

Data Sensing and Collection Using Raspberry Pi

Ruoxin Xiong, Ph.D.

Assistant Professor of Construction Management

rxiong3@kent.edu

Spring 2025

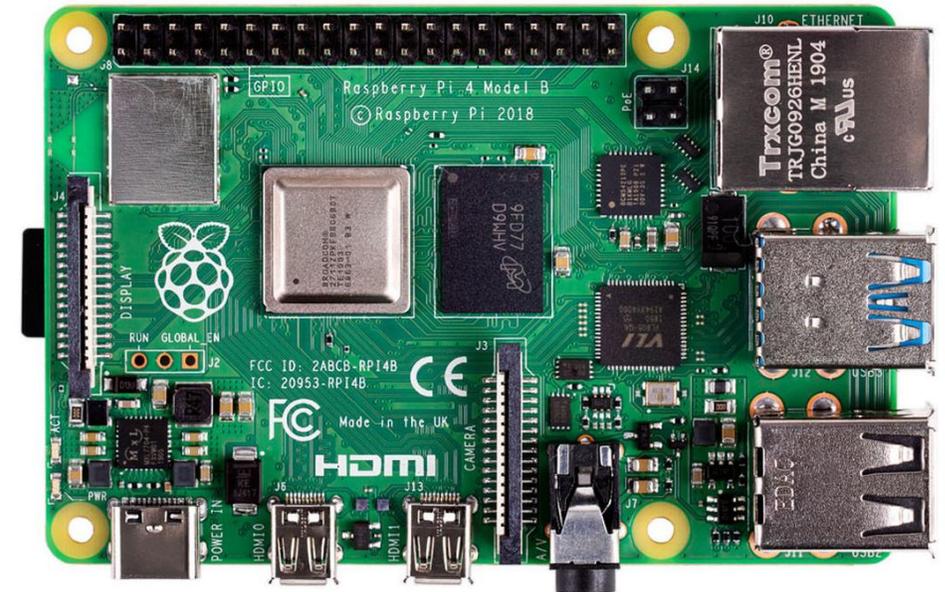
Learning Objectives

- Identify Essential Hardware and Software
- Implement Data Logging Techniques
- Integrate Networking for Remote Data Collection
- Design a Simple End-to-End Data Collection Project for Built Environment

