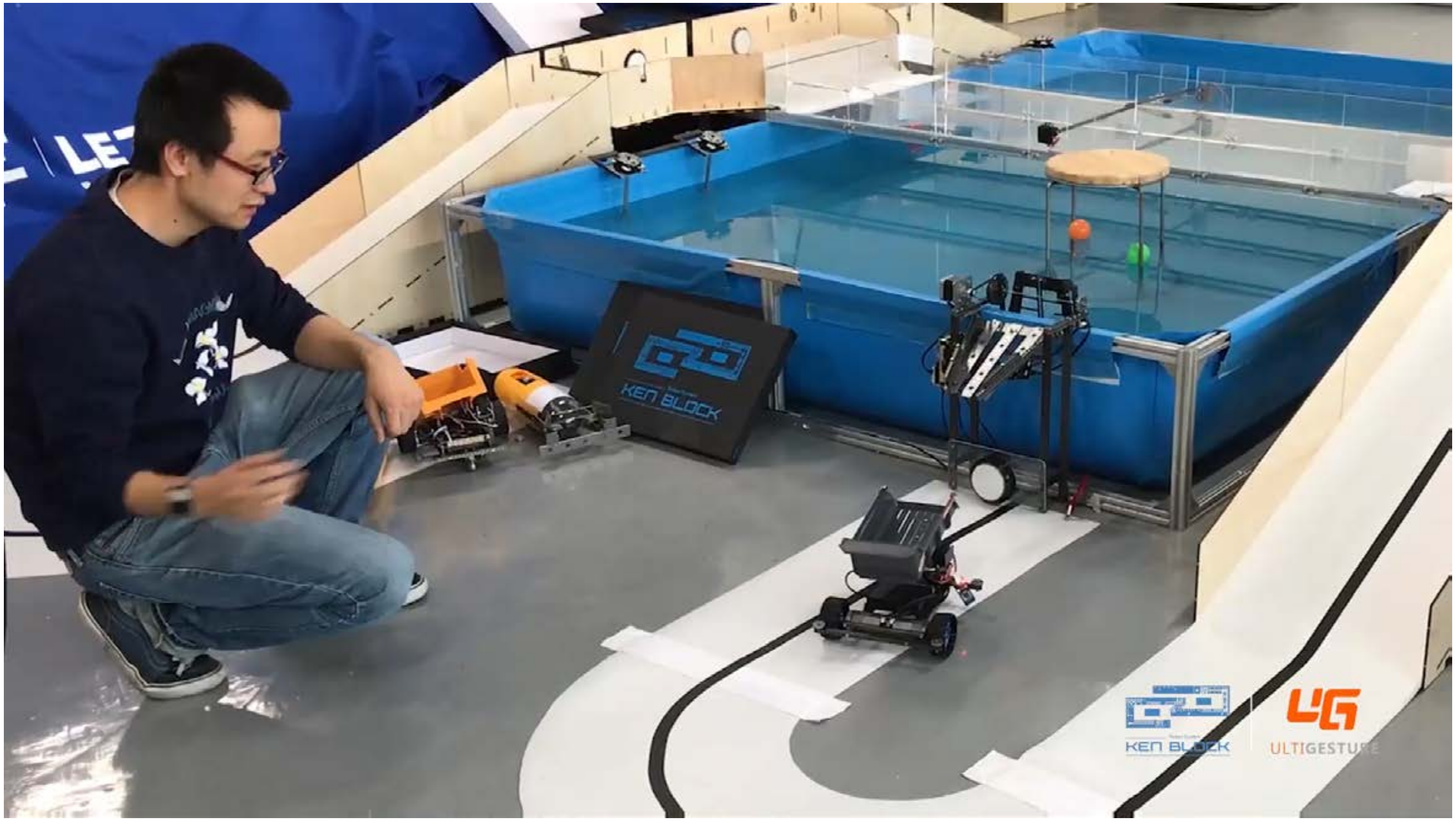
- Open API
  - Open data sensing APIs to Android developers.
- Comfortable to wear
  - PCB: 26mm length, 25mm width.
  - Shell: 47mm length, 31mm width, and 9mm thick.
- Affordable price
  - $29



