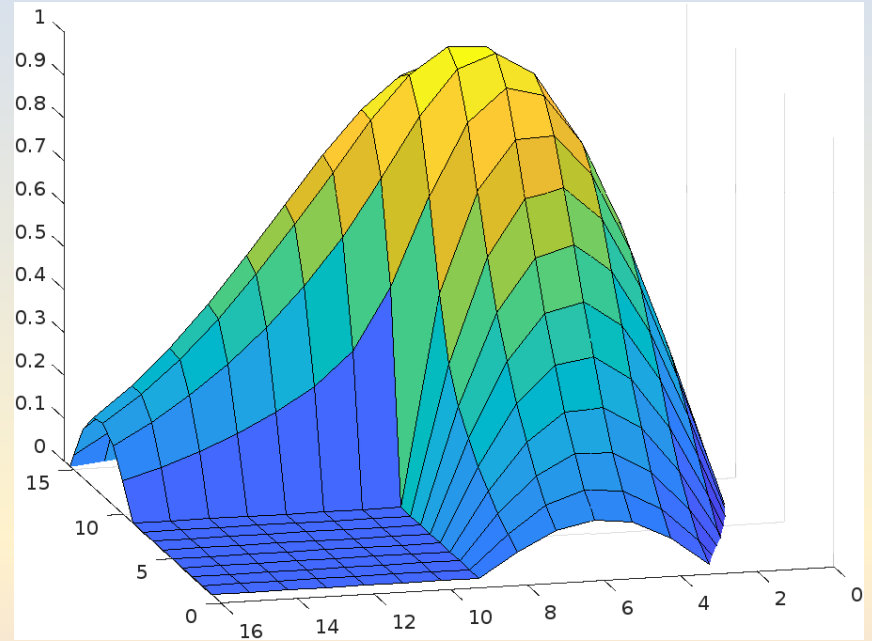


HANDLEE

Purpose

Plots and models are limited and constrained because it is difficult to visualize 3D on a 2D monitor.

Through visualization, one can develop a deeper understanding of the information and grasp the important details faster.



Project Overview

A 3D RGB LED matrix display controlled wirelessly by a mobile application and hand gestures read by a smart glove

Key Features:

- Input math function from mobile application connected via Bluetooth
- Display figure on 16x16x16 LED matrix
- Control figure with hand gestures sent through smart glove connected via Bluetooth



The Team



Ryan Chau

CAD, Distance Sensor



Eric Hsieh

LED Driver, Gesture Logic



Anna Koh

Cube Assembly, PCB



Sachen Sampath

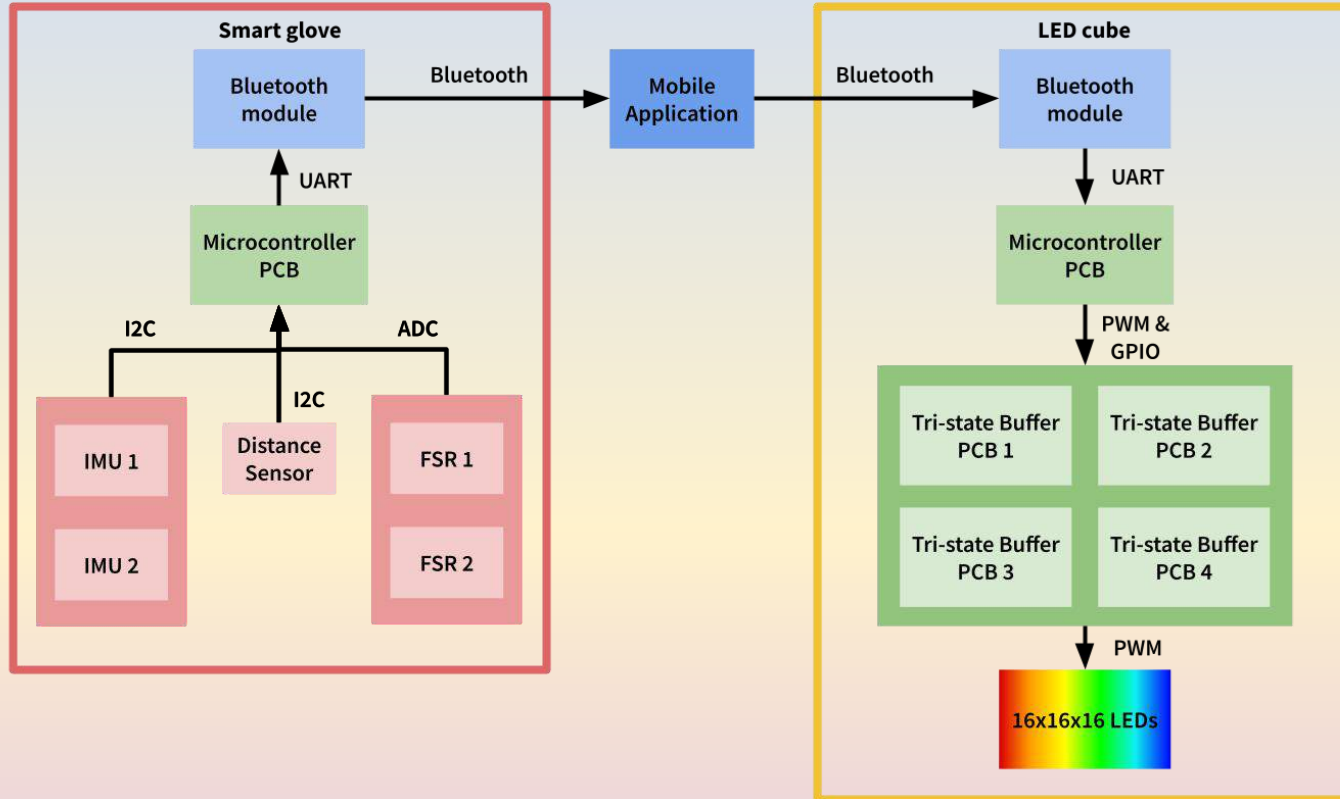
Mobile App, Bluetooth



Christine Wan

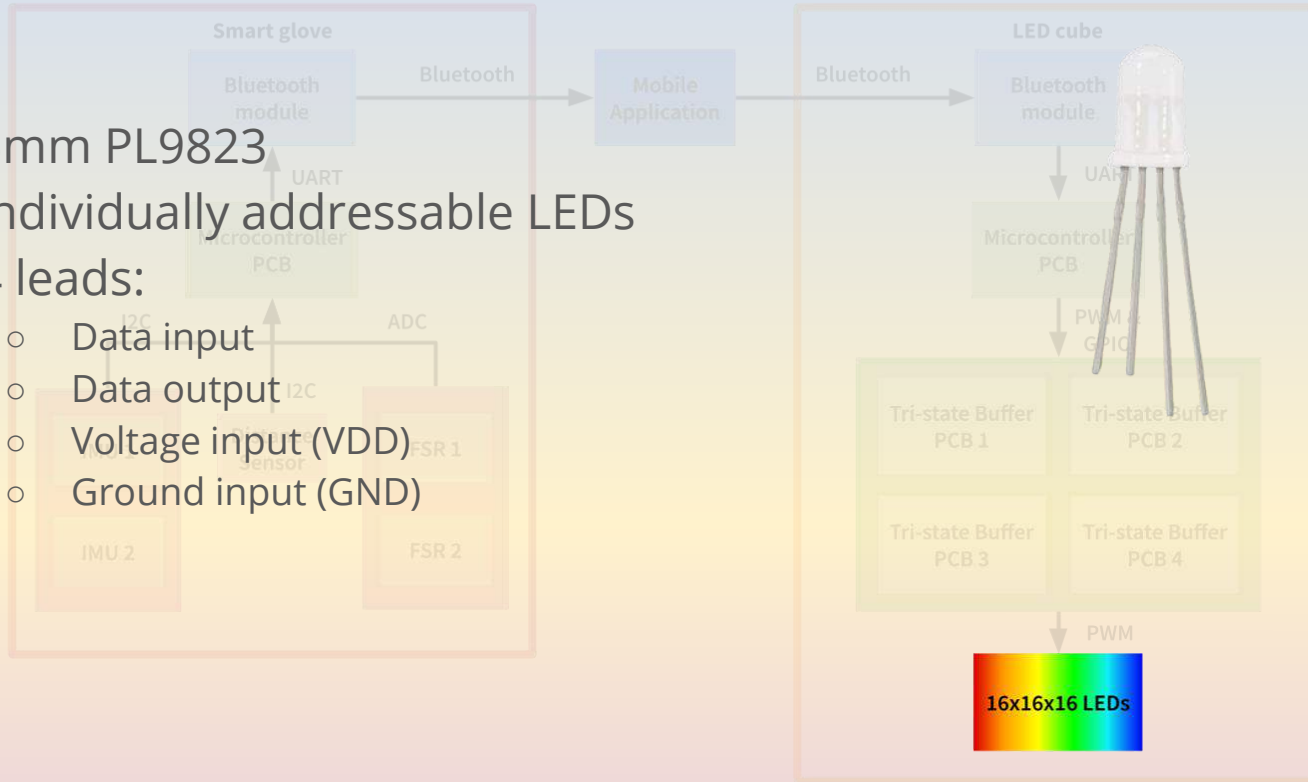
IMU, Smart Glove

Block Diagram



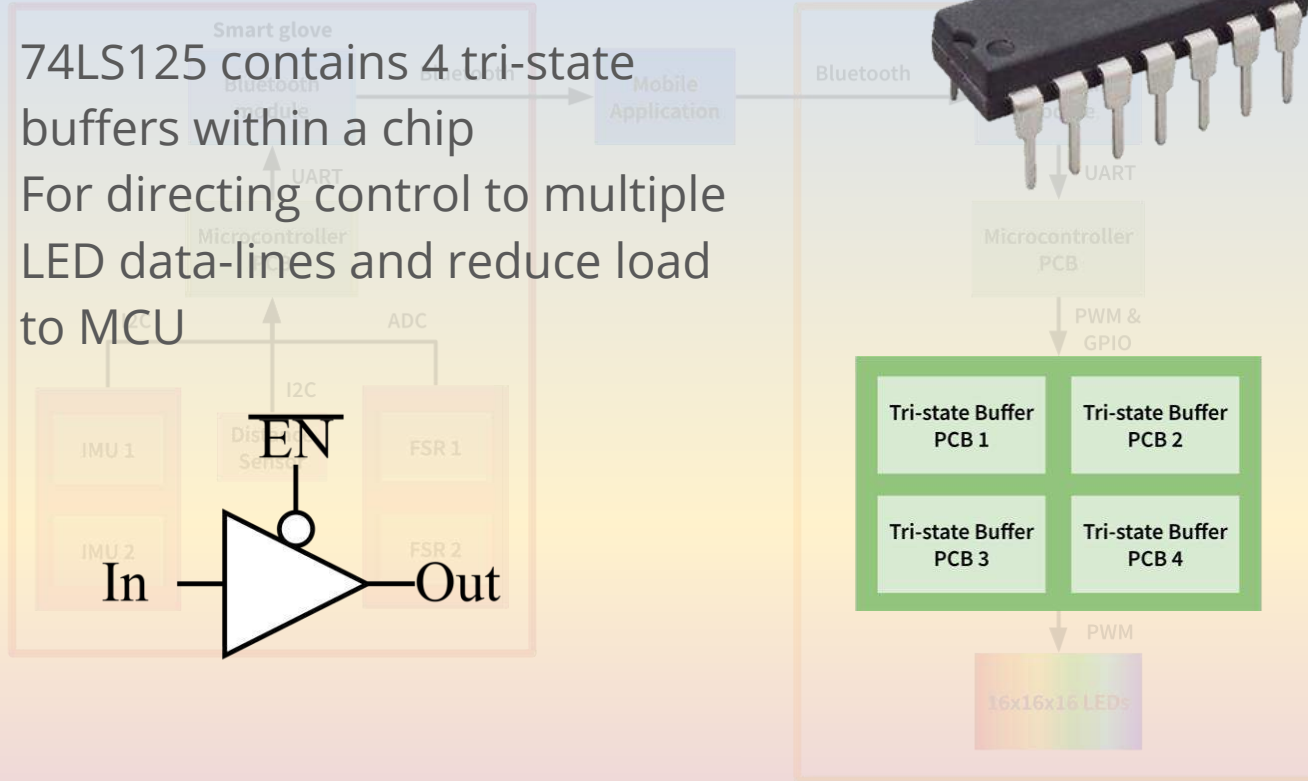
LEDs

- 5mm PL9823
- Individually addressable LEDs
- 4 leads:
 - Data input
 - Data output
 - Voltage input (VDD)
 - Ground input (GND)