What is Raspberry Pi

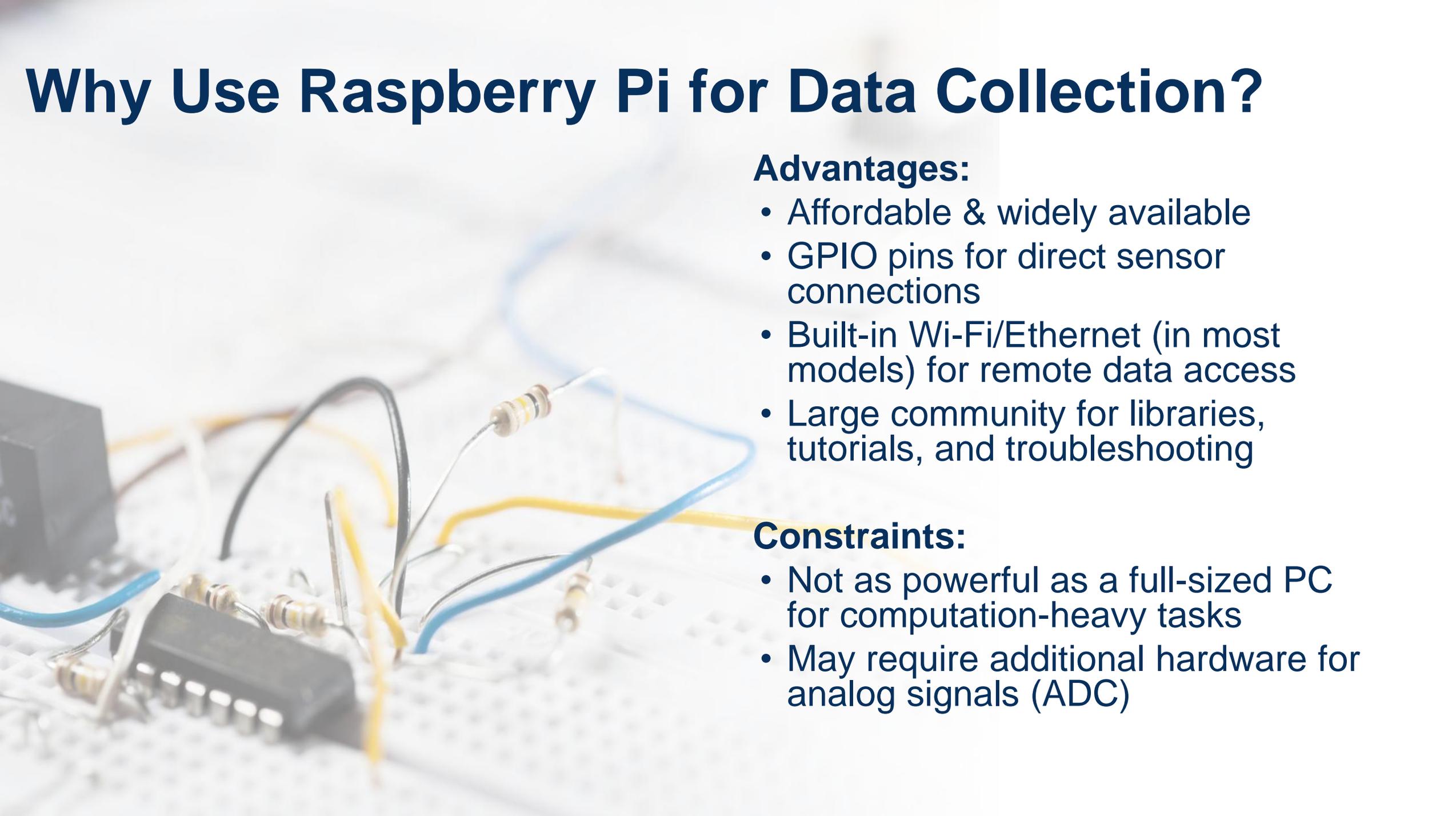
- **A small, affordable single-board computer**
 - e.g., Raspberry Pi Compute Module 5 (Wireless, 4GB RAM, 32GB eMMC) ~\$70.00
- **Key Features:**
 - General Purpose Input/Output (GPIO) pins
 - Linux-based operating system (e.g., Raspberry Pi OS)
 - Broad software & community support
- **Models:**
 - Raspberry Pi 5
 - Raspberry Pi 4
 - Raspberry Pi 3 Model B/B+
 - Raspberry Pi Zero, Zero W

No liquids and no drops!



Take care of the device!

Why Use Raspberry Pi for Data Collection?