Application of Gemote wristband-1



Application of Gemote wristband-2



Outline

- ~~Wristband hardware platform~~
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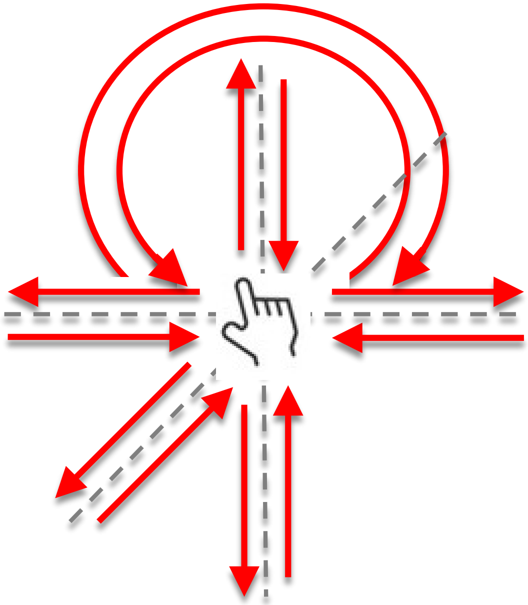
Gestures Definition

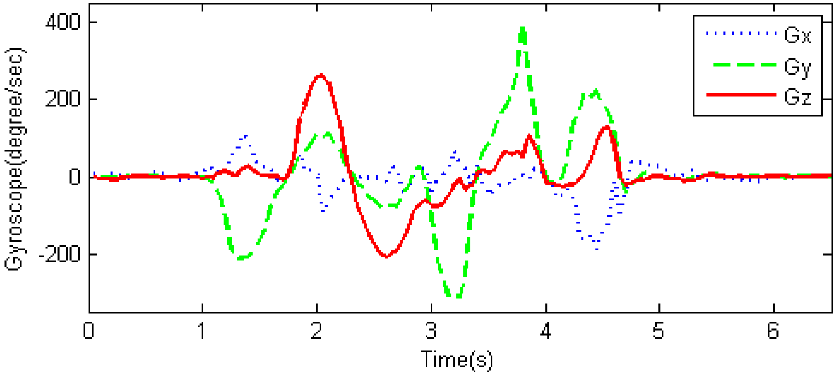
- □ Define gestures that best emulate a remote controller

Button Function	Gesture Definition
Up	Up
Down	Down
Left	Left
Right	Right
Select	Clockwise
Back	Anticlockwise
Home	Back&Forth



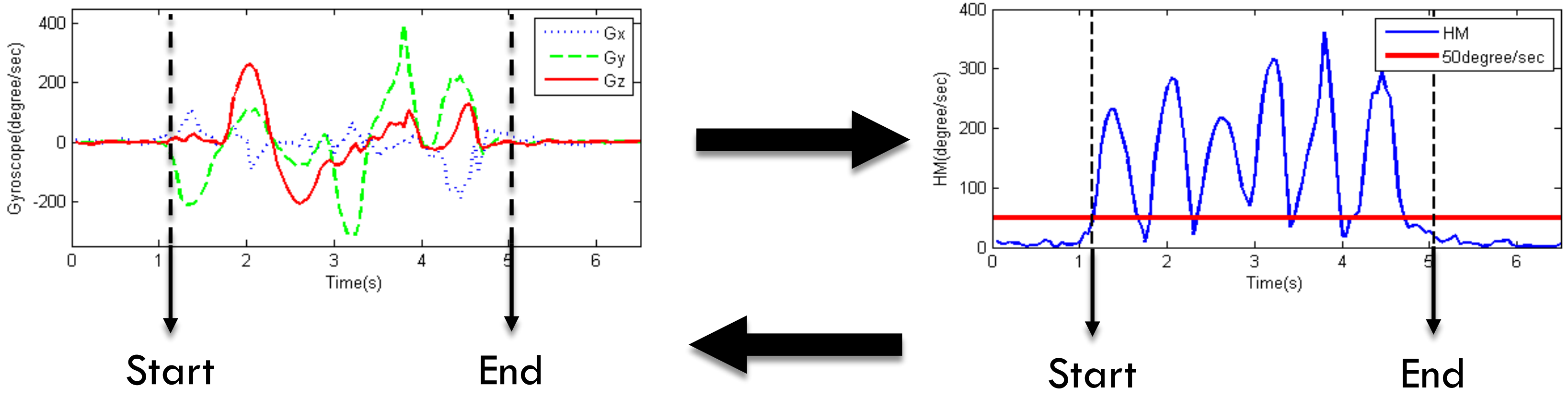
Continuous Hand Gesture Recognition

- How to retrieve and recognize seven defined gesture from a sequence of hand movements?
  - Raise hand->Left gesture->Back & Forth gesture->put down hand