Tri-State Buffer

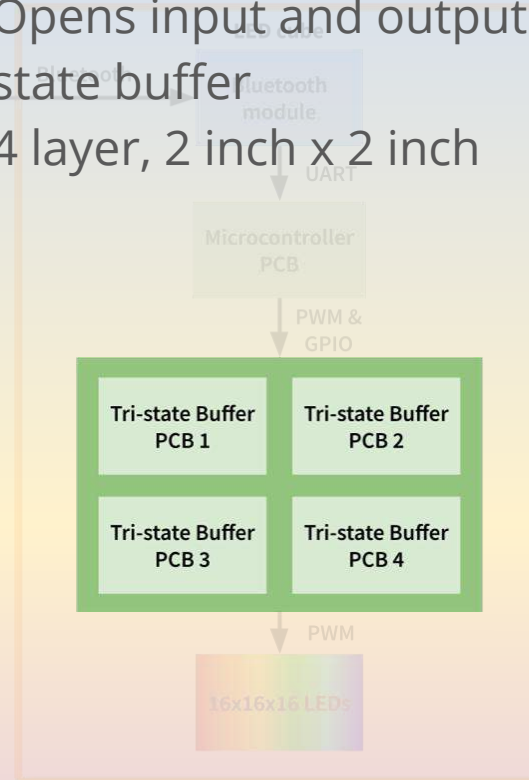
- 74LS125 contains 4 tri-state buffers within a chip
- For directing control to multiple LED data-lines and reduce load to MCU



Custom PCB: Tri-State Buffer

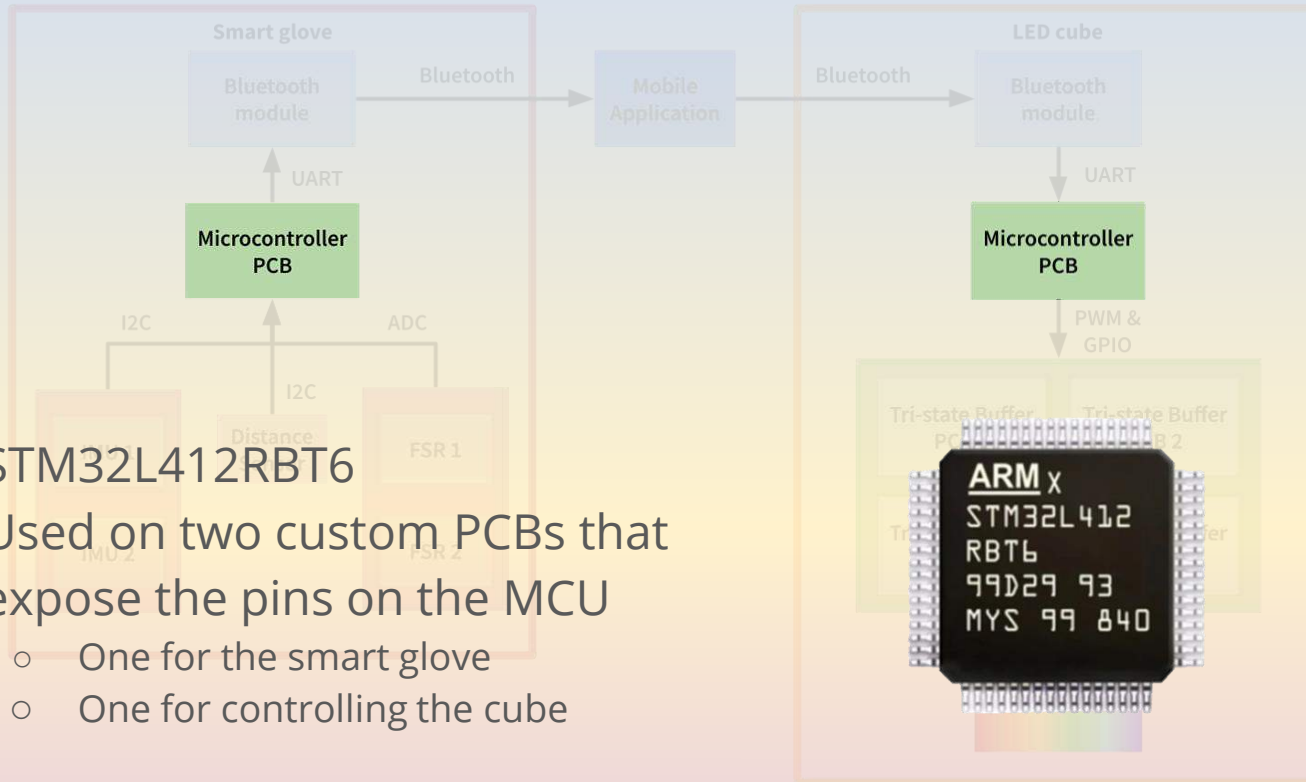


- Opens input and output pins for tri-state buffer
- 4 layer, 2 inch x 2 inch

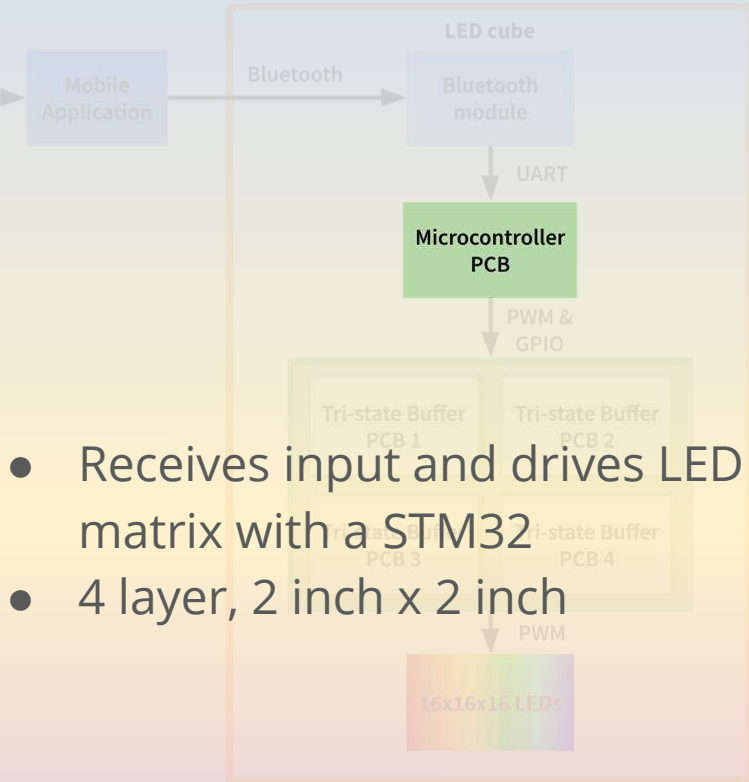
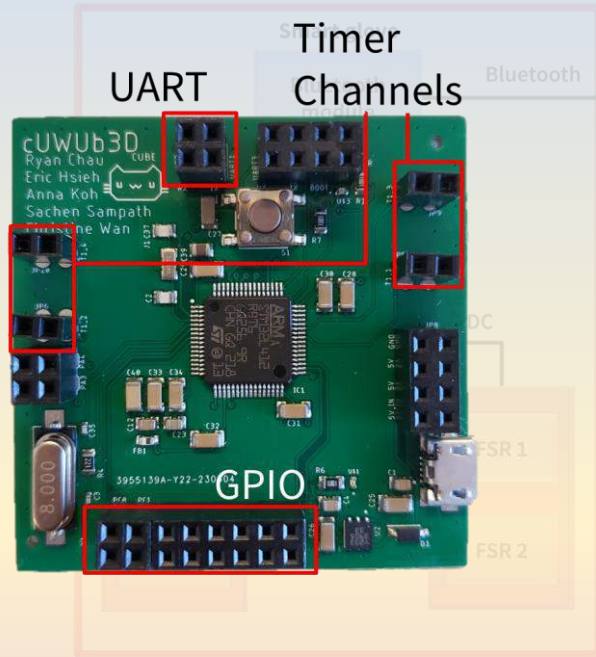


Microcontroller

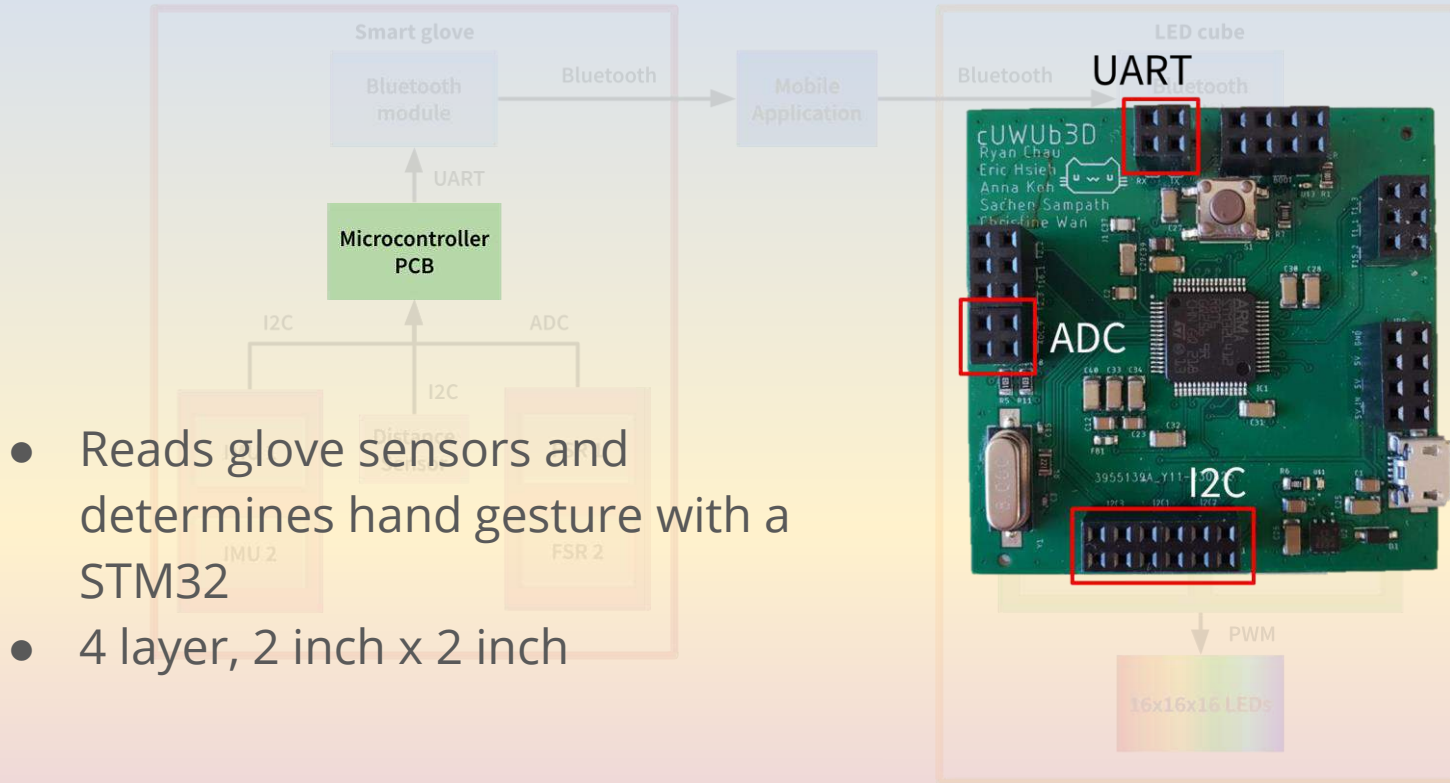
- STM32L412RBT6
- Used on two custom PCBs that expose the pins on the MCU
 - One for the smart glove
 - One for controlling the cube



