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Gesture Control Sleeve

Final Presentation

ECE 445 Team #56

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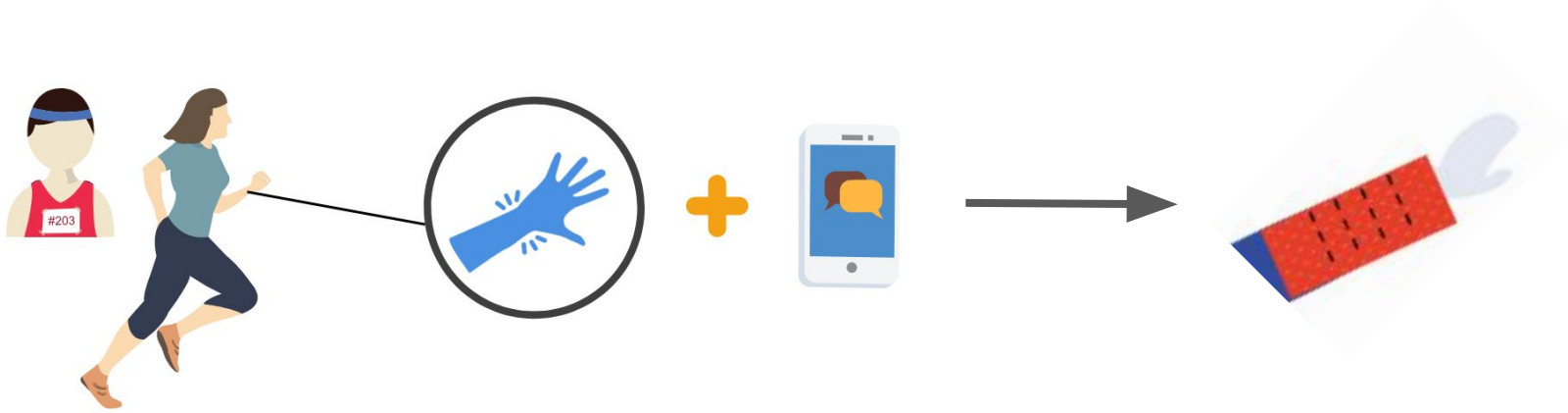
Introduction

- **Problem Statement:** Few functional textile applications targeted towards athletes and people on-the-go offer accessible connectivity
- **Proposed Solution:** Develop a touch-sensitive sensor that seamlessly integrates gesture detection and call/text alert into a wearable fabric sleeve



Gesture Control Sleeve Objectives

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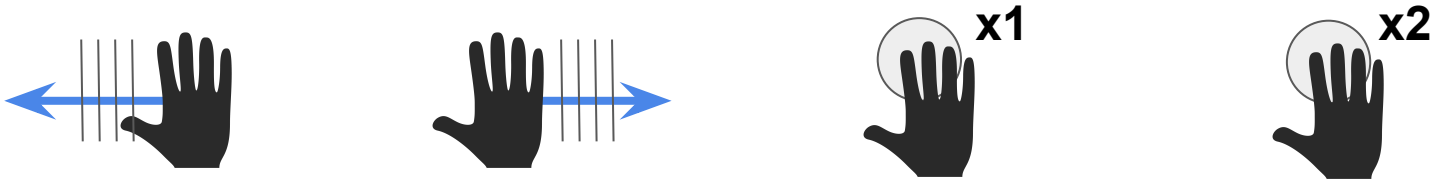
- Detect **four different hand gestures**:



- **Wirelessly communicate** with the phone / demo system within 0-5m.
- Provide incoming call alerts using **haptic feedback**
- **Physical dimensions** and characteristics:
  - Weight: The sleeve module must weigh < 125 g
  - Size: Length of Grid is 12-16 cm, Width is < 35 cm