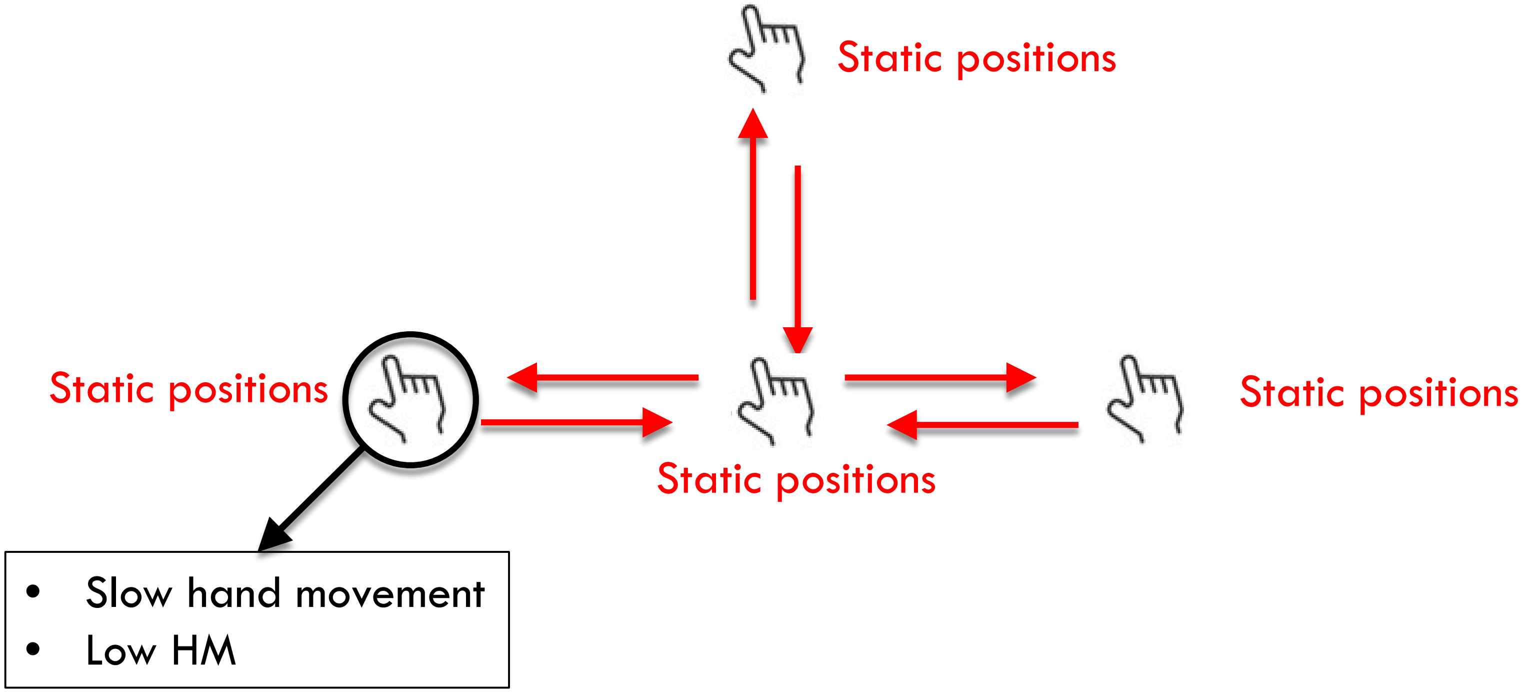
Sequence Start/End Detection

- Lightweight threshold-based detection metric
  - $HM = \sqrt{Gyro_x^2 + Gyro_y^2 + Gyro_z^2}$
  - Start of hand movement: HM > 50
  - End of hand movement: HM < 50 for 400ms



Within-sequence gesture separation

- □ Gestures start/end in positions with slow hand movement
- □ Static positions: positions with slow hand movement
- □ Static positions ⇔slow hand movement ⇔ low HM