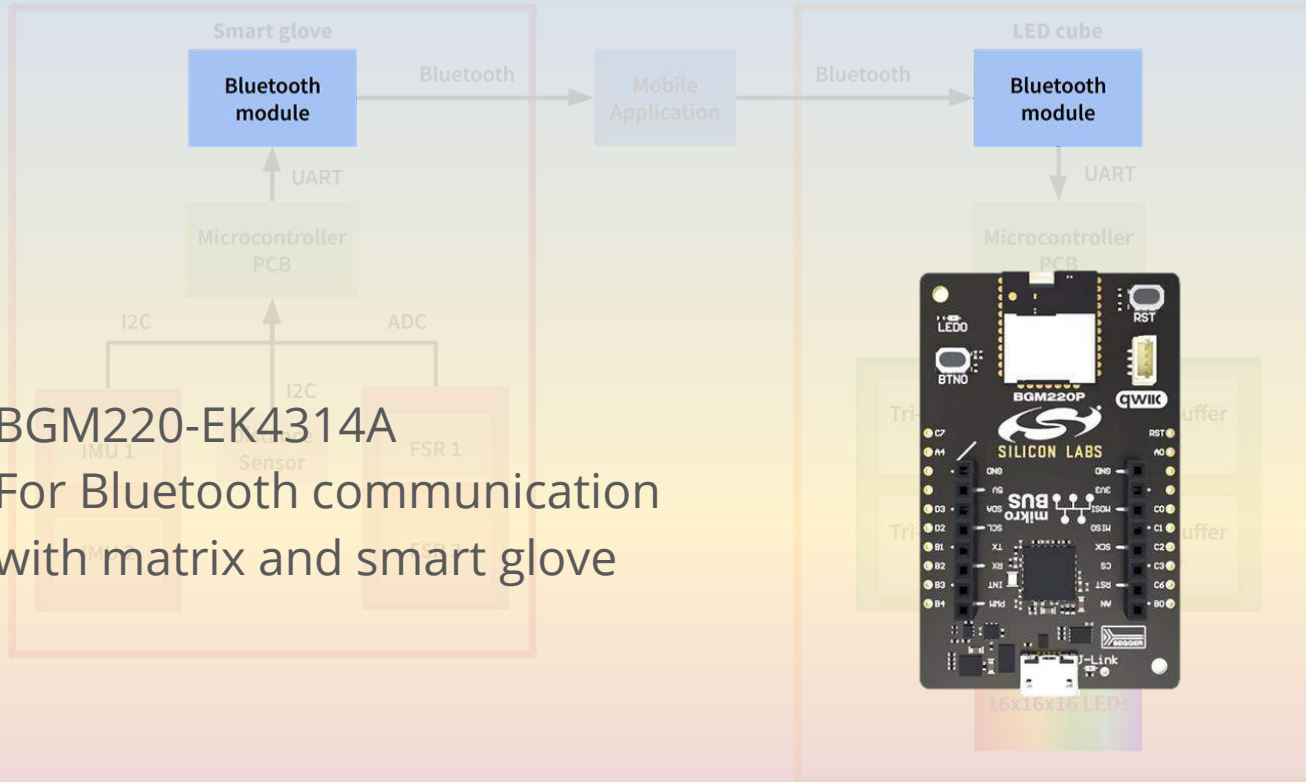
Custom PCB: LED Cube



Custom PCB: Smart Glove



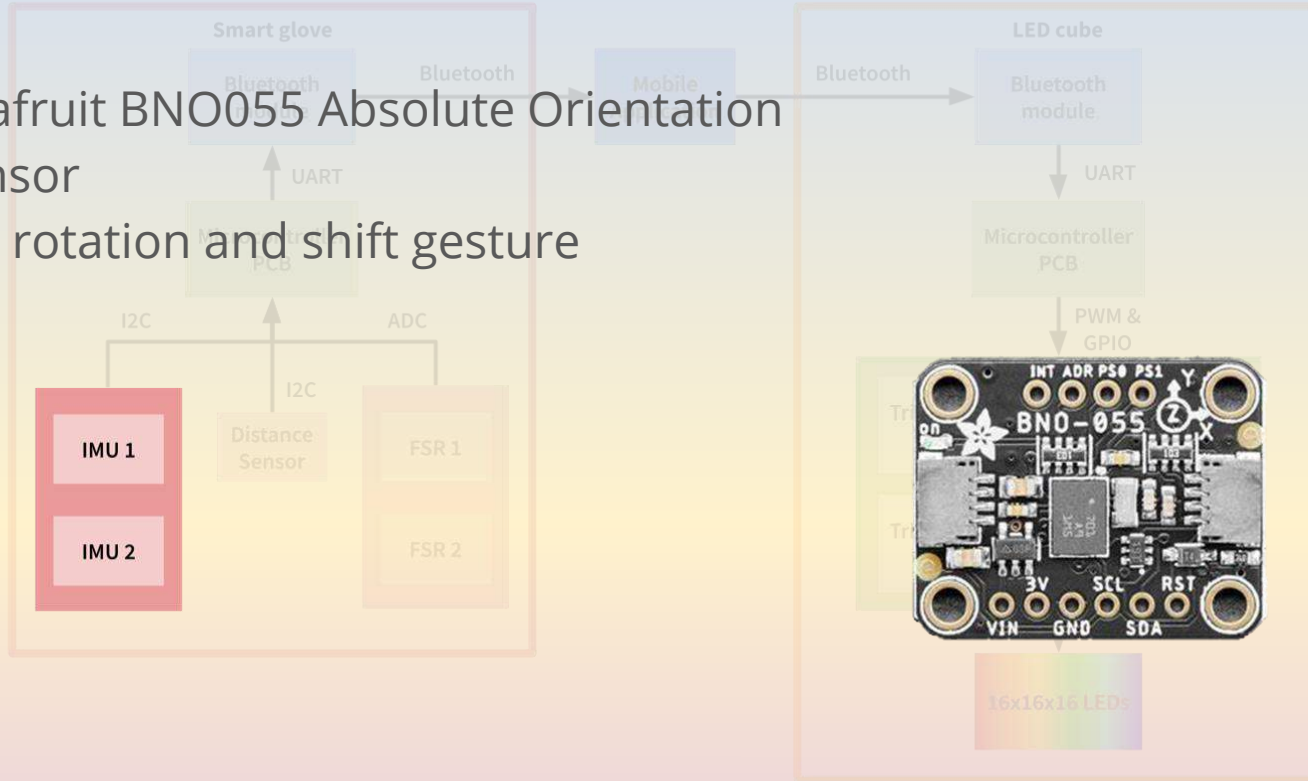
Bluetooth Module



- BGM220-EK4314A
- For Bluetooth communication with matrix and smart glove

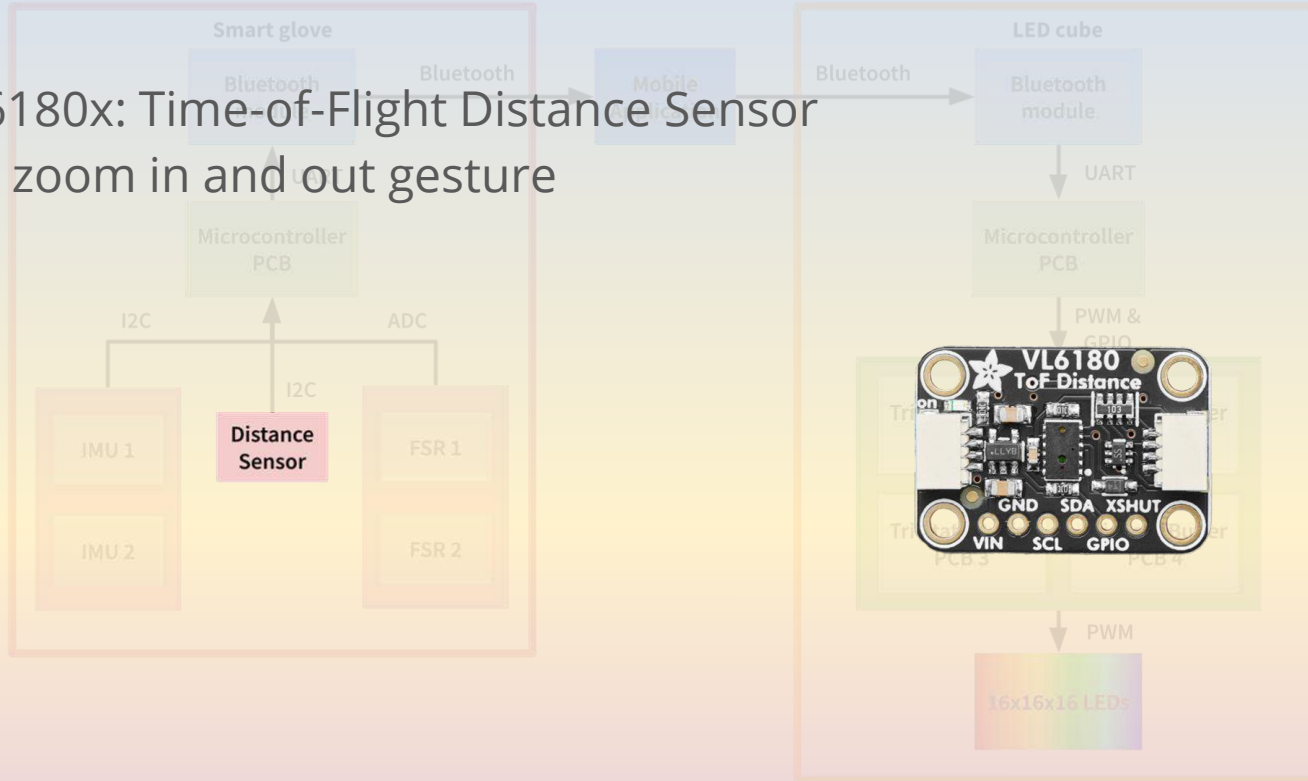
Inertial Measurement Unit (IMU)