Potential Applications & Benefits

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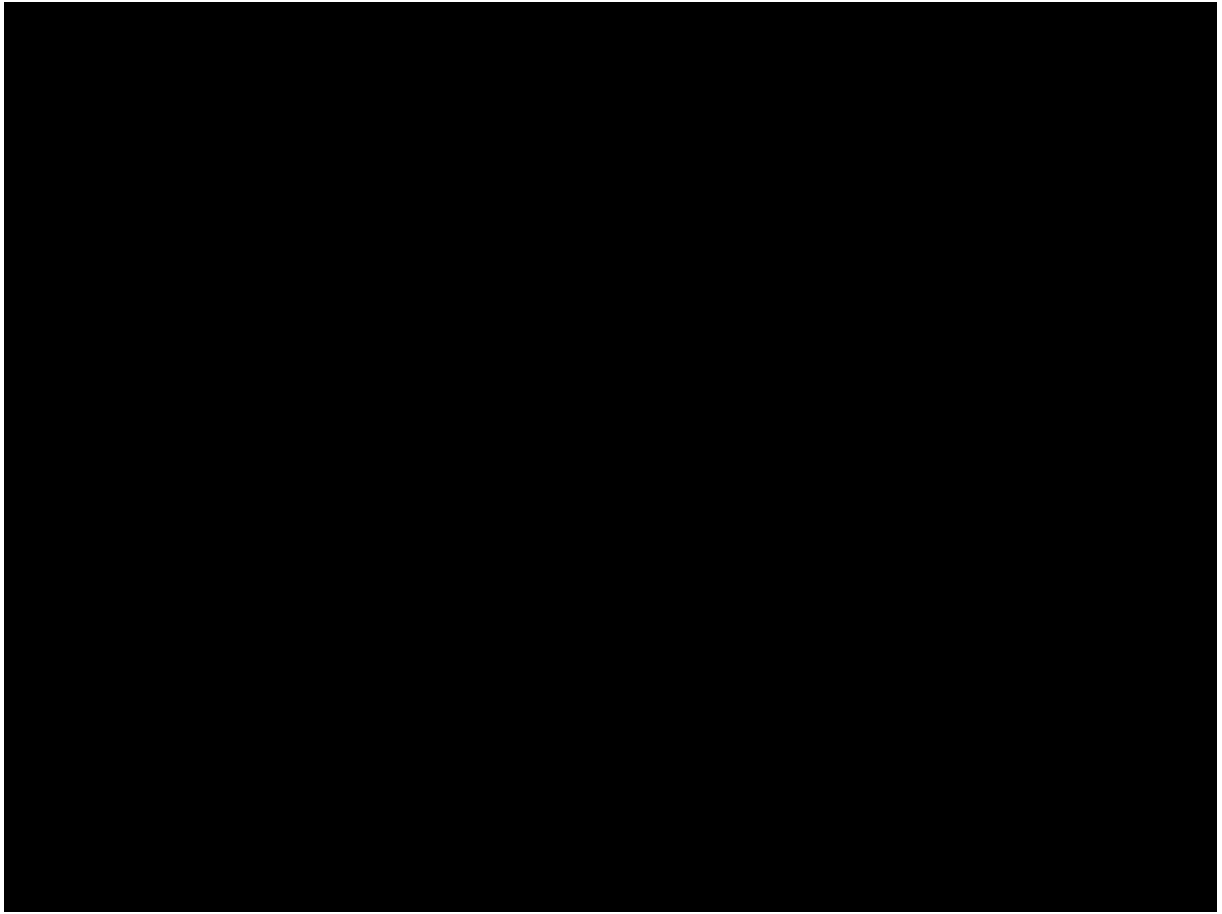
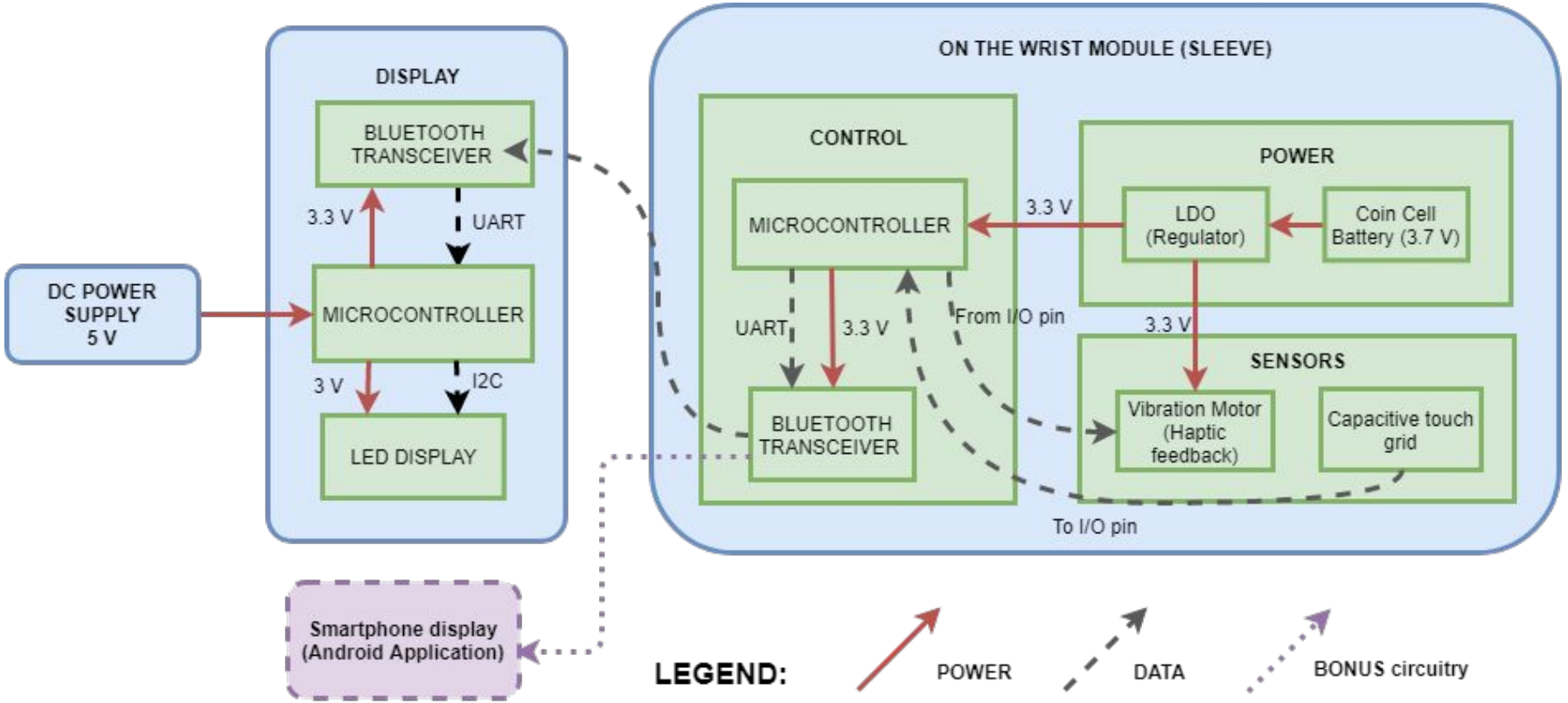
- **Natural Control:** Interact with your smartphone device seamlessly
- **Communication:** Handle calls and texts without handling your device
- **Navigation:** Stay focused on where you’re going, not your screen
- **Music:** Stay in your groove by controlling music with different gestures