Static positions

Static positions

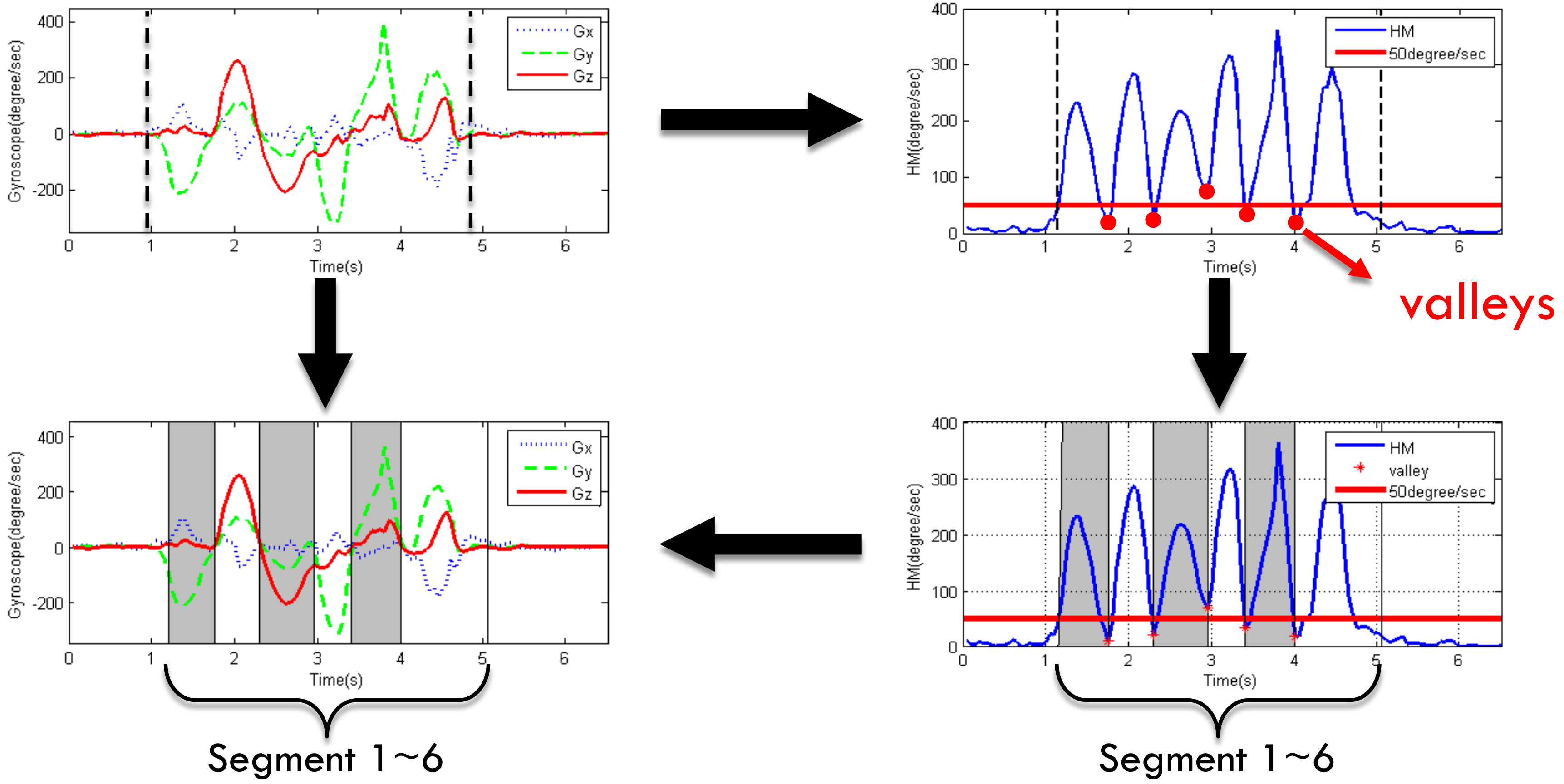
Static positions

Static positions

- Slow hand movement
- Low HM

Within-sequence gesture separation

- Valleys in HM curve are potential start/end positions of gestures.
- Apply sliding window to detect valleys of HM curve.



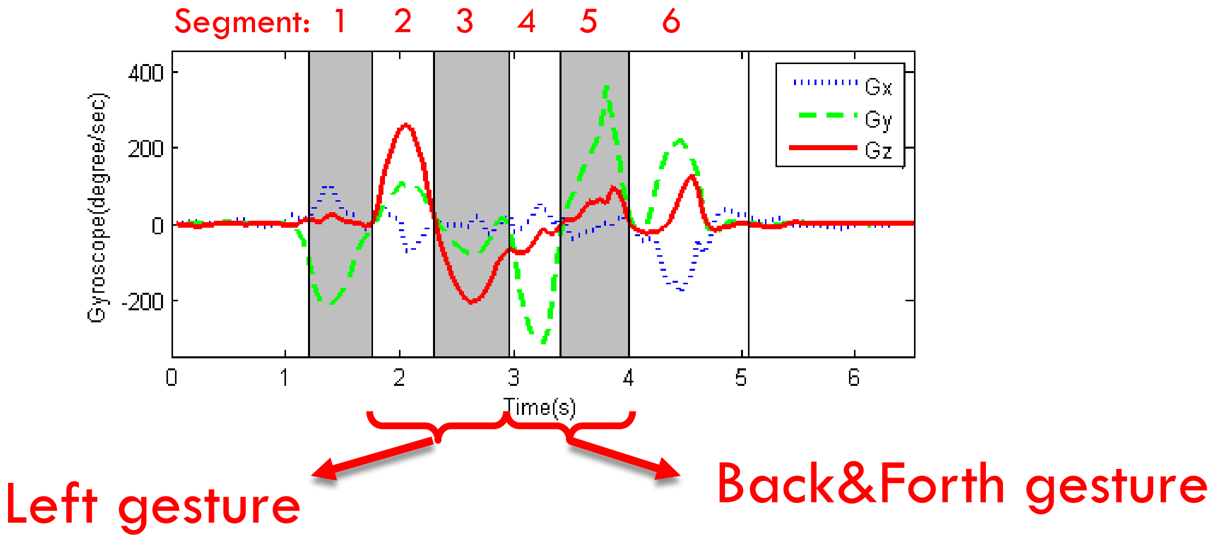
valleys

Segment 1~6

Segment 1~6

Merging Adjacent segments

- One gesture may lie in one segment or several adjacent segments.