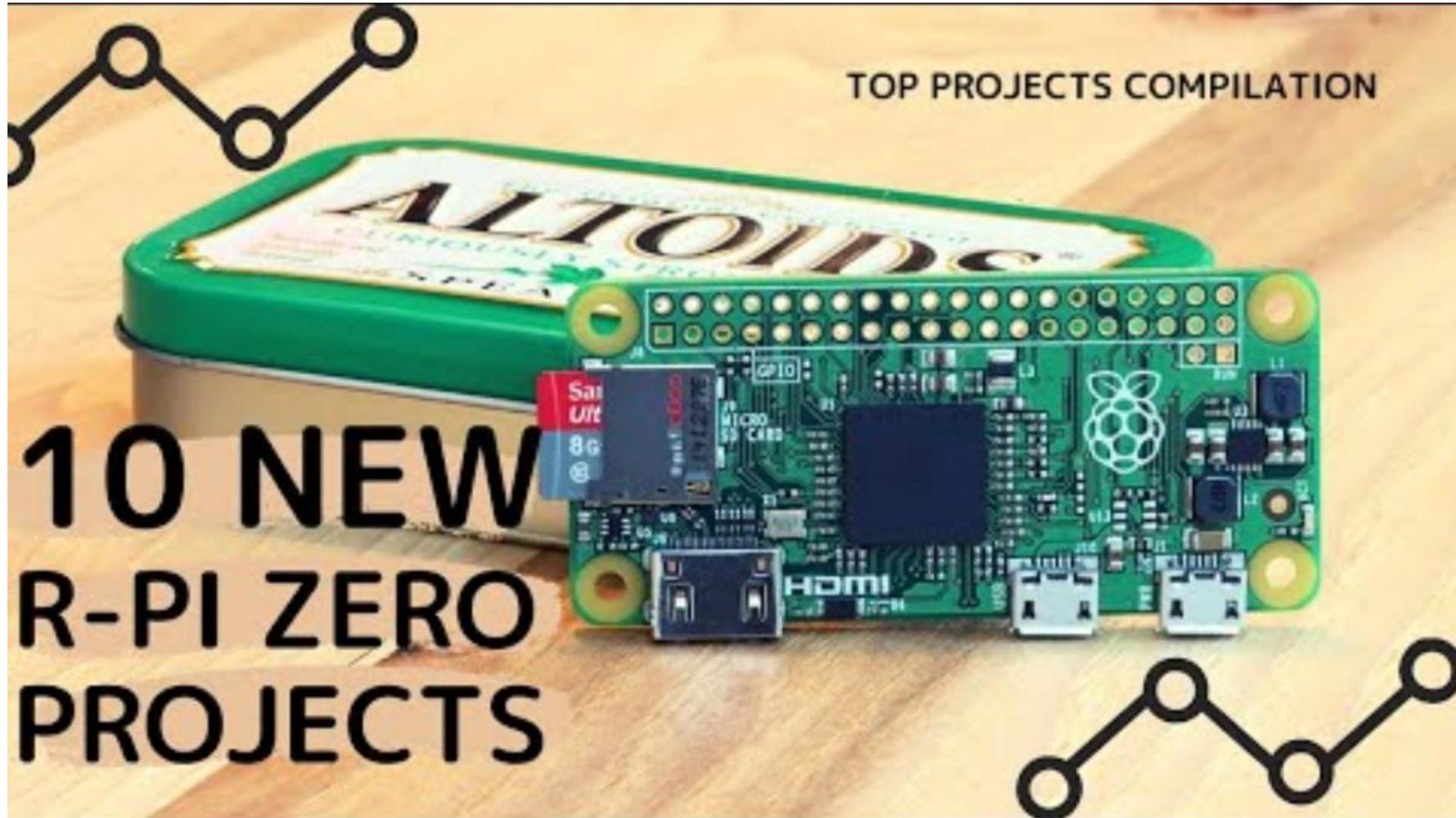
Advantages:

- Affordable & widely available
- GPIO pins for direct sensor connections
- Built-in Wi-Fi/Ethernet (in most models) for remote data access
- Large community for libraries, tutorials, and troubleshooting

Constraints:

- Not as powerful as a full-sized PC for computation-heavy tasks
- May require additional hardware for analog signals (ADC)