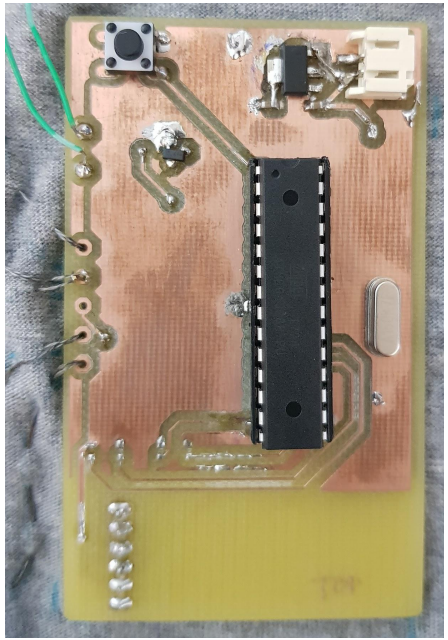
Gesture Detection Demo Video



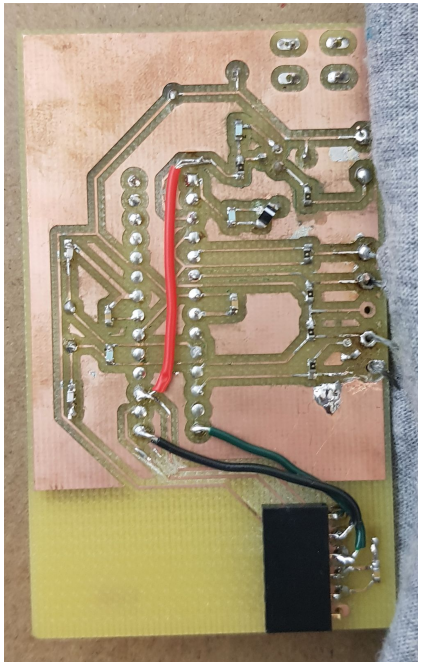
Block Diagram



Sleeve PCBs

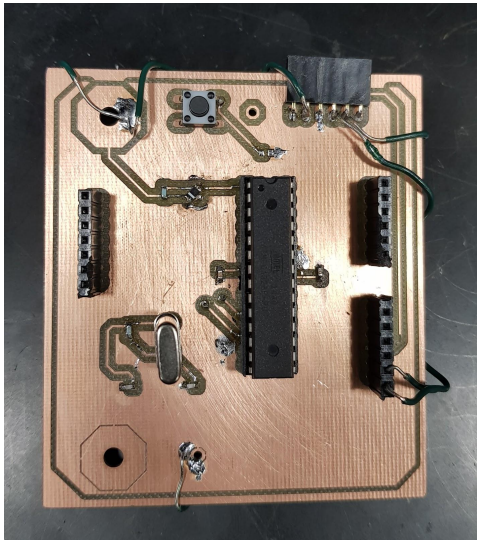


Sleeve PCB (Top)

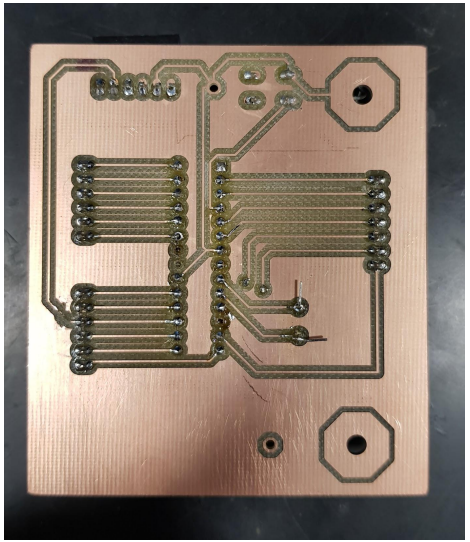


Sleeve PCB (Bottom)

Demo PCBs



Demo PCB (Top)



Demo PCB (Bottom)

Bluetooth Modules

Purpose: Provide wireless data transmission between MCUs on sleeve and LED demo

Specifications:

- **Power:** 3.3V operation and logic input, 30mA
- **Baud rate:** 38400 bps
- Serial communication
- Up to 20m transmission distance
- Master-slave binded
- Bi-directional communication