Left gesture

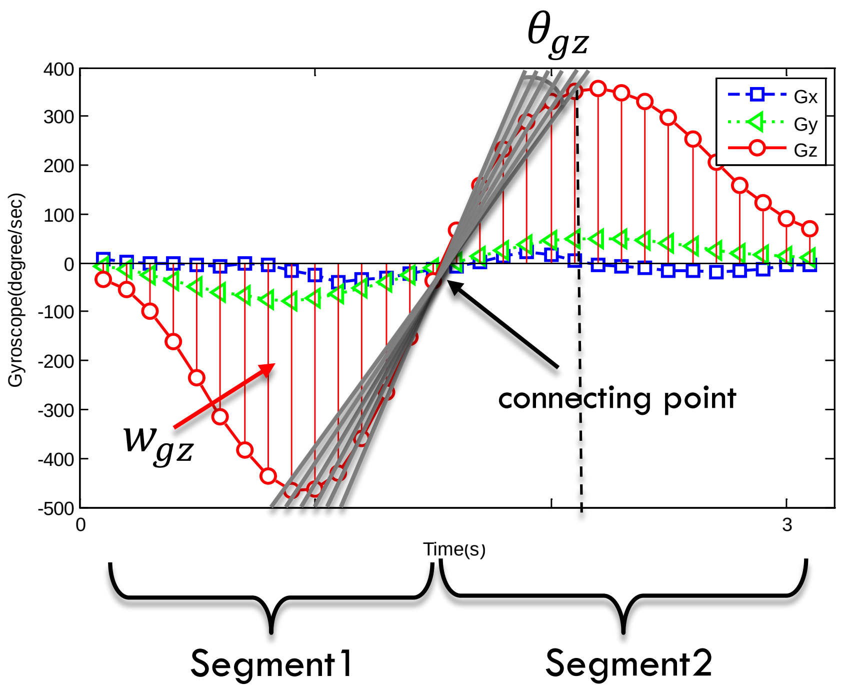
Back&Forth gesture

- Merge adjacent segments so that each segment only contains one gesture
  - Gesture Continuity
  - Gesture Completeness

Gesture Continuity

- If two segments have similar slopes near connecting points, these segments belong to one gesture

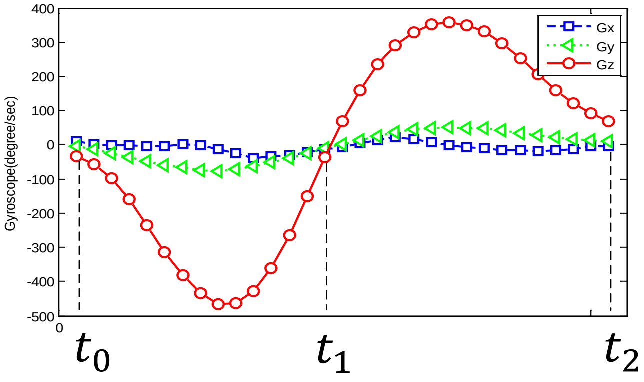
- Find points before connecting point within time window 300ms as $t_a, t_b, t_c, t_d, t_e, t_f$, and points after as $t_g, t_h, t_i, t_j, t_k, t_l$
- Form 12 lines and find the maximum angle as θ_{gi}.
- Compute weight w_{gi} as the area size of the curve g_i
- Gesture Continuity (Con)
  - $Con(t_1) = \frac{\sum(w_{gi} \cdot \theta_{gi})}{\sum w_{gi}}$