- Adafruit BNO055 Absolute Orientation Sensor
- For rotation and shift gesture



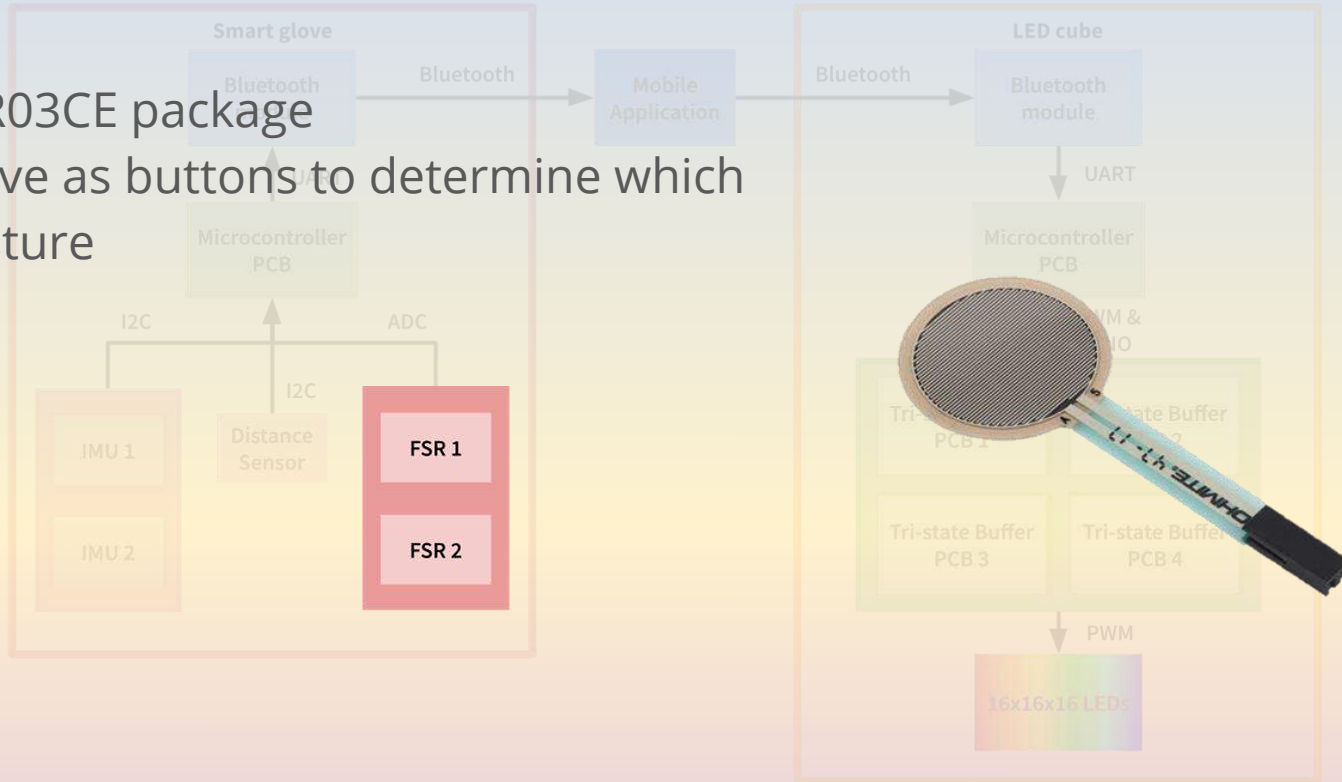
Distance Sensor

- VL6180x: Time-of-Flight Distance Sensor
- For zoom in and out gesture

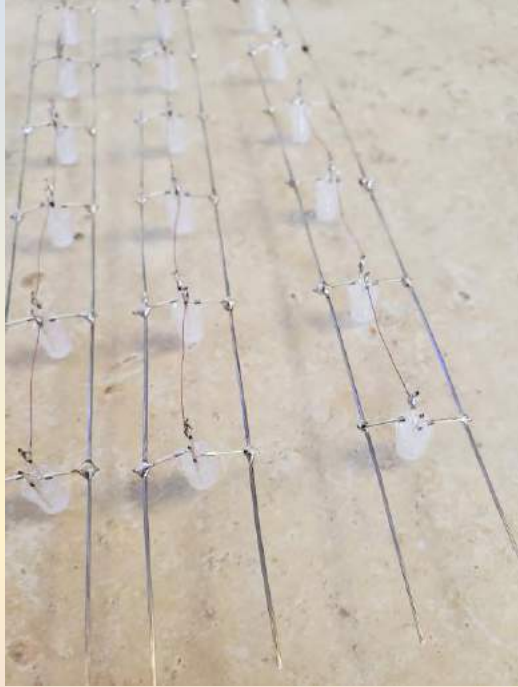


Force Sensitive Resistor (FSR)