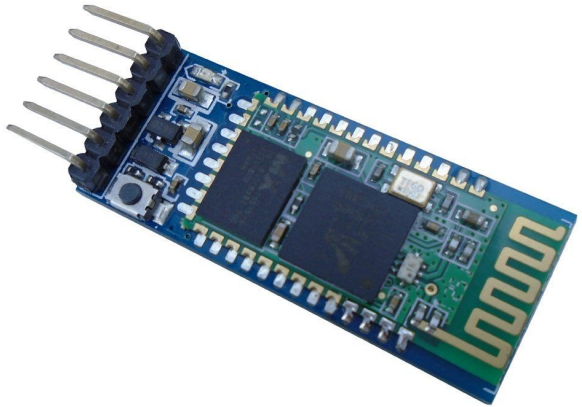


Image source: DSD Technology

Demo System

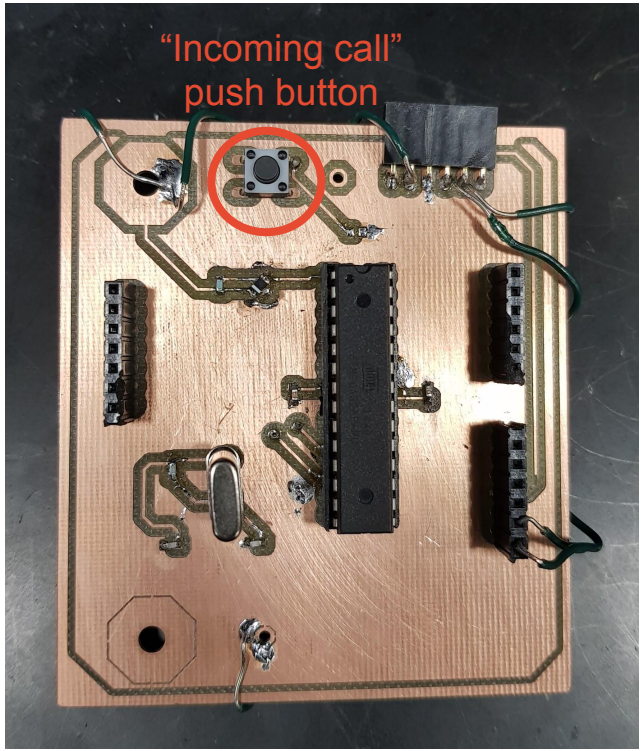
“Phone Call” Demo Module

Purpose:

- Use push button to mimic incoming call/text
- Have maximum call ring length (~10 seconds)

Specifications:

- Push button = active LOW
- When pushed = active HIGH
  - Registers as “Incoming Call”
- Max call ring length (~10 seconds)



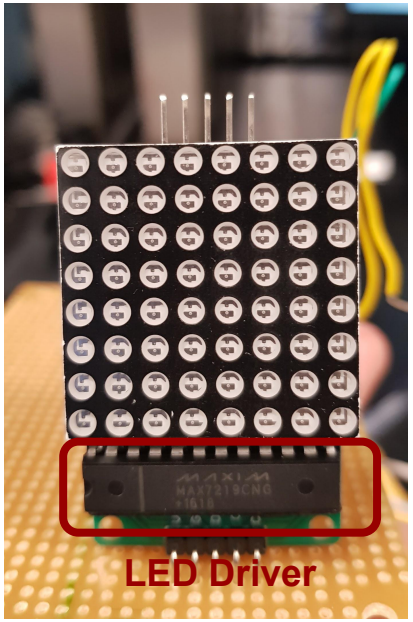
Demo PCB (Top)

LED Matrix

Purpose:

- Display gestures detected from sleeve system
- 8x8 LED array
- Displays 4 different light patterns corresponding to gestures
- Operates in real-time via bluetooth communication

- **Power:** 3.3 V, ~30 mA (when ON)



Sleeve System

Power Module

Purpose: Main supply unit for on-sleeve electronic components

Two components:

- Battery (LiPo 3.7 V, 2000 mAh)
- Voltage regulator (LDO 3.3 V)

Considerations:

- Minimize size and weight
- Maximize operating time
  - Total max. current consumption -127.5 mA
  - Approximate run time - (2000/127.5) = 15.68 hrs

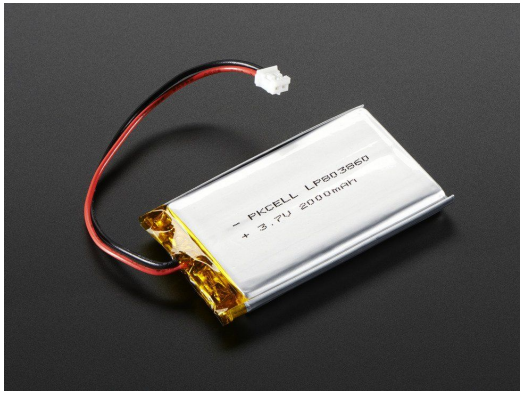
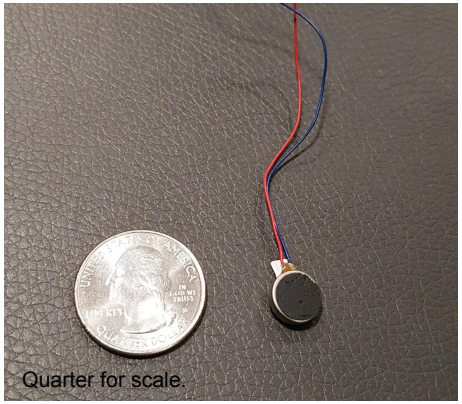