Gesture Completeness

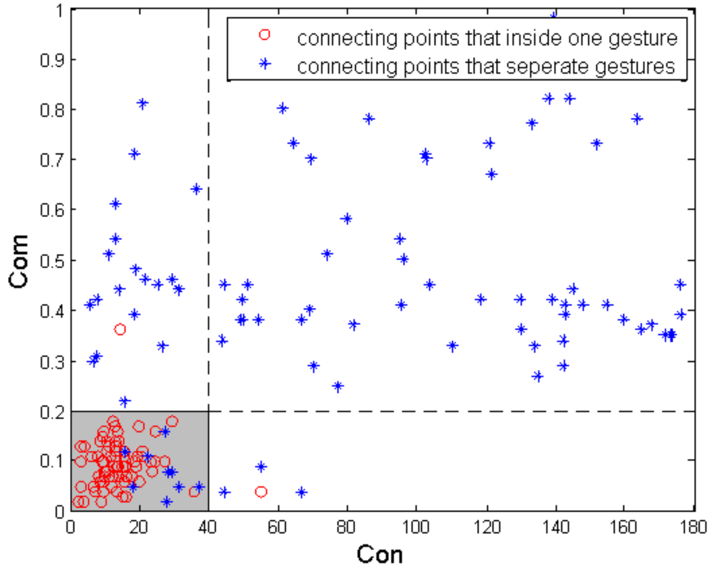
- The defined gestures start/end in the same position
  - The sum of sensor readings should be close to 0 for a complete gesture

- Gesture Completeness (Com)
  - $Com(t_1) = \frac{\left|\sum_{t_0}^{t_2} g_x\right| + \left|\sum_{t_0}^{t_2} g_y\right| + \left|\sum_{t_0}^{t_2} g_z\right|}{\sum_{t_0}^{t_2} |g_x| + \sum_{t_0}^{t_2} |g_y| + \sum_{t_0}^{t_2} |g_z|}$