Some Cool Projects



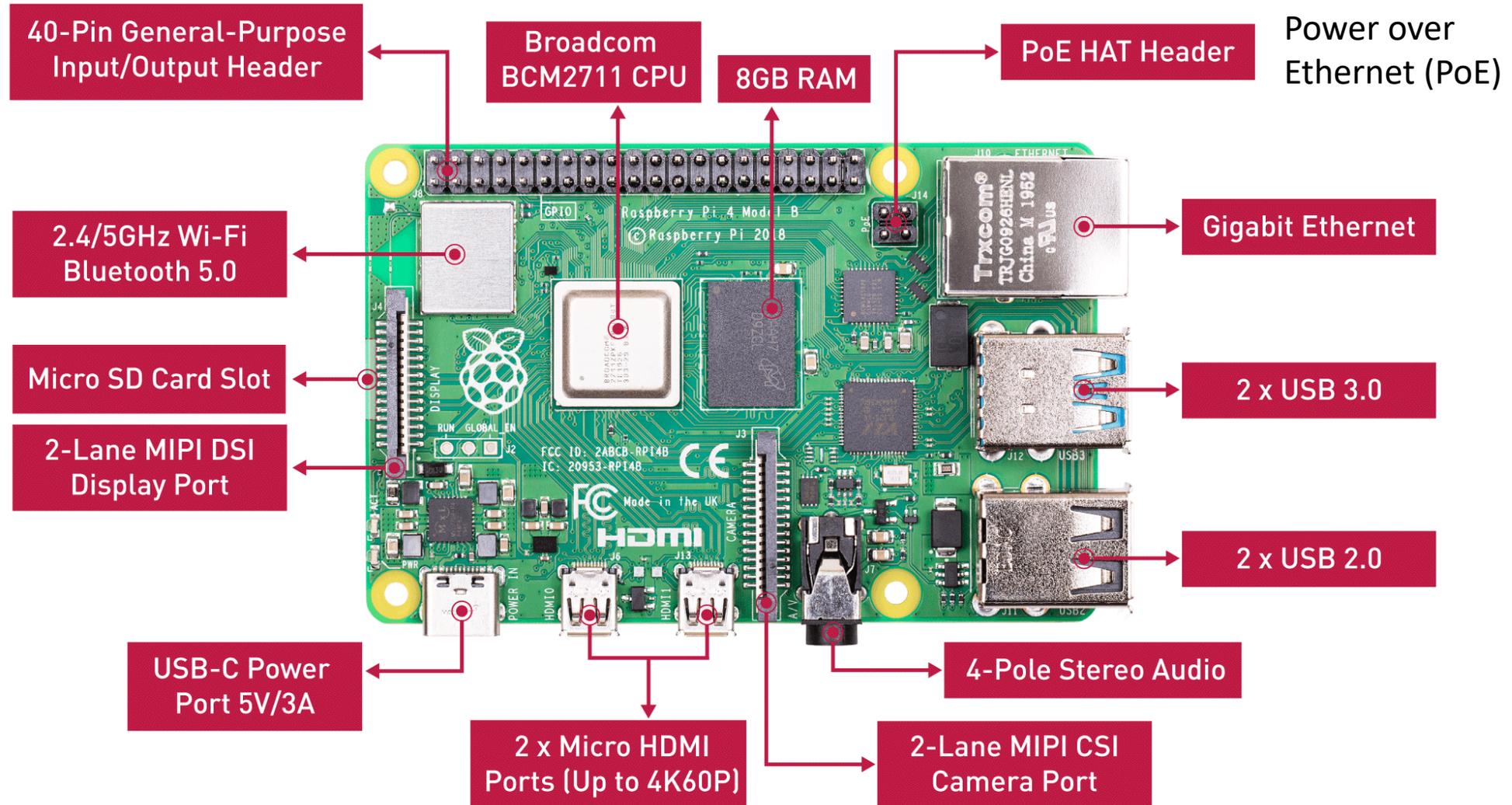
Advanced Topics

- Machine learning on Pi (TensorFlow Lite, etc.)
- Real-time edge computing with Pi clusters
- Low-power sensor networks (LoRa, Zigbee)
- Build robots with AI

Advanced Topics



Setting Up the Raspberry Pi



Setting Up the Raspberry Pi

Hardware Setup:

- MicroSD card with Raspberry Pi OS (32 GB or larger recommended)
- Power supply (5V, 2-3A depending on model)
- Keyboard, mouse, monitor (optional if not **headless**)

Software Setup:

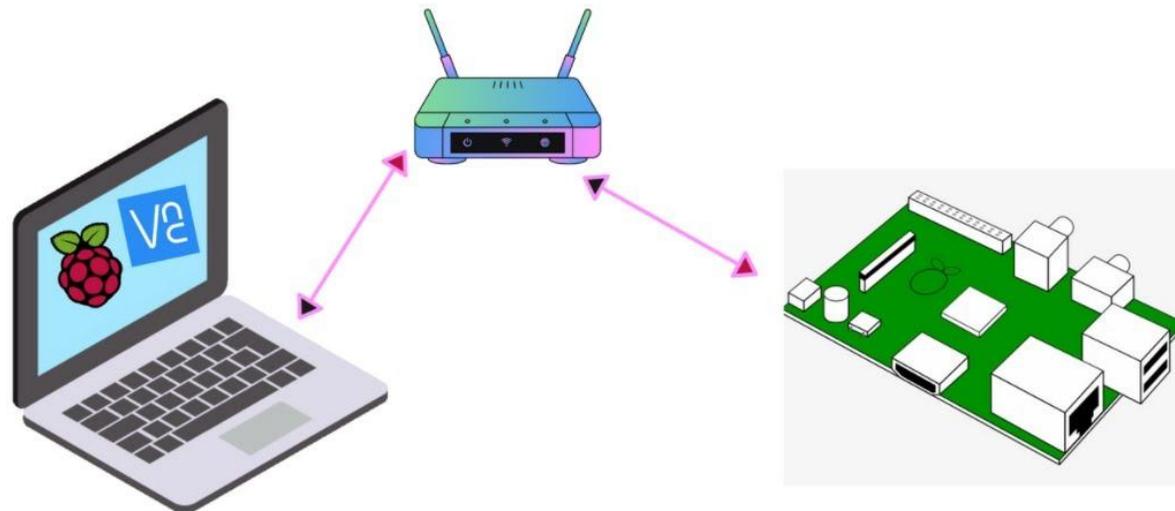
- Configure **Wi-Fi, VNC, & Secure Socket Shell (SSH)** if using headless setup
- Keep system updated:

```
`` sudo apt-get update sudo apt-get upgrade ``
```

Virtual Network Computing (VNC) connection

- Allows a user to remotely control another computer
- Share the remote computer's screen, keyboard, and mouse over a network
- Two computers that are located on the **same local area network (LAN)**

Virtual Network Computing



Setting up a Raspberry Pi headless

Virtual Network Computing (VNC) connection

- **How to set up a VNC connection**

- Download the **Realvnc viewer** app

https://www.realvnc.com/en/connect/download/viewer/?lai_vid=QX0wR9aMrTdjQ&lai_sr=5-9&lai_sl=1&lai_p=1

- Select the remote computer.
- Authenticate using the system username and password for the remote computer.