Image source: Adafruit

Vibration Motor

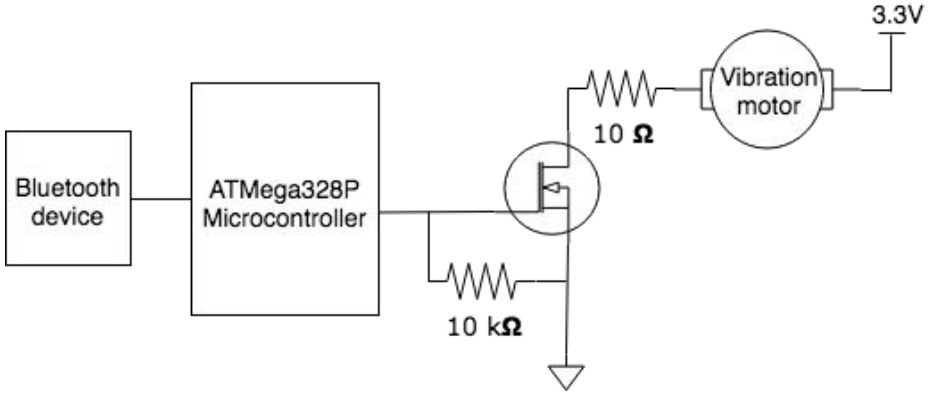
Purpose:

- Provide haptic feedback to alert user of incoming call
- Can be muted by single tapping the sensor grid

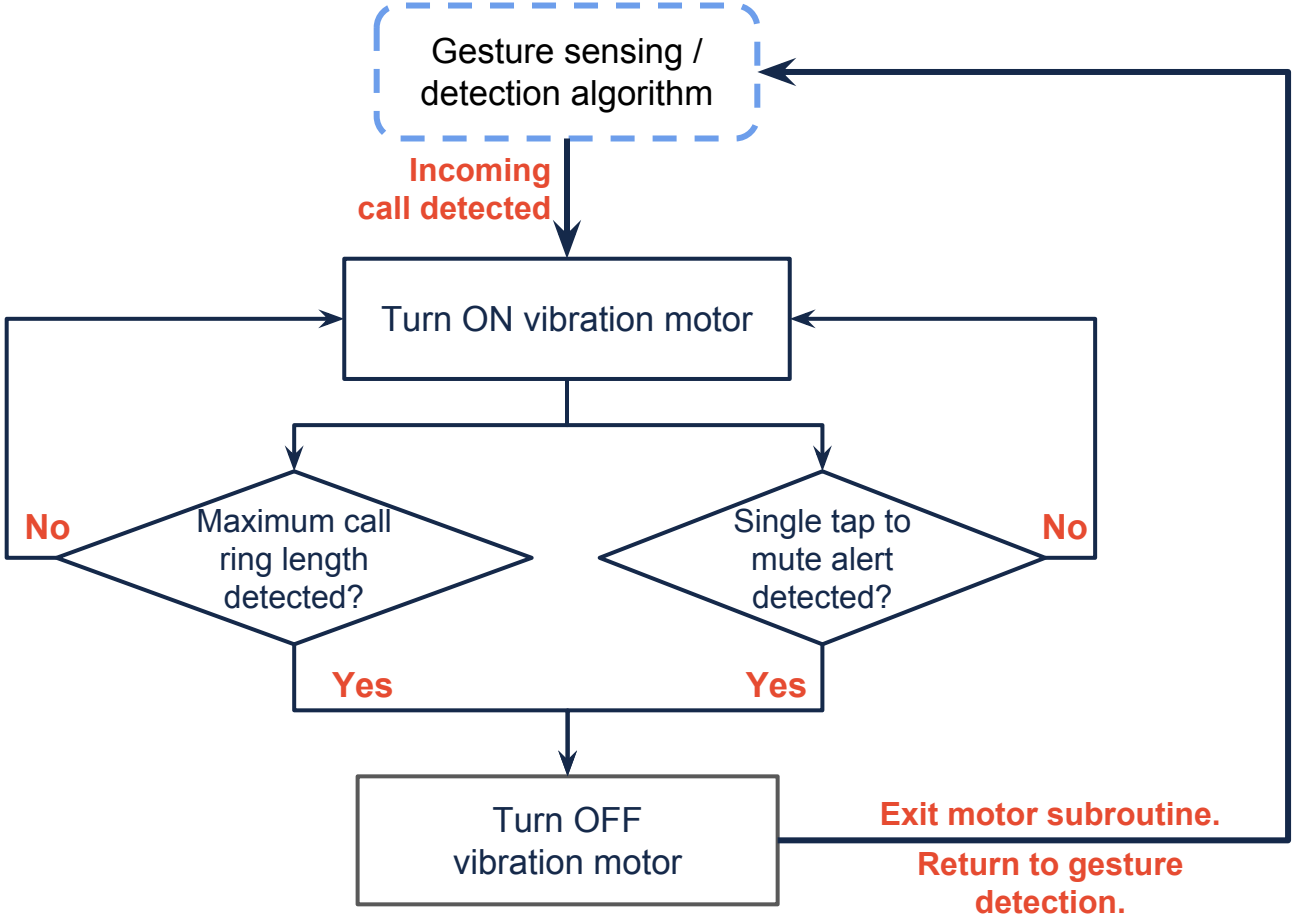


Specifications:

- **Power:** 3.3V, ~50-70mA (when ON)
- Driven by PWM N-channel MOSFET



Vibration Motor: Operational Logic



Conductive Thread Grid

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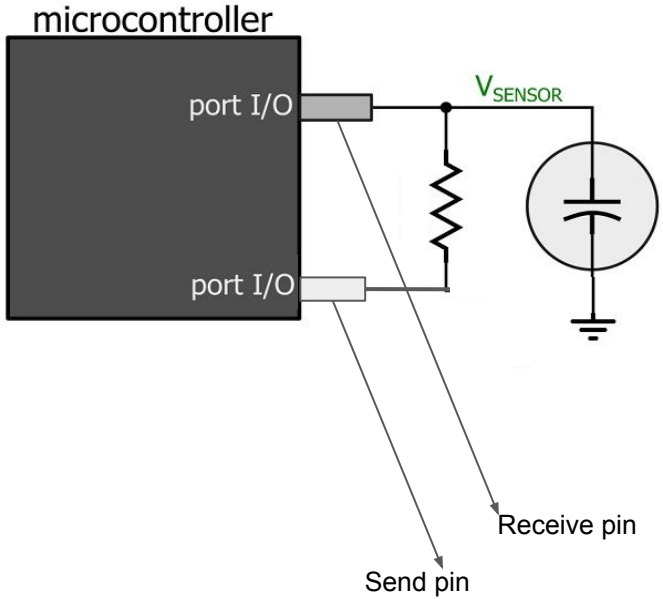
- **Purpose:** Detect four different hand gestures using capacitive sensing algorithm
  - Swipe up
  - Swipe down
  - Single tap
  - Double tap

Grid: Capacitive Sensing



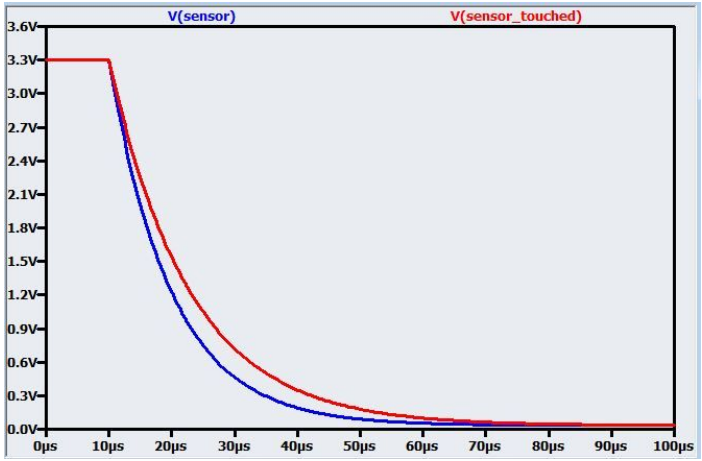


*Image source: All About Circuits

Grid: Gesture Timing Data

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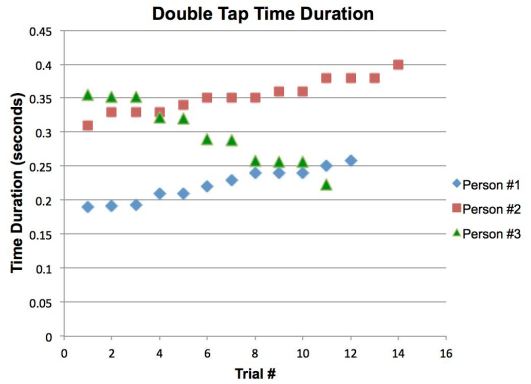
Swiping Deltas

Length	# of conductive lines	Distance b/w lines (cm)	Time b/w each line (ms)
14	2	4.7	140.014
14	3	3.5	106.015
14	**4**	**2.8**	**84.008**
14	5	2.3	70.007
14	6	2	60.006
14	7	1.8	52.505

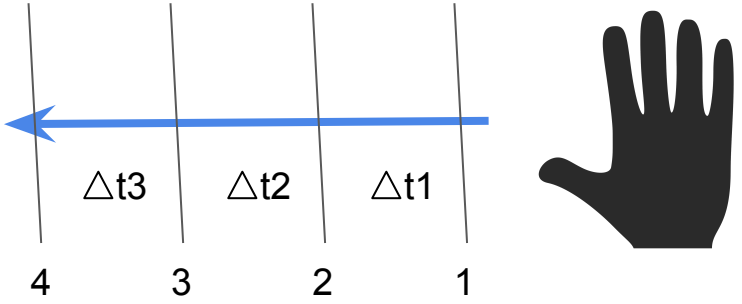
Interval Between Double Tap

	Person #1	Person #2	Person #3	
Average (sec)	0.223	0.354	0.298	**0.290**
Min time duration (sec)	0.190	0.310	0.224	**0.19**
Max time duration (sec)	0.259	0.400	0.355	**0.40**