- FSR03CE package
- Serve as buttons to determine which gesture



LED Cube Construction



LED strips



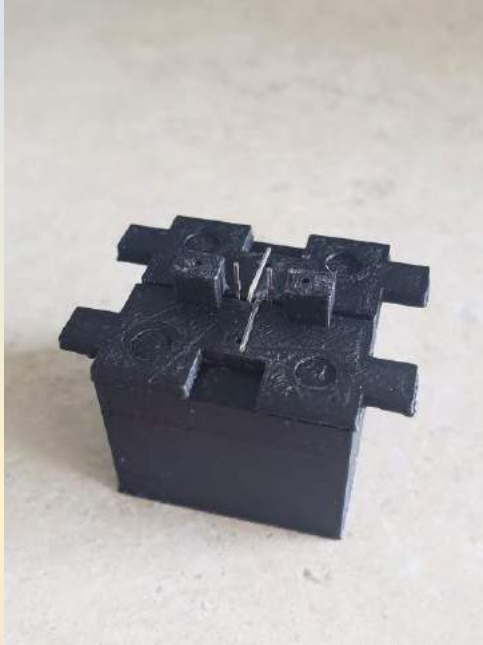
LED Matrix

Metal Sheet

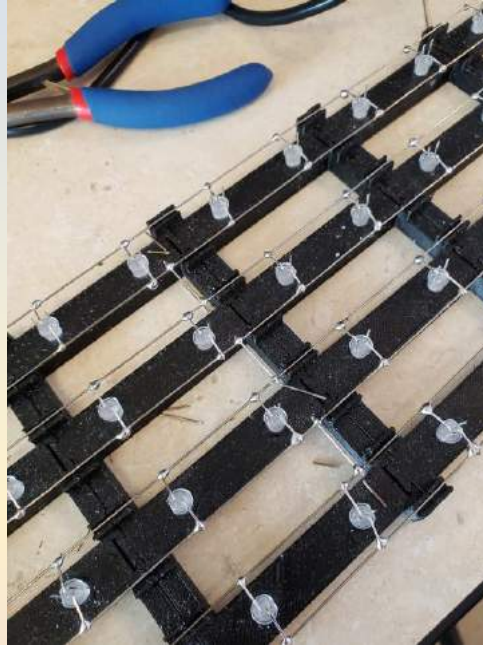
Power Supply

Circuits

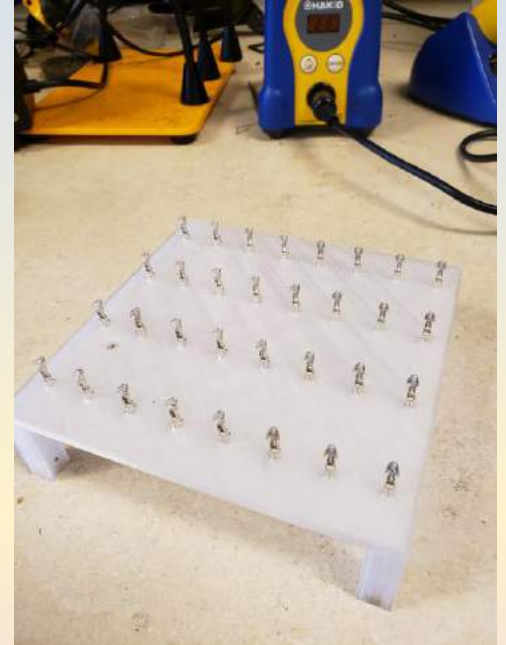
LED Cube Construction



LED bending jig

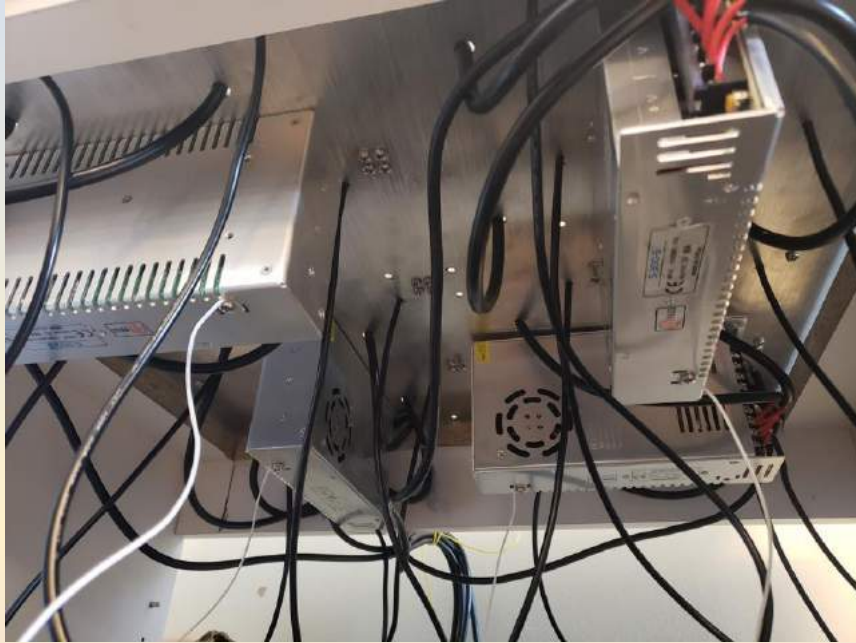


LED strip assembly

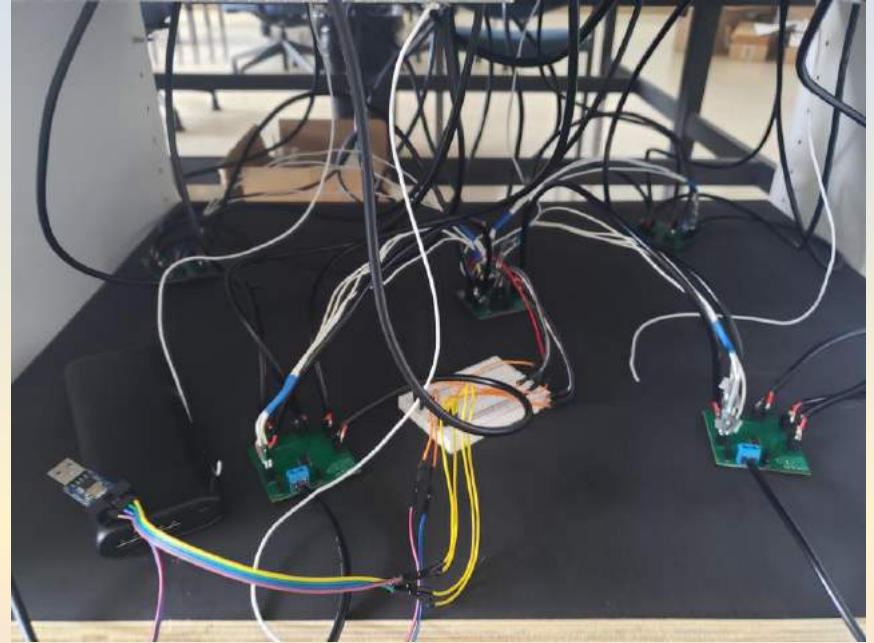