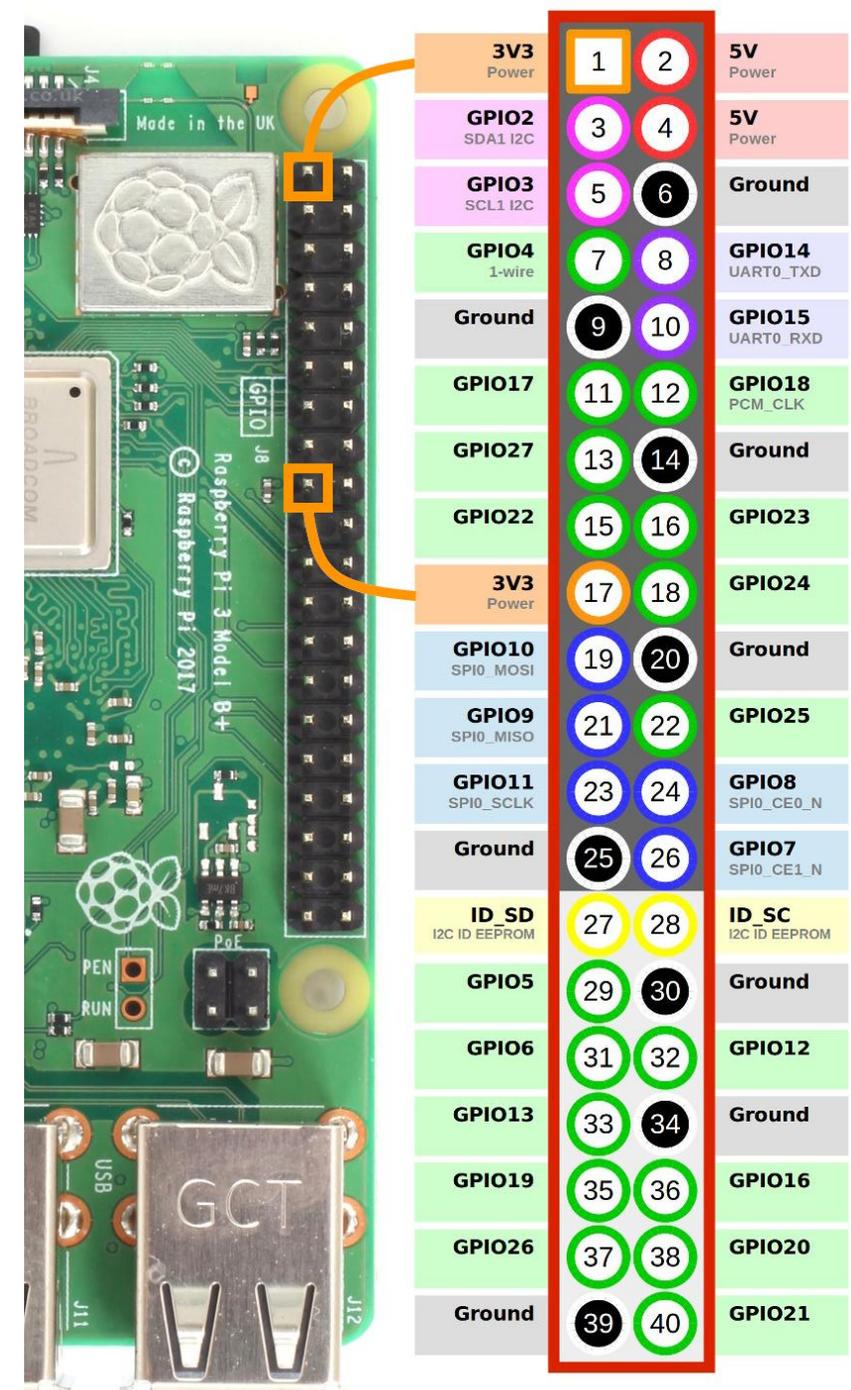
- **Requirements**

- **IP Address:** read from the Wi-Fi connection or `ping -4 raspberrypi.local`
- **username:** dihub
- **passcode:** dihub123

Let's try the VNC connection!

Introduction to GPIO

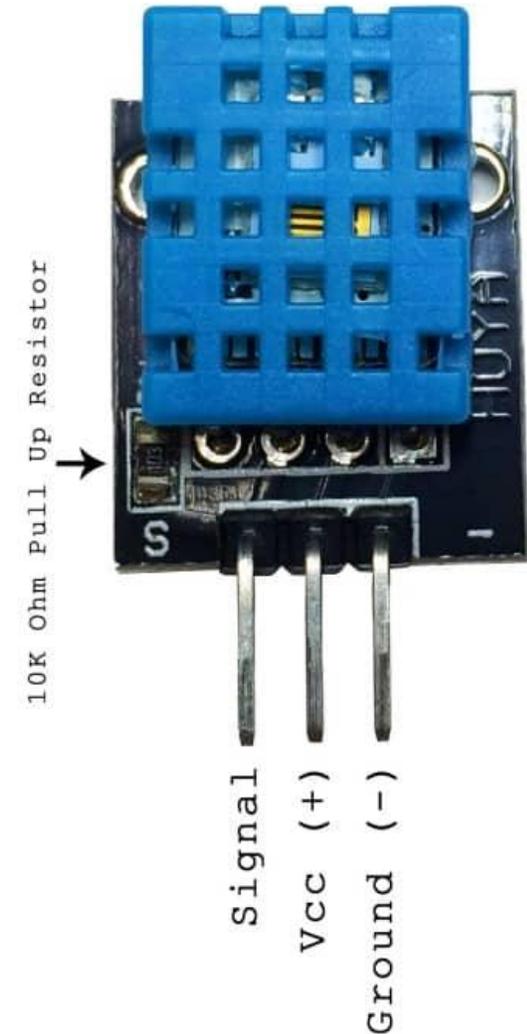
- **General Purpose Input/Output (GPIO) pins** for interacting with external devices
- **Pin Layout (40-pin header) with:**
 - **GPIO pins:** Digital I/O
 - **Power pins:** 3.3V, 5V, ground
 - **Communication protocols (will not be covered):** SPI, I²C, UART