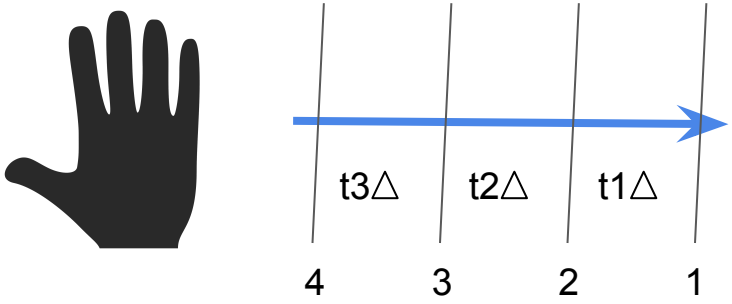


Grid: Gesture Sensing Logic

Swipe Up



Swipe Down



Conditions:

- Order:
  - Swipe Up: Lines #1, 2, 3, 4 (all lines) touched in order
  - Swipe Down: Lines #4,3,2,1 (all lines) touched in order
- Time deltas t1, t2, t3 within 0s < t < 1 s
- Specific Considerations:
  - Swipe Down: Line #1 RC Value > Line #4 RC Value
  - Swipe Up: Line #4 RC Value > Line #1 RC Value

Grid: Gesture Sensing Logic

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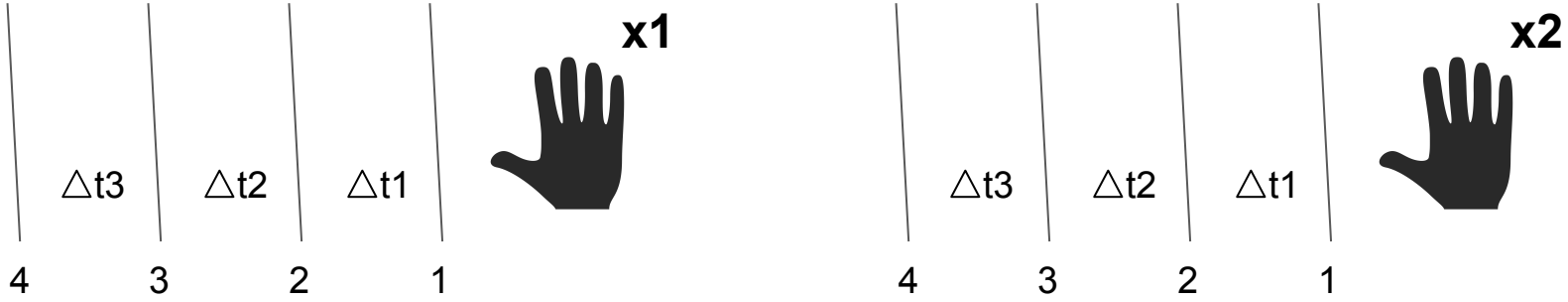
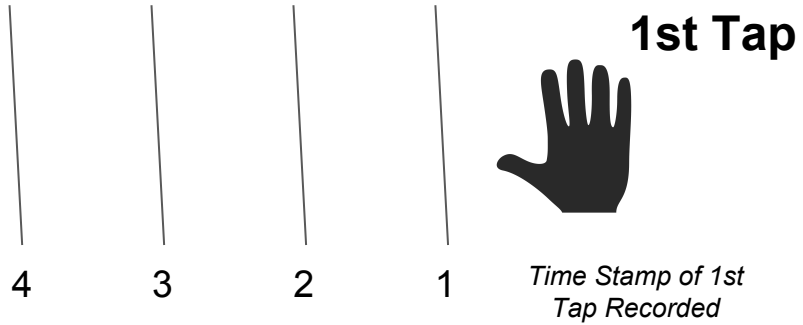
Taps

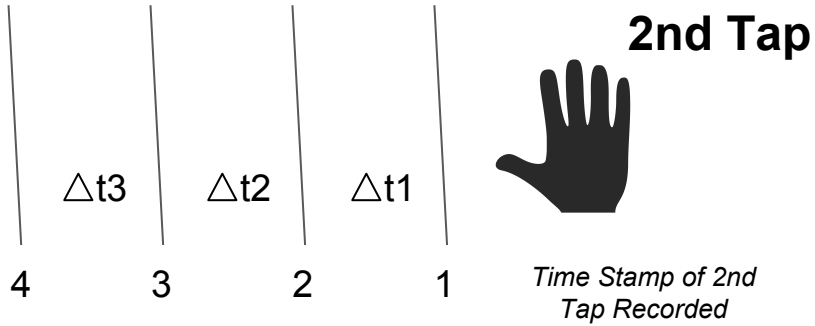


Conditions:

- Only lines 2 and 3 touched (1 and 4 cannot be)
- Time delta t2 within -40ms < t < 40ms
- Register single tap if second tap has not been detected within 0.4 s
    - Else, if second tap has been performed within interval, register double tap

False Positive Considerations





- Prolonged touch:
  - Single Taps: Minimum of **0.4s** required after the first tap is performed before additional taps are recognized
  - Double Taps: Minimum of **0.1s** required between the second tap of a double tap and a closely following single tap / double tap to prevent repeat detection