Tower base

LED Cube Construction

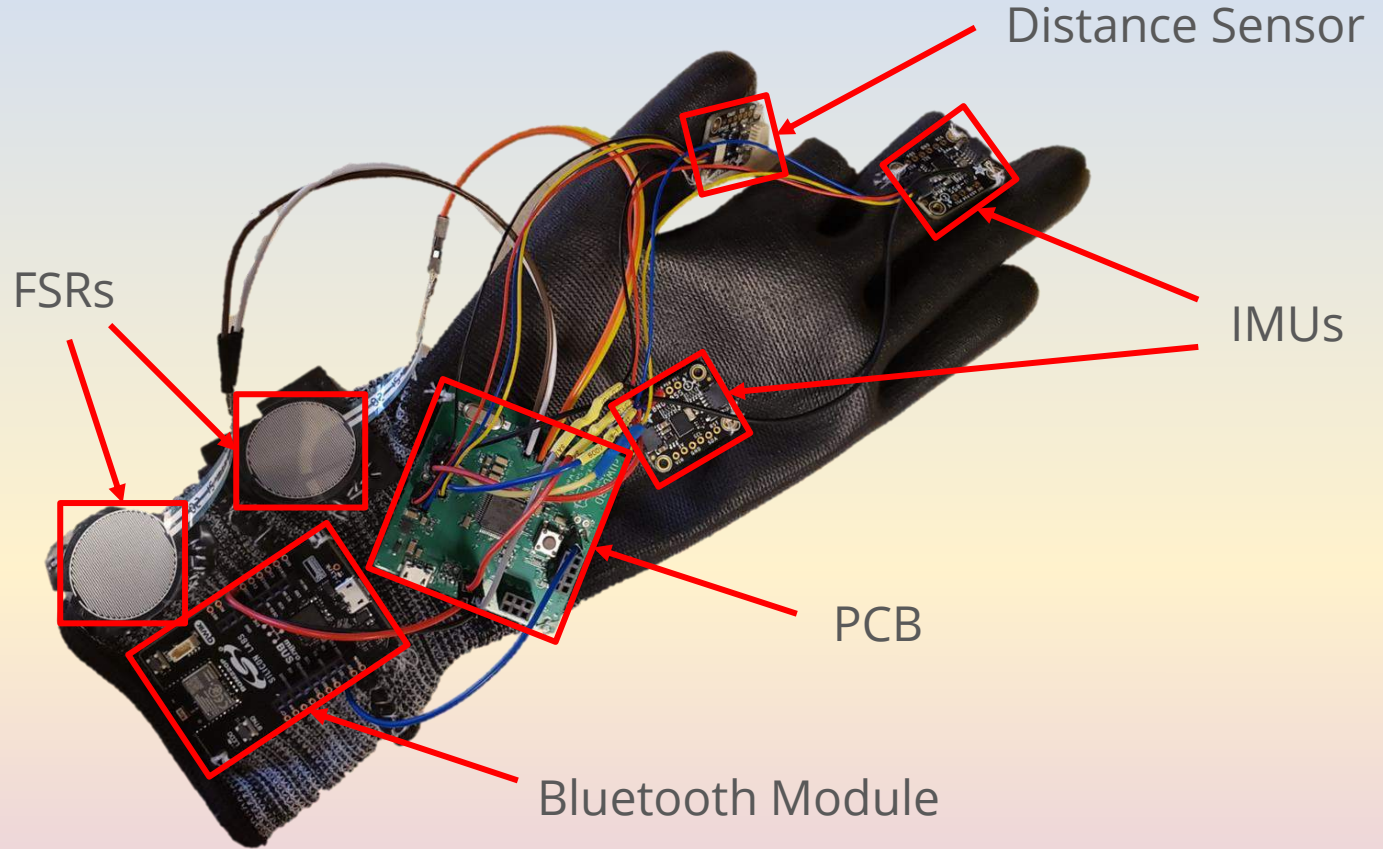


Power supplies
beneath the matrix

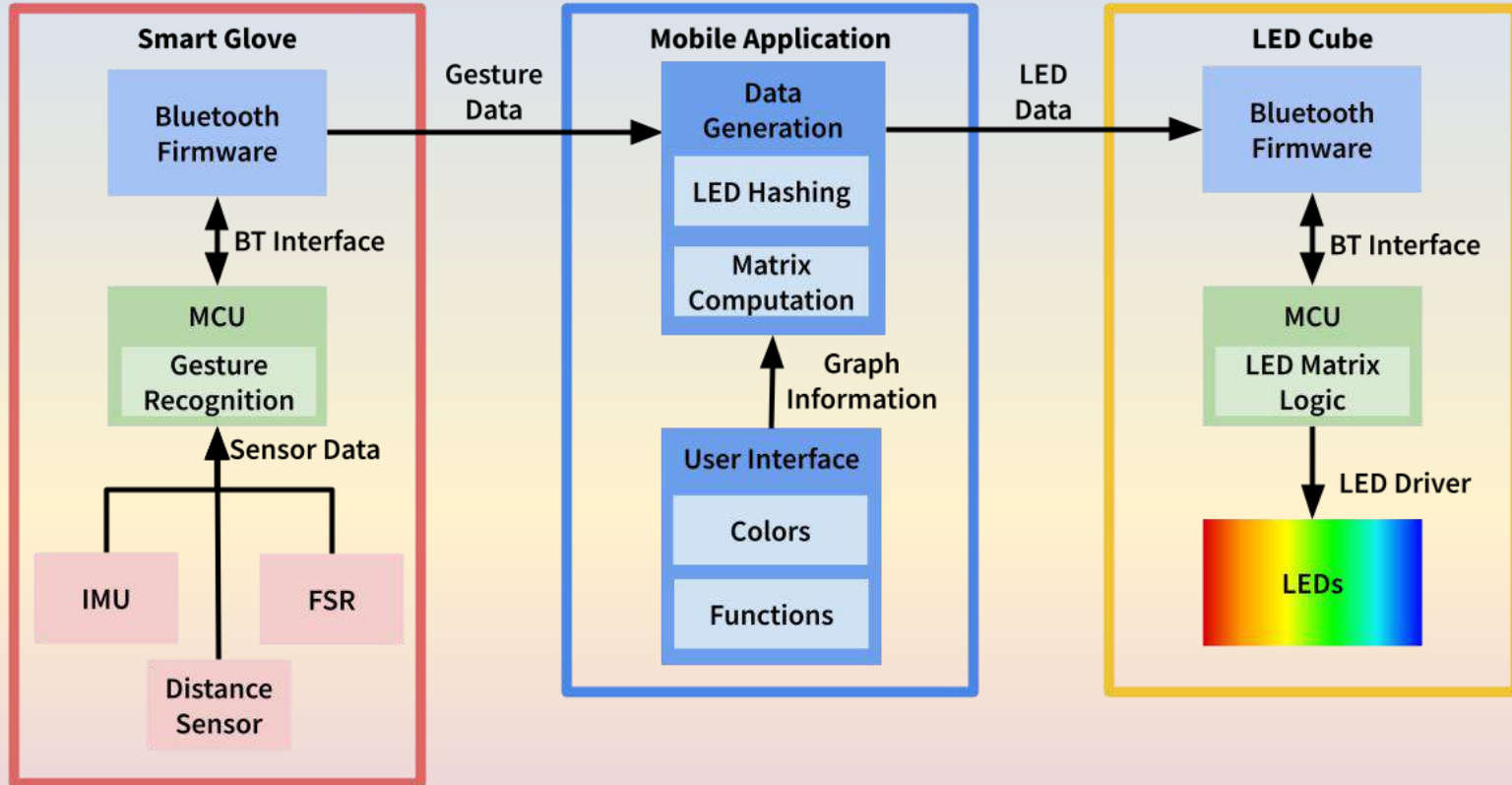


LED matrix driver
circuit

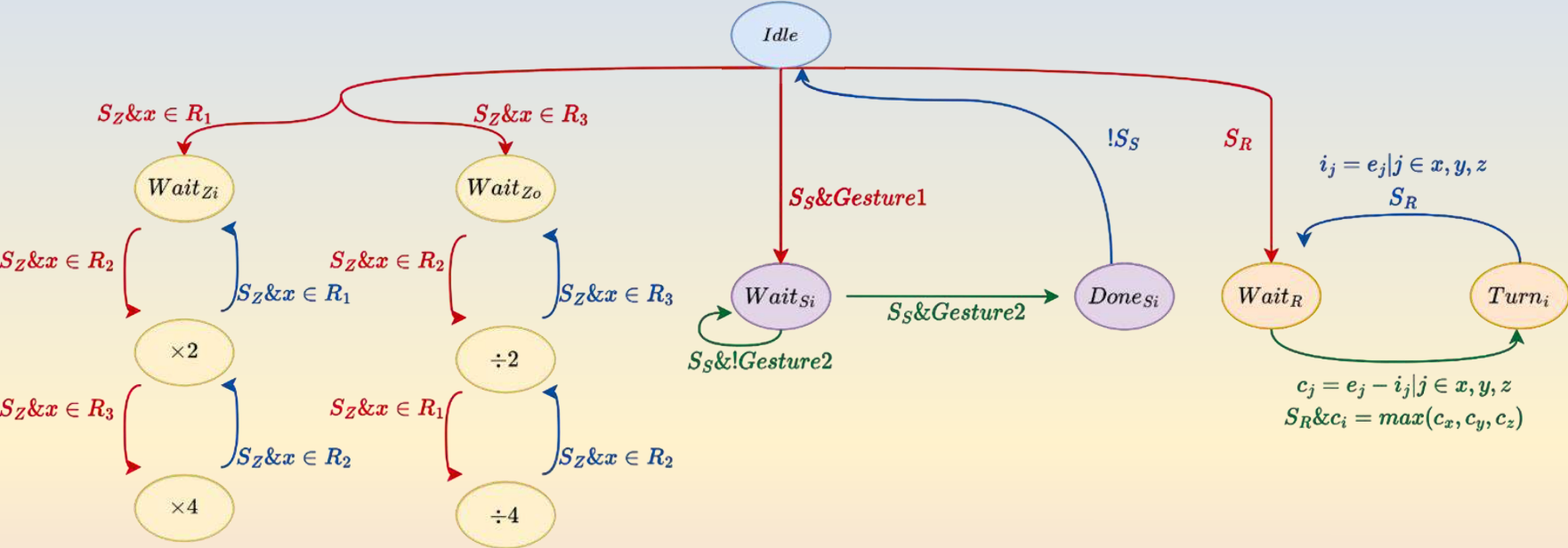
Smart Glove Construction



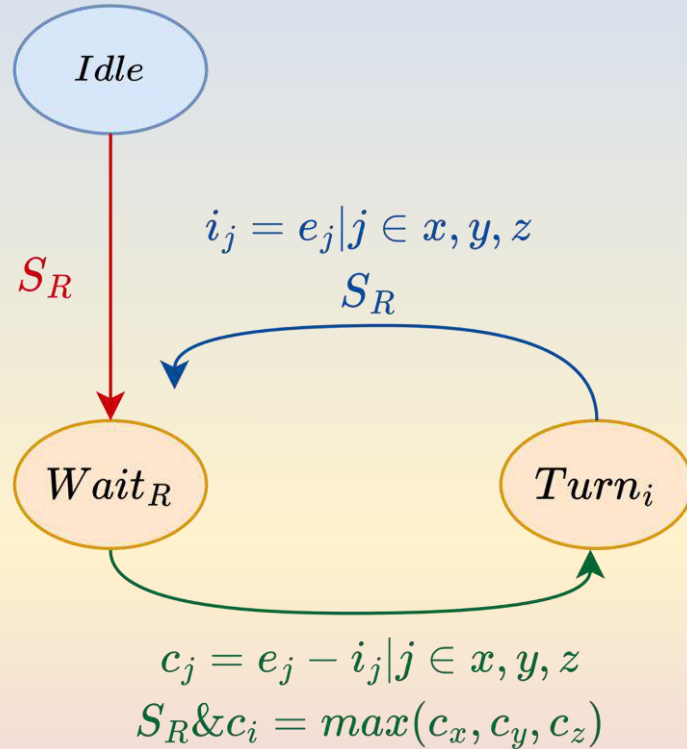
Software Flow



Smart Glove Gesture Recognition

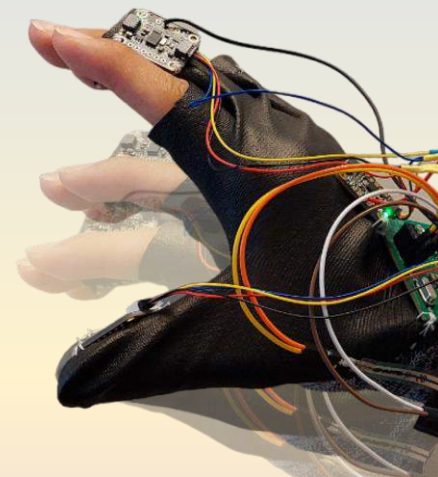
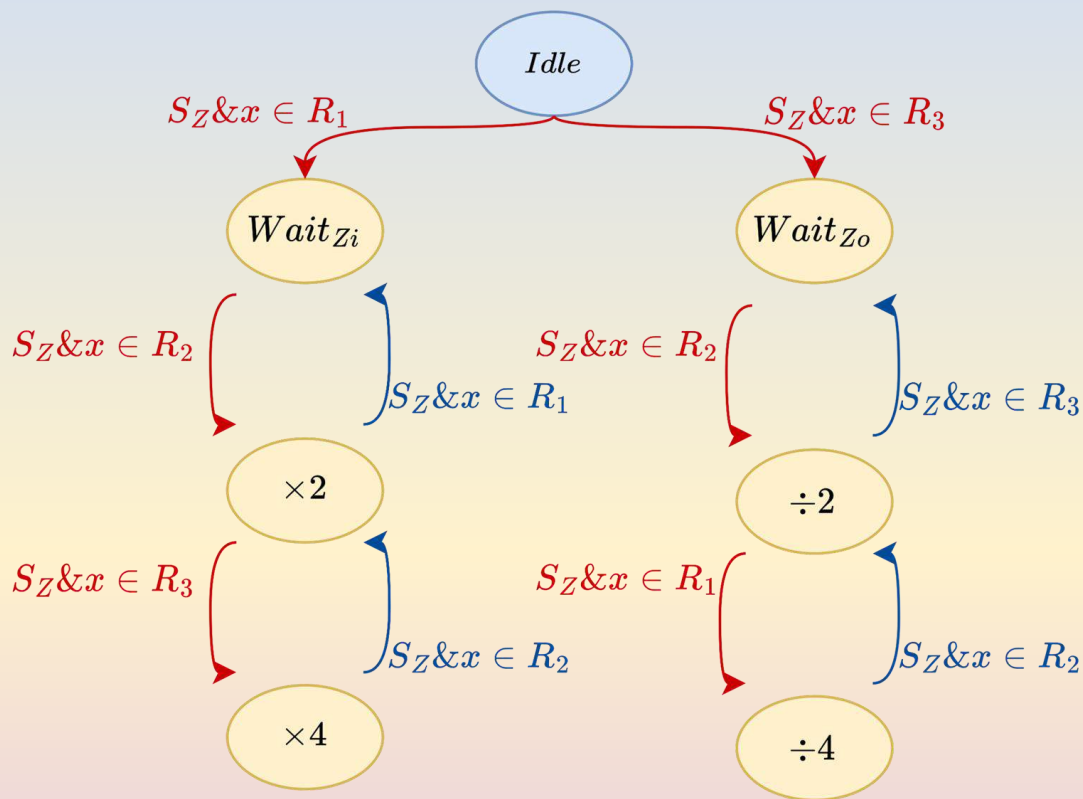