Common Sensors and Interfaces

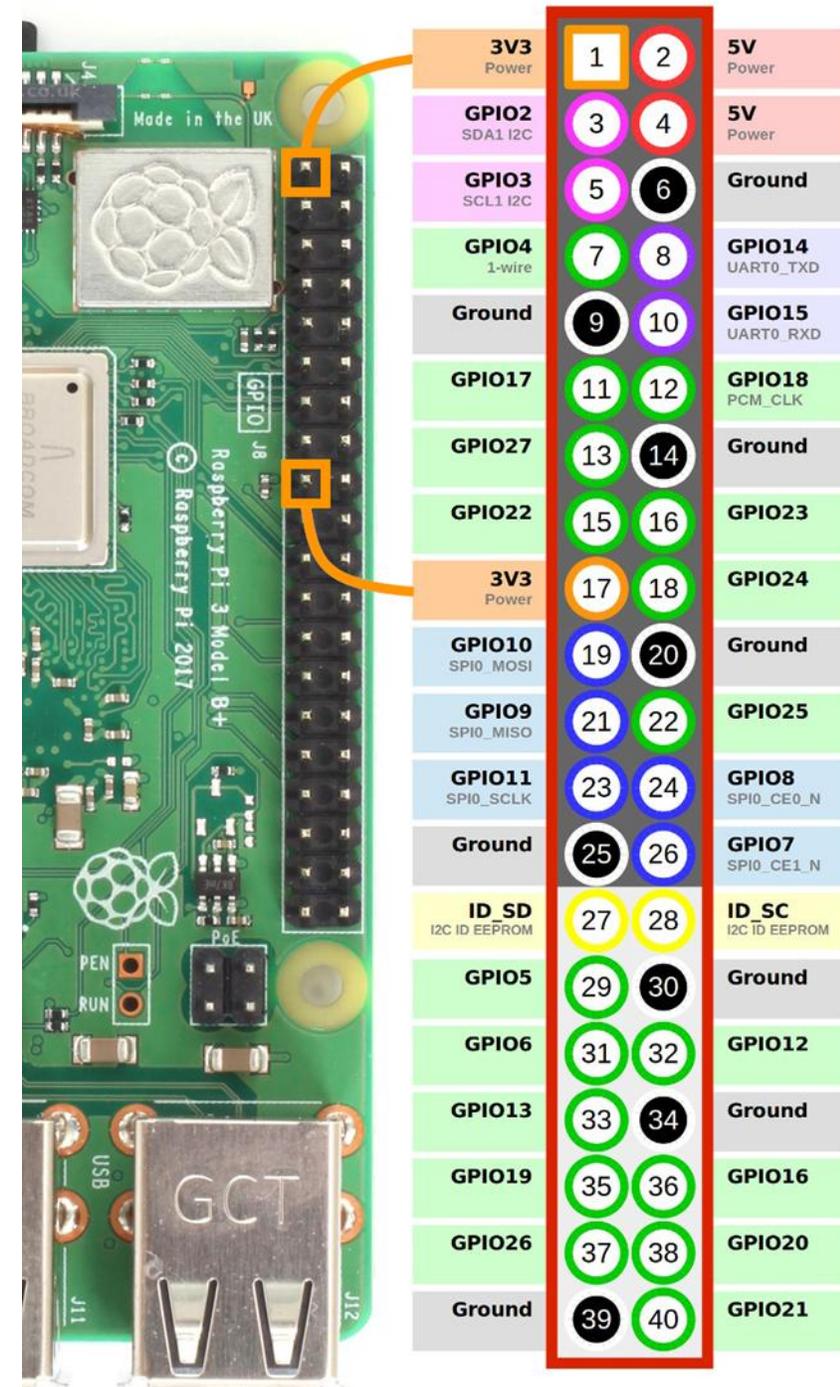
- **Digital Sensors:**
 - DHT11 / DHT22 (temperature & humidity)
 - Passive infrared (PIR) motion sensor (digital output)
 - Ultrasonic distance sensors (HC-SR04)

- **Analog Sensors (require analog-to-digital converter (ADC) module):**
 - Analog temperature sensors (e.g., LM35)
 - Photoresistor (light sensor)