Wearable Sleeve Physical Design

- Compact PCB design, fits forearm
- Detachable PCB from sleeve for easy washing
- Sewable conductive snaps
- Double layered sleeve for insulation

Conclusion

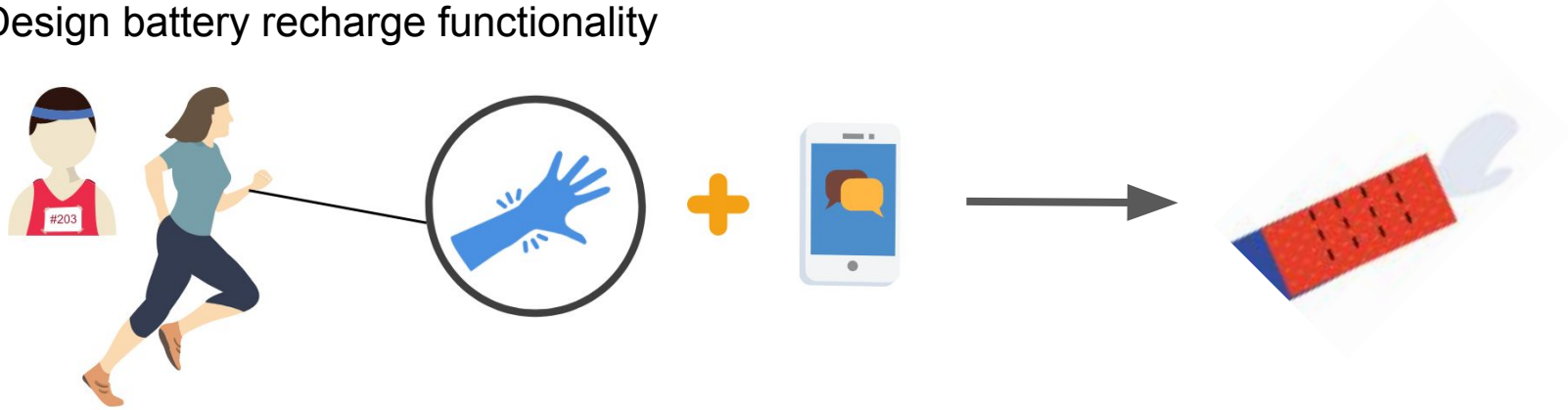
- Fully integrated all modules on breadboard / PCB
- Vibration motor as tactile alert for incoming call
- Bluetooth devices for wireless connectivity
- >75% gesture detection accuracy

Challenges

- Hard-to-soft connections (PCB to fabric)
- Double tap timing thresholds and false positives

Future Work

- Improve hard-to-soft connections (PCB to fabric)
- Improve robustness of gesture sensitivity by accounting for more false positives
- Reduce size of capacitive sensor grid
- Reduce size of PCB
- Build in Android phone connectivity
- Design battery recharge functionality



Special Thanks

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References

“Detecting Common Gestures.” Android Developers Documentation. Retrieved March 11, 2018. Available at: https://developer.android.com/training/gestures/detector.html.

“Handling Tap Gestures.” Apple Developer Documentation. Retrieved March 11, 2018. Available at: https://developer.apple.com/documentation/uikit/touches_presses_and_gestures/handling_uikit_gestures/handling_tap_gestures.

“How to Drive a Vibration Motor with Arduino and Genuino.” Precision Micro Drives Tech Blog. Retrieved March 6, 2018. Available at: https://www.precisionmicrodrives.com/tech-blog/2016/05/16/how-drive-vibration-motor-arduino-and-genuino.

“PhoneStateListener.” Android Developers Documentation. Retrieved February 18, 2018. Available at: https://developer.android.com/reference/android/telephony/PhoneStateListener.html.

“Transistor Motor Control.” Arduino Tutorial. Retrieved March 7, 2018. Available at: https://www.arduino.cc/en/Tutorial/TransistorMotorControl.

“UITapGestureRecognizer - Single Tap and Double Tap.” Stackoverflow. Retreived March 12, 2018. Available at: https://stackoverflow.com/questions/8876202/uitapgesturerecognizer-single-tap-and-double-tap

Currey, Martyn. “Connecting 2 Arduinos by Bluetooth Using a HC-05 and a HC-06: Easy Method Using CMODE.” Retrieved February 25, 2018. Available at: http://www.martyncurrey.com/connecting-2-arduinos-by-bluetooth-using-a-hc-05-and-a-hc-06-easy-method-using-cmode/.

Choudhury, S. et. al. “Calibration of Sensors Using Arduino.” Department of Electronics and Communication, NIT Rourkela. November 2015.

Frenzel, Lou. “What’s the Difference Between Bit Rate and Baud Rate?” Electronic Design Communications. Retrieved March 12, 2018. Available at: http://www.electronicdesign.com/communications/what-s-difference-between-bit-rate-and-baud-rate.

Mathavan, Hariharan. “Control an Arduino with Bluetooth.” All About Circuits Projects. Retrieved February 25, 2018. Available at: https://www.allaboutcircuits.com/projects/control-an-arduino-using-your-phone/.

Wu, F., et. al. “Development of a Wearable-Sensor-Based Fall Detection System.” International Journal of Telemedicine and Applications, Vol. 2015. Hindawi Publishing Corp.

Questions?