Smart Glove Gesture Recognition: Rotate

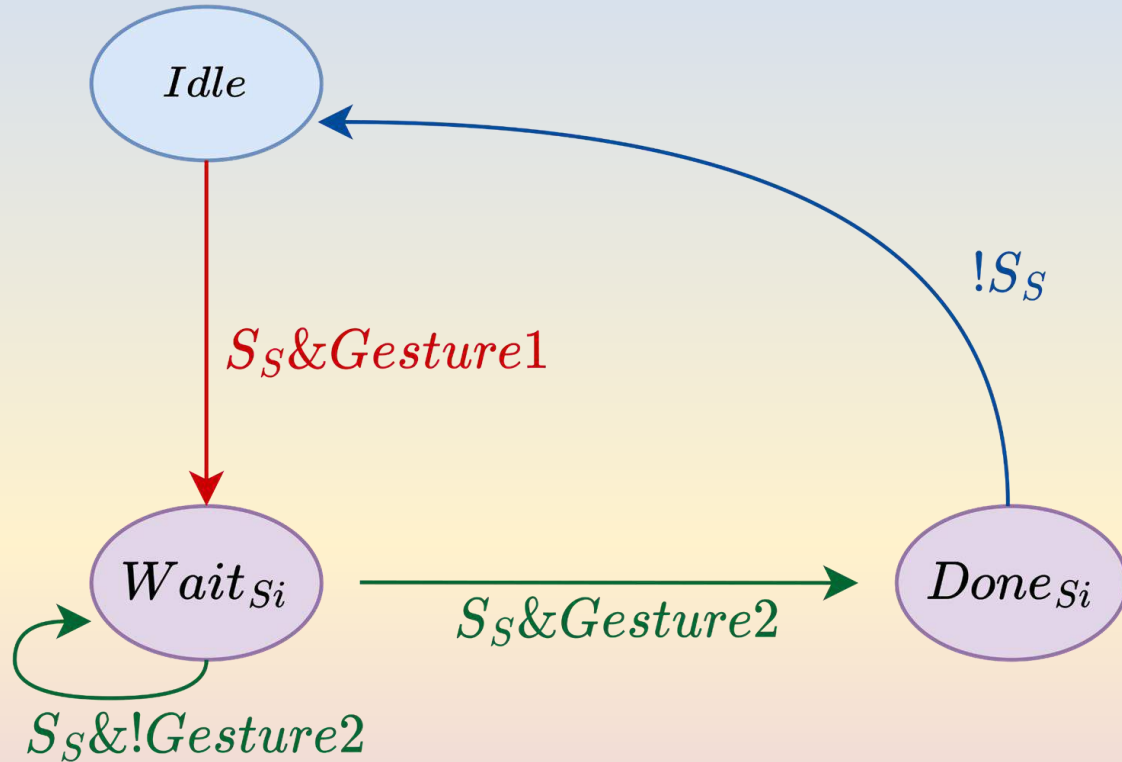


- Rotate every 10 degrees change
- 3 directions: roll, pitch and yaw

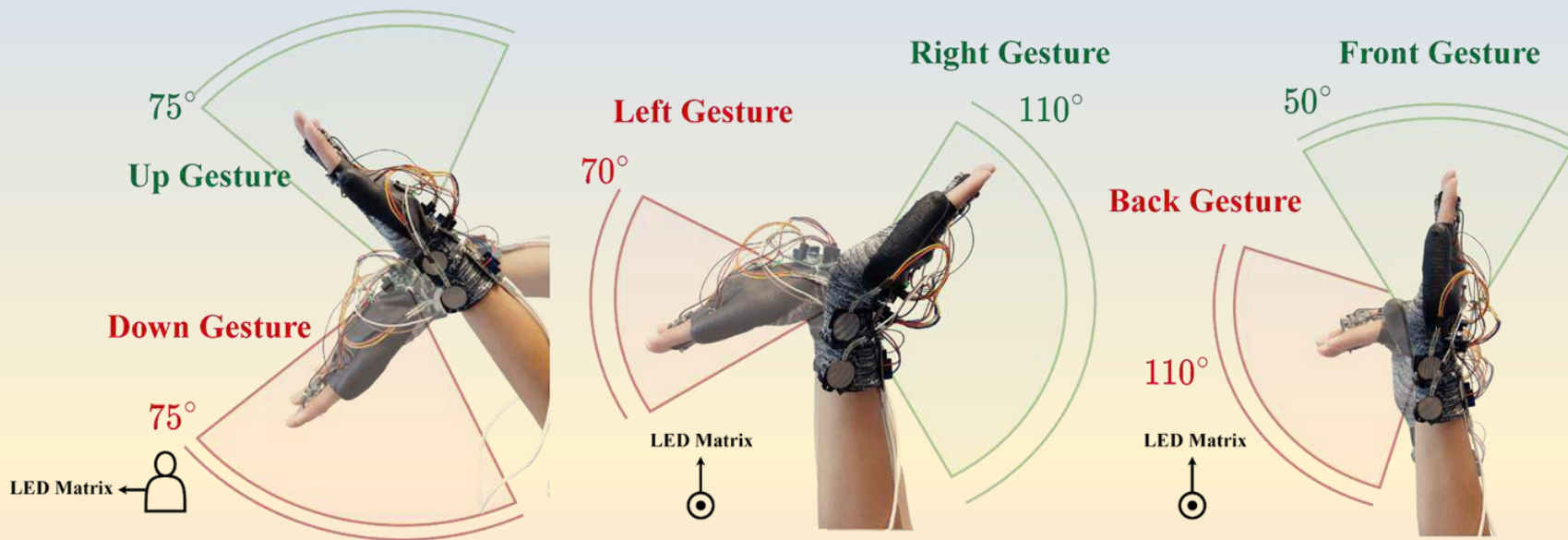
Smart Glove Gesture Recognition: Zoom



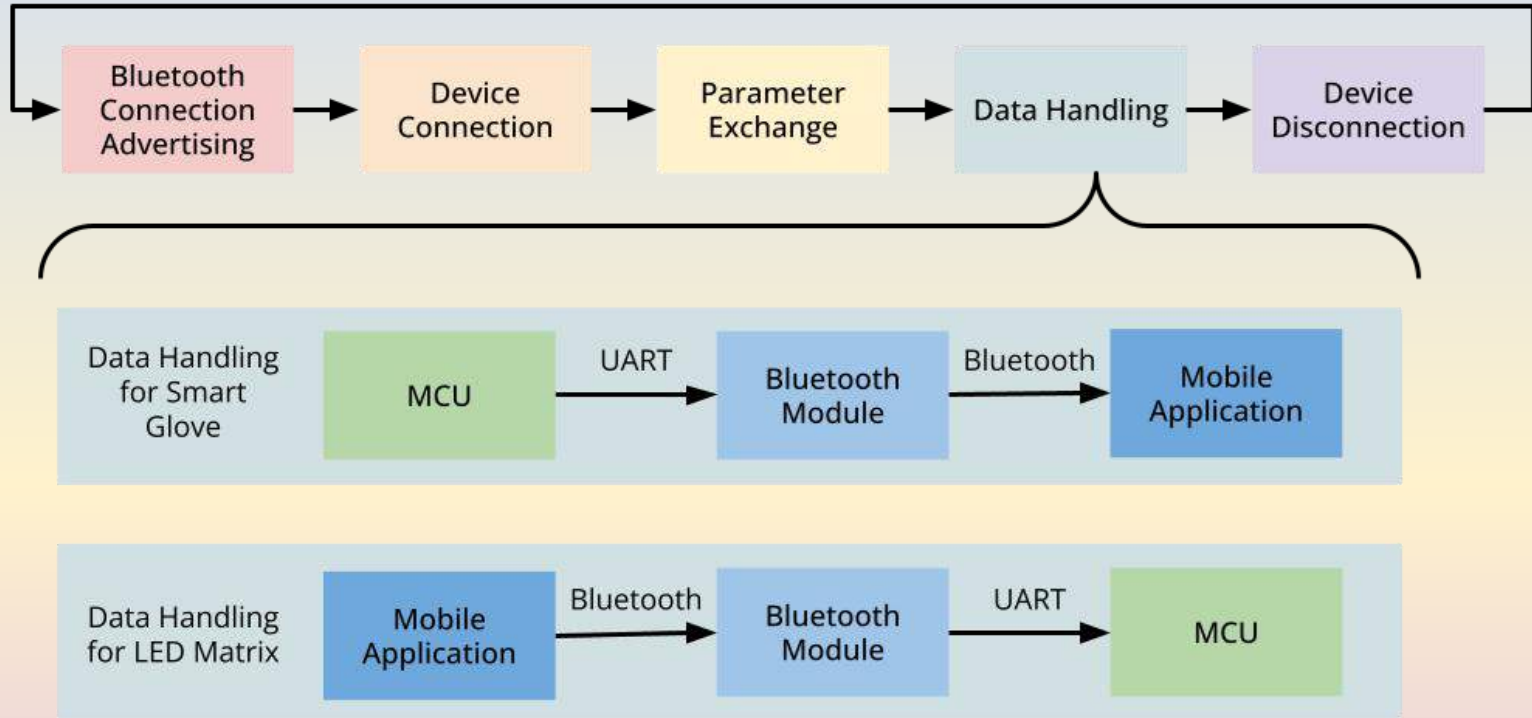
Smart Glove Gesture Recognition: Shift



Smart Glove Gesture Recognition: Shift



Bluetooth Module Firmware

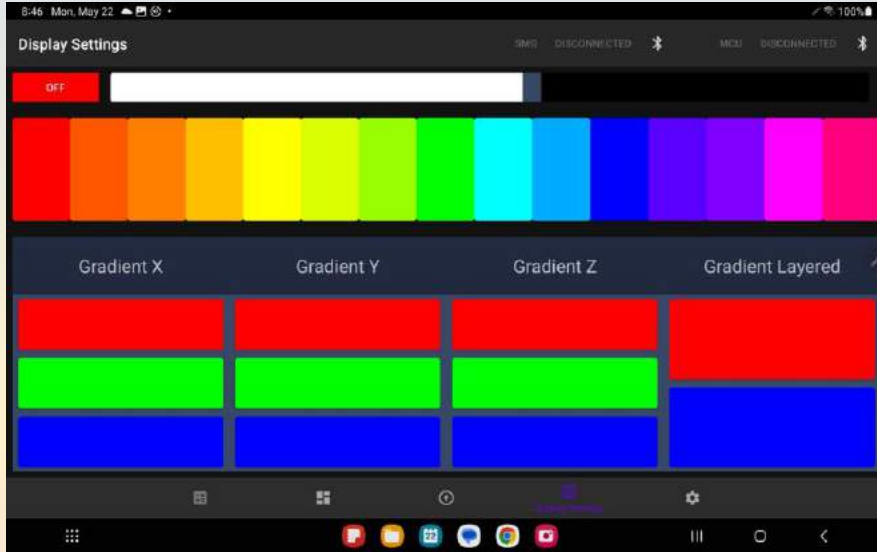


Mobile Application: Math Logic



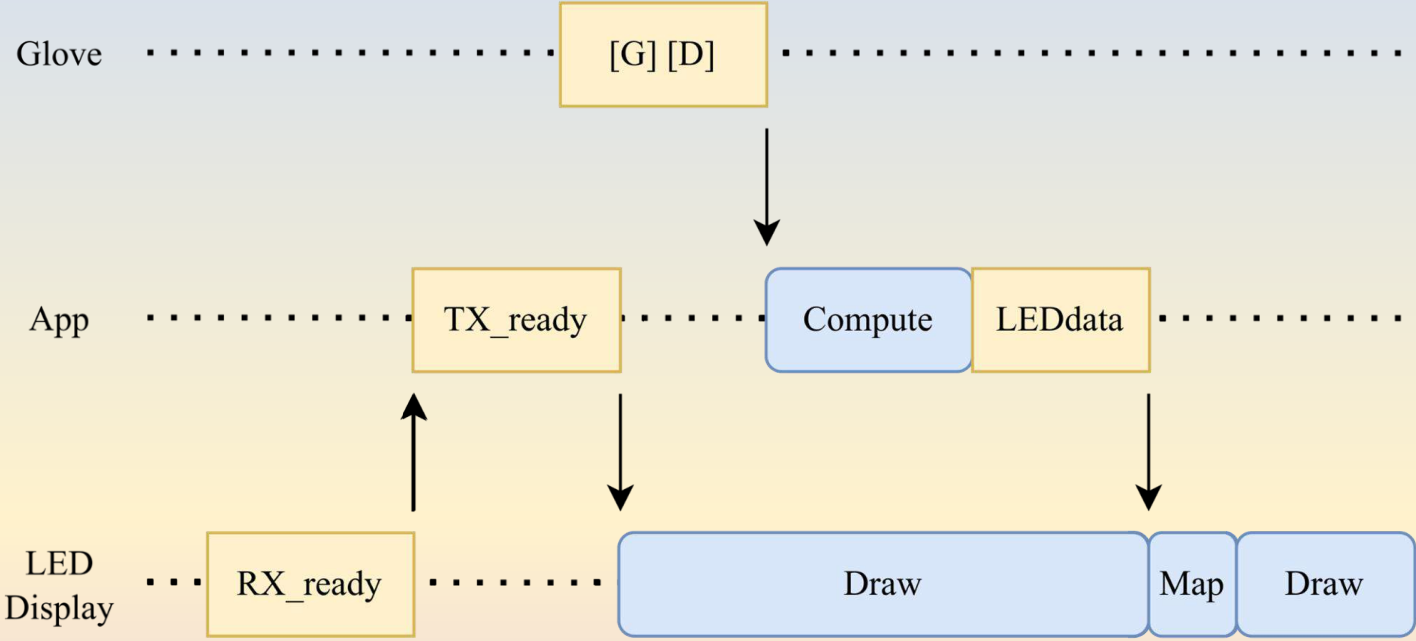
- Function provided by user
- Algorithm iterates through x and y values within the chosen resolution
- Root finding algorithm evaluates the function at each (x, y)
- Round z value to nearest pixel

Mobile Application: Data

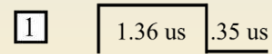
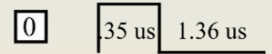
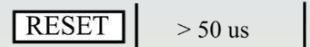
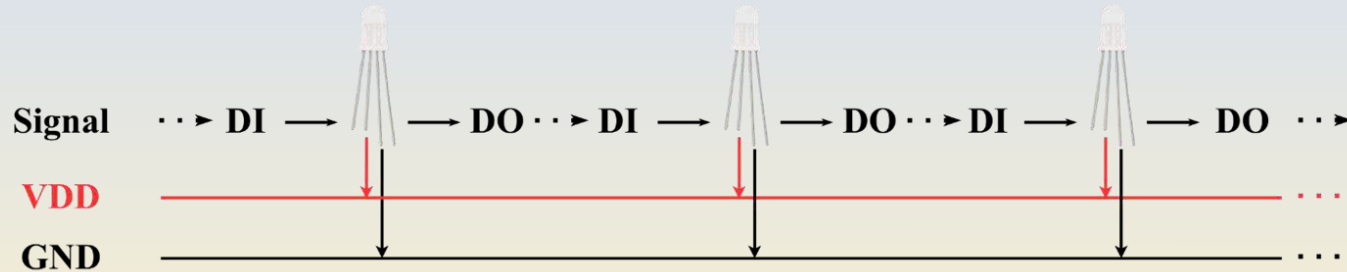


- Users can choose color scheme
- Byte array is mapped to format for LED Matrix Driver
- Byte array can be compressed 2x

Mobile Application: Handshake with LED Cube

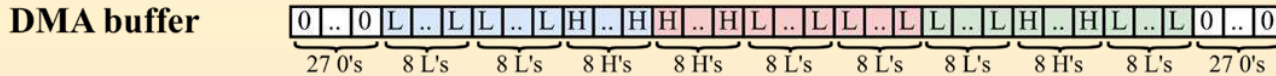
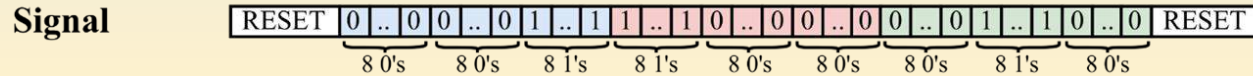