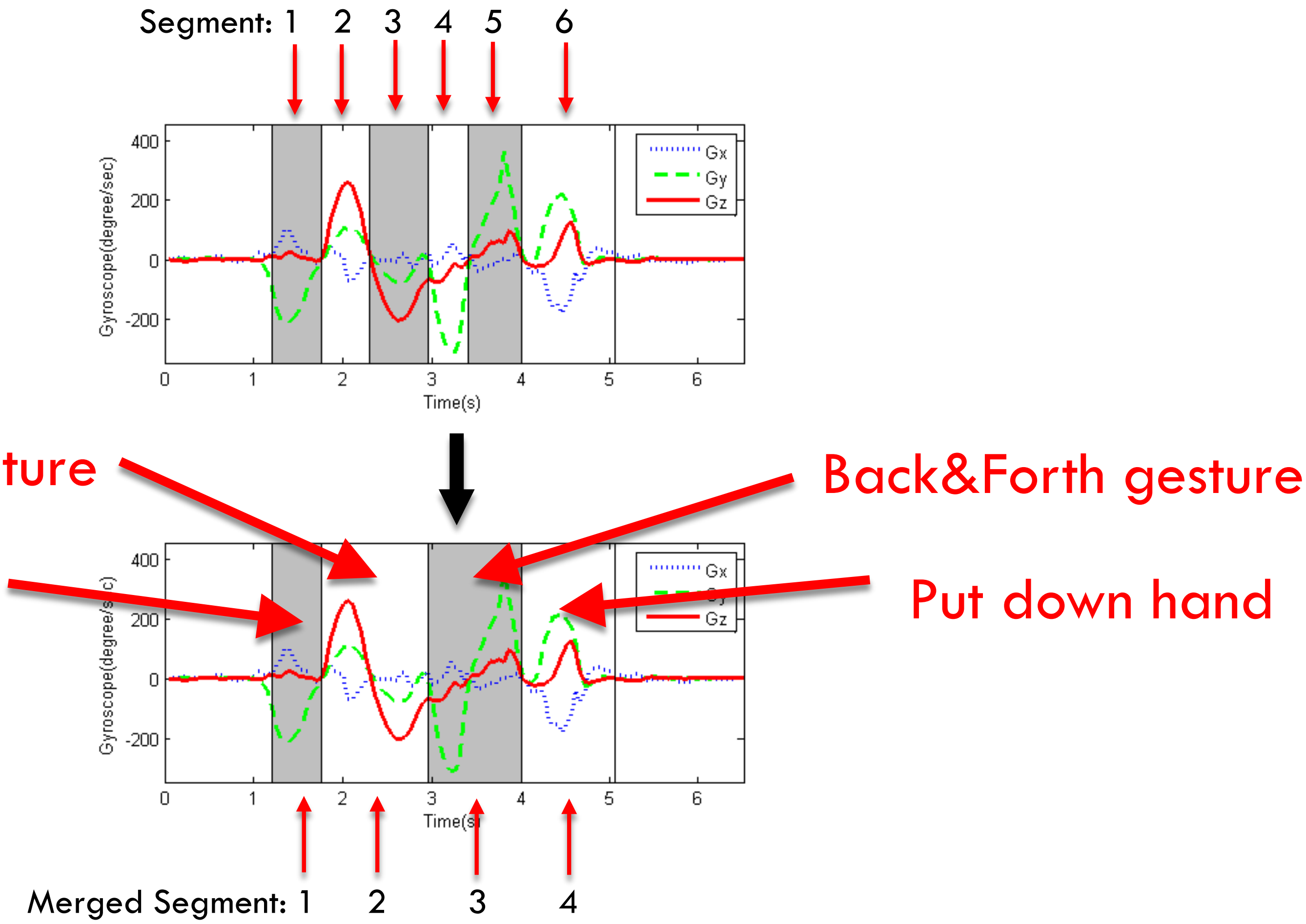
Con VS Com

- 100 continuous gestures: 177 connecting points
  - Blue stars: connecting points that separate two gestures
  - Red circles: connecting points that are inside gestures
- Merge two adjacent segments if Con < 40 degree and Com < 0.2



Merging Adjacent Segments

- After merging, each segment contains exactly one gesture



Segment: 1 2 3 4 5 6

Left gesture

Raise hand

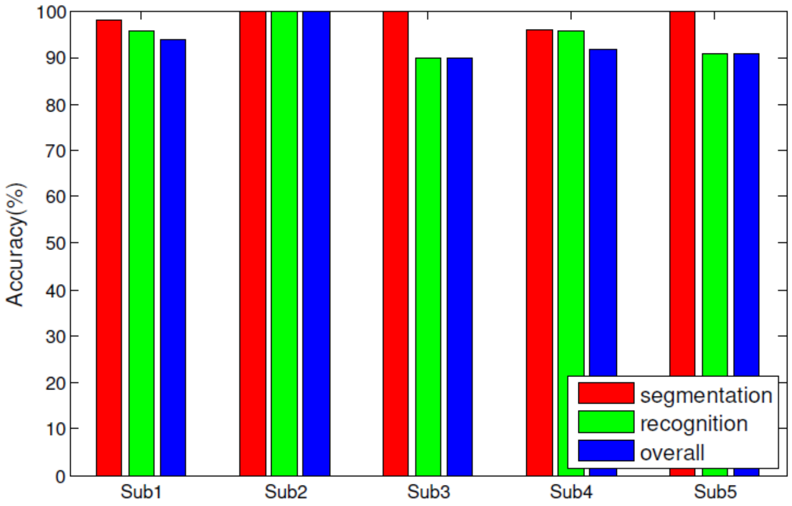
Back&Forth gesture

Put down hand

Merged Segment: 1 2 3 4

Hand Gesture Recognition

- Features Extraction
  - Raw, first-derivative and the integral of acceleration data and gyroscope data
- Classification
  - Hidden Markov Model
- Accuracy
  - Segmentation: 98.8%
  - Recognition: 95.7%
  - Overall: 94.6%



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- □ ~~Wristband hardware platform~~
- □ ~~Continuous hand gesture segmentation and recognition framework~~
- □ Introduction to APIs

UG wristband Open API

- API definition (three classes)
  - UGManager
    - Used to scan UG devices
  - UGDevice
    - Used to connect to certain UG device and collect sensor data from it.
  - UGProfile
    - Used to represent the current status of a UG device.

Open API for UG wristband

- UGManager
  - Void startScan(ScanCallback cb)
  - Void stopScan()
  - Interface ScanCallback{

    ```
        void onScanCallback(UGDevice device);
    }
    ```

Open API for UG wristband

- UGDevice
  - Void Connect (StatusChangeCallback cb)
  - Void Disconnect()
  - Void startDataSensing (DataAvailableCallback cb, int rate)
  - Void stopDataSensing()
  - Void setLED(Byte[] ledMask)
  - Void getBatteryLevel()
  - String getAddress()
  - Interface StatusChangeCallback{
        void onStatusChange (UGDevice device, int status);
    }
  - Interface DataAvailableCallback{
        void onSensorDataAvailable (UGDevice device, float[] data);
        void onBatteryLvlAvailable (UGDevice device, int data);
    }

Open API for UG wristband

- UGProfile
  - public static final int *STATUS_DISCONNECTED* = 0;
  - public static final int *STATUS_CONNECTED* = 1;
  - public static final int *STATUS_DATA_SENSING_ON* = 2;
  - public static final int *STATUS_DATA_SENSING_OFF* = 3;

Steps to use UG APIs

- Import packages
- Use UGManager class to scan UG wristbands
- Use UGDevice class to connect to UG wristbands
- Use UGDevice class to read data from UG wristbands

Import packages

-
  ```
  import com.ultigesture.ug.UGDevice;
  import com.ultigesture.ug.UGManager;
  import com.ultigesture.ug.UGProfile;
  ```