LED Matrix Driver: PL9823 LED Control



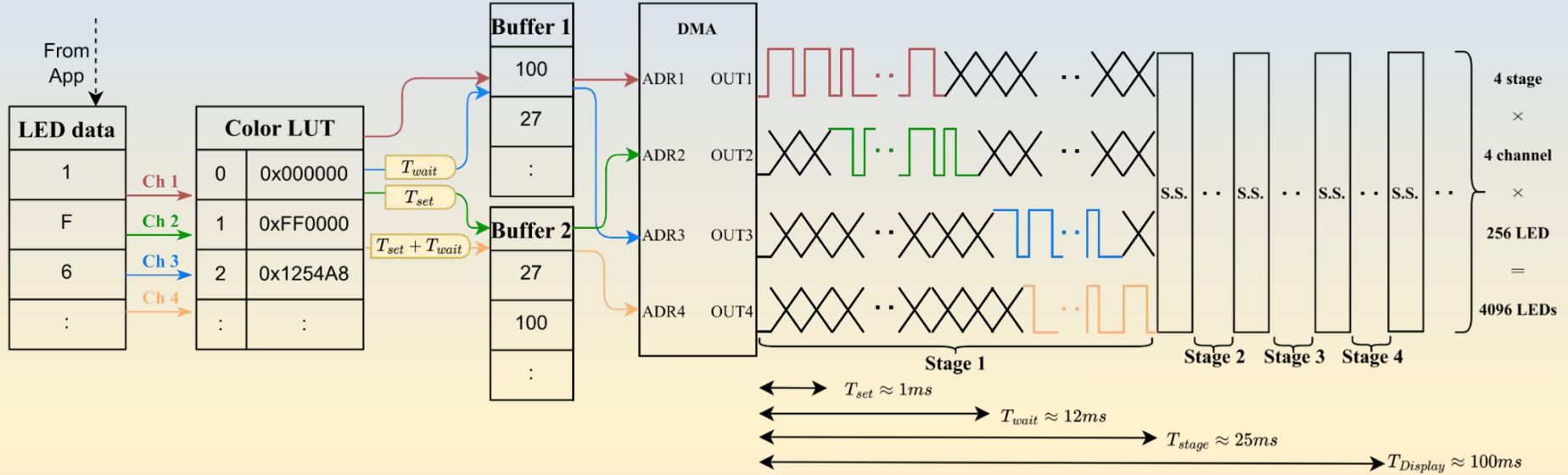
E.g.:

Blue(0x0000FF) Red(0xFF0000) Green(0x00FF00)

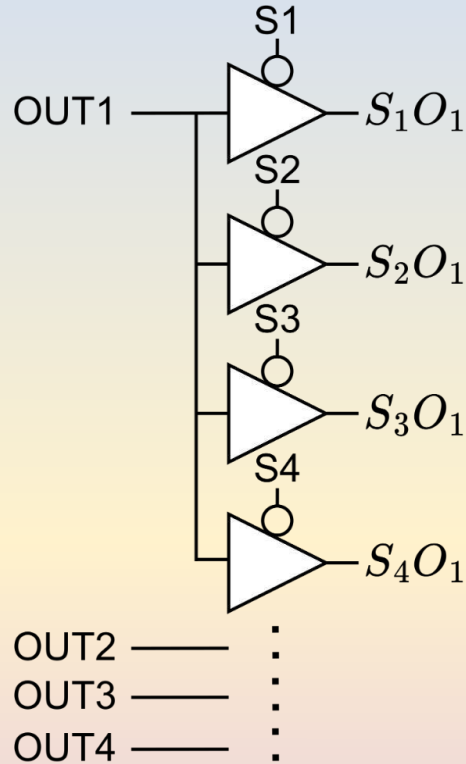


L = 27, H = 100

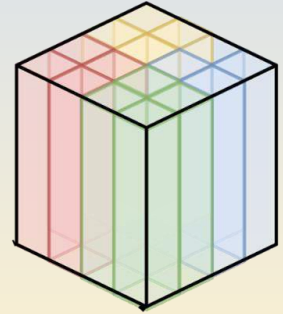
LED Matrix Driver: Data Flow and Timing



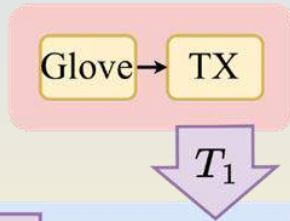
LED Matrix Driver: Tri-State Buffer Control of Matrix



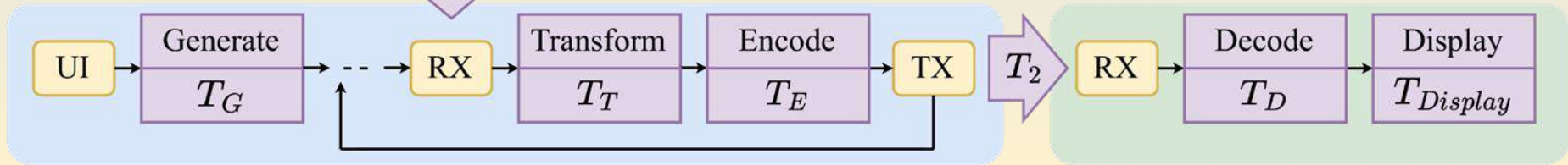
$S_4 O_4$	$S_3 O_4$	$S_4 O_3$	$S_3 O_3$
$S_1 O_4$	$S_2 O_4$	$S_1 O_3$	$S_2 O_3$
$S_4 O_1$	$S_3 O_1$	$S_4 O_2$	$S_3 O_2$
$S_1 O_1$	$S_2 O_1$	$S_1 O_2$	$S_2 O_2$



Gesture Response Time



$$T_{Total} = T_1 + T_T + T_E + T_2 + T_D + T_{Display}$$



	Preset shapes	User-defined equations
Rotate	260 ms	260 ms
Shift / Zoom	260 ms	350 ms ~ 1 s

HANDLEED

Acknowledgements

Yogananda Isukapalli

Teaching Assistants:

Venkat Krishnan, Jimmy Kraemer,
Alex Lai

Cube Assembly Help:

Christopher Wimmel, Adam Yu,
Simon Yu, Michael Cheng

Malt Whiskey

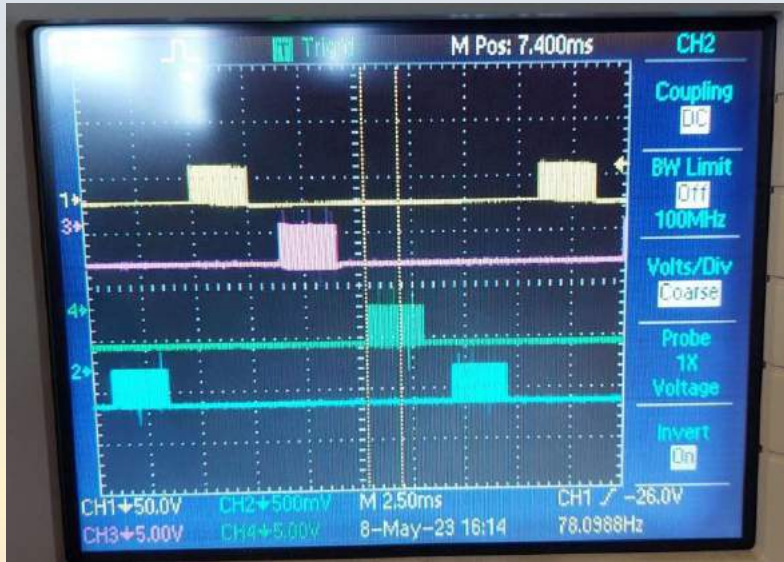


Questions?

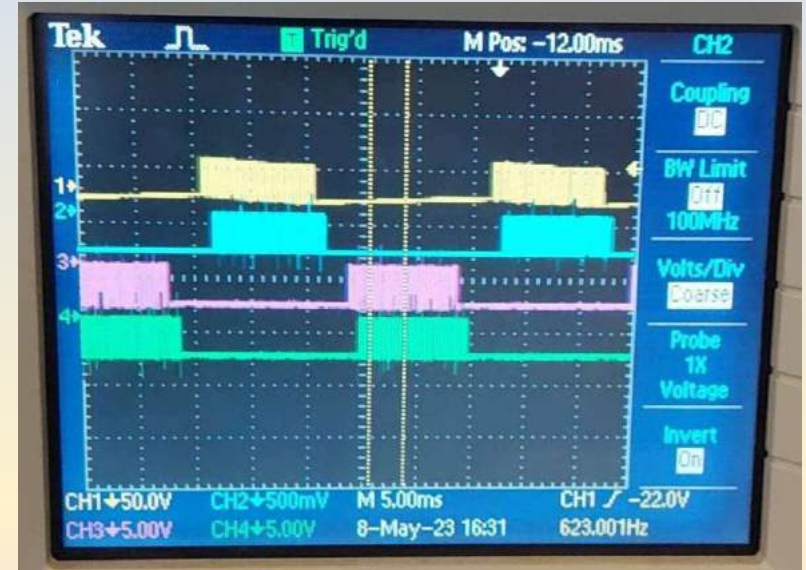
Power Consumption for 0xFFFFFFFF

	1 PL9823 LED		4096 PL9823 LEDs	
	Current	Power	Current	Power
0% brightness	~ 8 mA	~ 0.04 W	~ 32 A	~ 160 W
30% brightness	~ 18 mA	~ 0.09 W	~ 73 A	~ 365 W
50% brightness	~ 27 mA	~ 0.135 W	~ 110 A	~ 550 W
100% brightness	~ 53 mA	~ 0.265 W	~ 217 A	~ 1.08 kW

LED Matrix Driver: Buffer Optimization

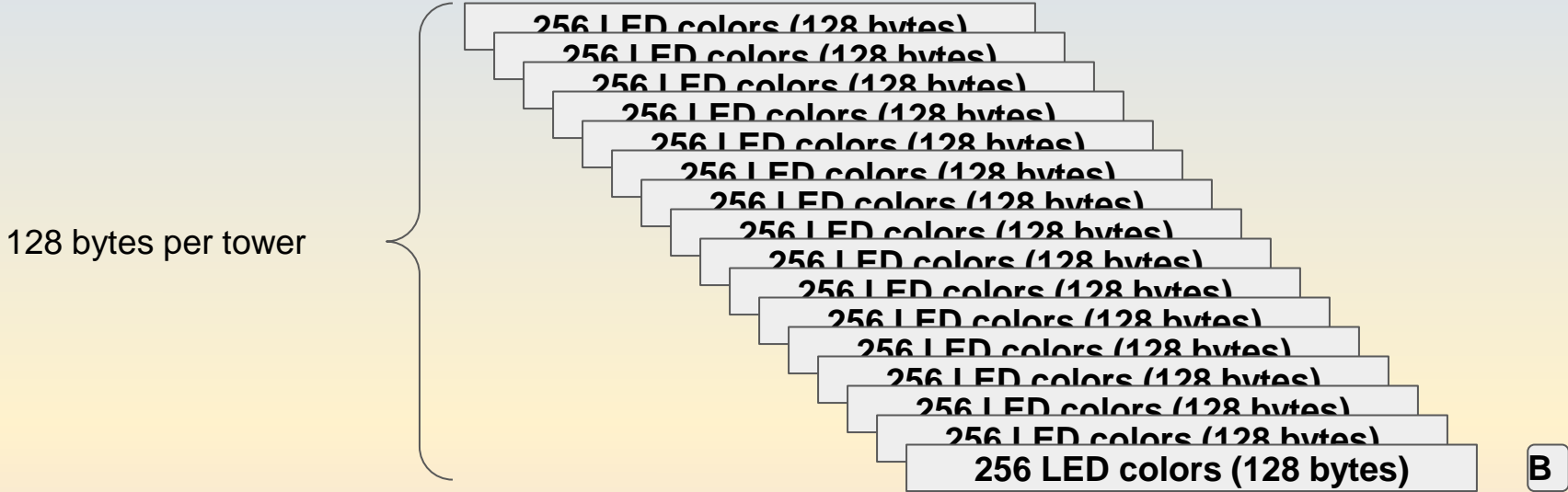


One DMA buffer present



Two DMA buffer present

Brightness Control Detail



Total data size: 2049 bytes

Choose of MicroController - STM32L412RBT6

- STM32 low-power series
- 40 KB RAM
 - DMA buffers for LED transfer takes up 12KB memory each.
- 2 ADCs