Use UGManager class to scan UG wristbands

- Create an object of UGManager class
- Call startScan() method to scan nearby UG wristbands
  - UGManage mUGManager = new UGManager(this);
  - mUGManager.startScan(mScanCallback);

Use UGDevice class to connect to UG wristbands

- □ Implement callback functions to receive scan results.
- □ Call connect() method to connect to a UG wristband

```
private UGManager.ScanCallback mScanCallback = new UGManager.ScanCallback(){
    @Override
    public void onScanCallback(UGDevice device) {
        device.connect(mConnectionStateChangeCallback);
    }
};
```

Use UGDevice class to read data from UG wristbands-1

- Implement callback functions to receive the status of a UG wristband
- Check if a UG wristband is connected
- Call startDataSensing() method to collect sensor data from a UG wristband

```
private UGDevice.StatusChangeCallback mConnectionStateChangeCallback =
 new UGDevice.StatusChangeCallback(){
        @Override
        public void onStatusChange(UGDevice device, int status) {
            if (status == UGProfile.STATUS_CONNECTED){
                device.startDataSensing(mDataAvailableCallback, 100);
            }
        }
    };
```

Sampling interval: 100ms

Use UGDevice class to read data from UG wristbands-2

- Implement callback functions to receive data from UG wristbands.

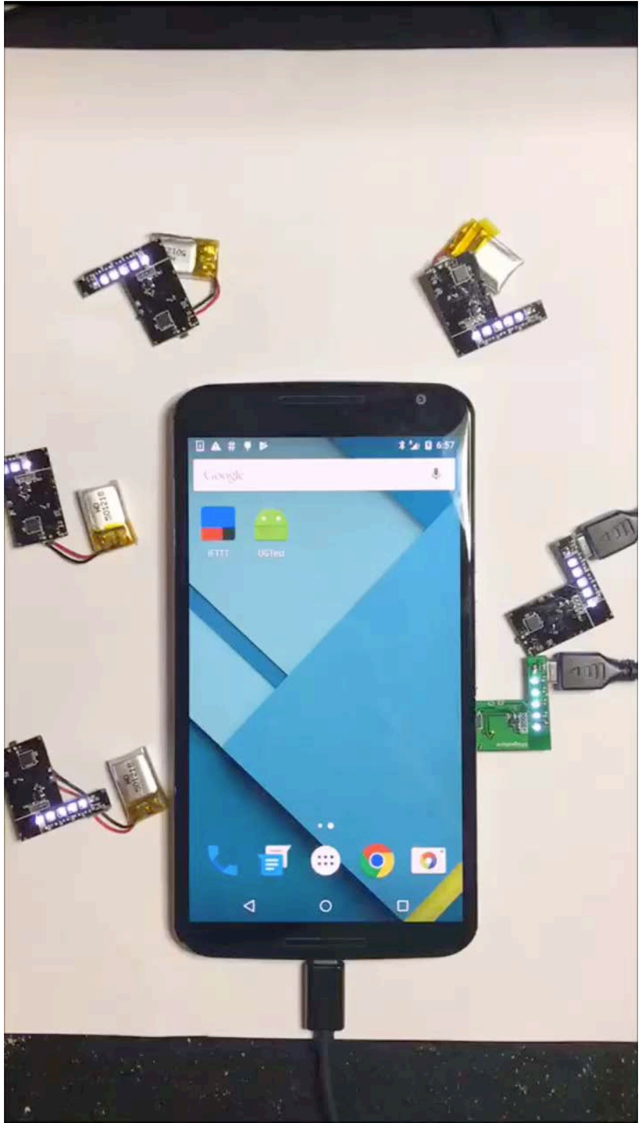
```
private UGDevice.DataAvailableCallback mDataAvailableCallback =
new UGDevice.DataAvailableCallback(){
    @Override
    public void onSensorDataAvailable(UGDevice ugDevice, float[] data) {
        // data[0]: AccX        data[1]: AccY        data[2]: AccZ
        // data[3]: GyroX       data[4]: GyroY       data[5]: GyroZ
        // data[6]: MagX        data[7]: MagY        data[8]: MagZ
    }

    @Override
    public void onBatteryLvlAvailable(UGDevice device, int data) {
        // data: battery level
    }
};
```

Demo-1

QuickTime Player
File
Edit
View
Window
Help
100%
搜狗拼音
Sat 6:31 PM
UGTest
Screen Shot 2017-06...PM.png
Screen Shot 2017-06...PM.png
SEP
16

Demo-2



Conclusion

- Wristband hardware platform
  - Comfortable to wear
  - Open API
  - Affordable price
- Continuous hand gesture segmentation and recognition framework
  - Lightweight
  - Accurate
- Introduction to APIs

Question?