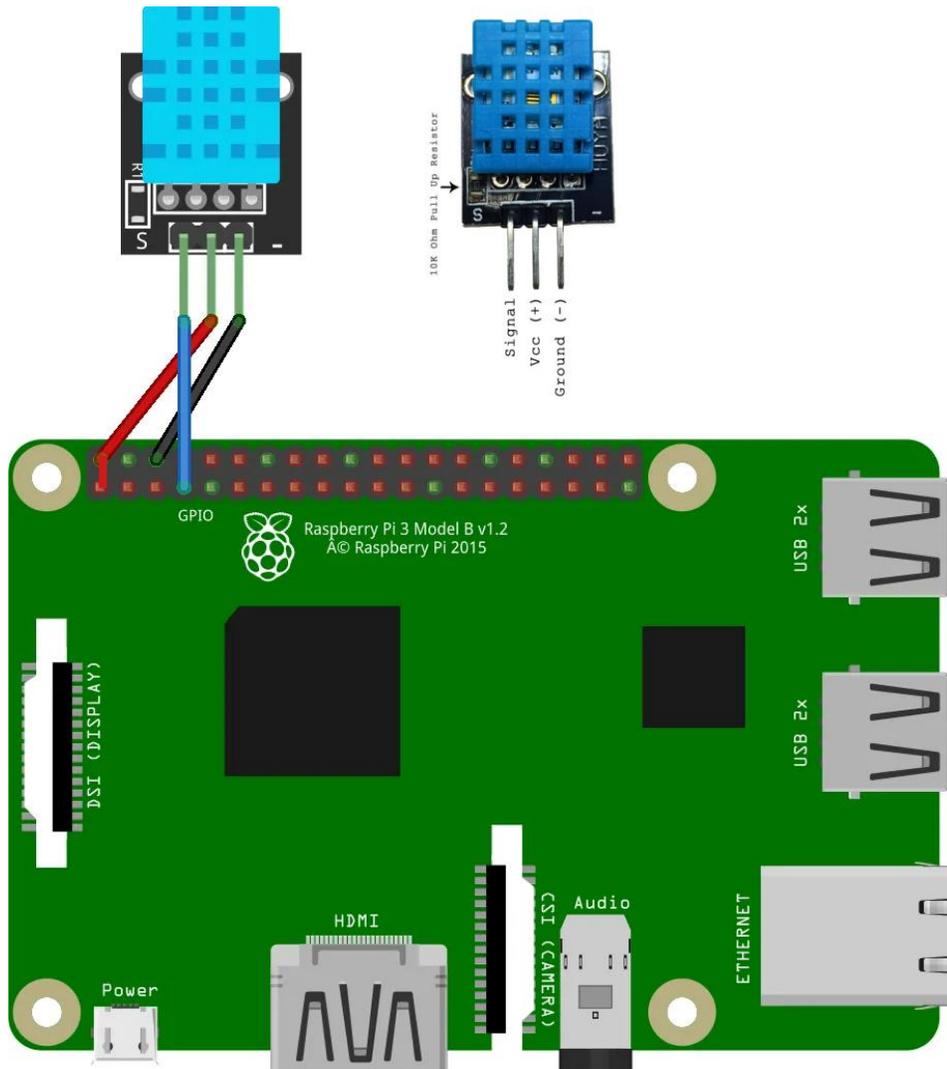


Wiring Sensors

- **Power Supply:**
 - Most sensors need 3.3V or 5V supply; ensure voltage compatibility
- **Signal Lines:**
 - Digital vs. Analog signals
- **Breadboard:**
 - Simplify connections and keep wiring organized



Wiring Sensors



Pi Model B/B+			
3V3 Power	1	2	5V Power
GPIO2 SDA1 I2C	3	4	5V Power
GPIO3 SCL1 I2C	5	6	Ground
GPIO4	7	8	GPIO14 UART0_TXD
Ground	9	10	GPIO15 UART0_RXD
GPIO17	11	12	GPIO18 PCM_CLK
GPIO27	13	14	Ground
GPIO22	15	16	GPIO23
3V3 Power	17	18	GPIO24
GPIO10 SPI0_MOSI	19	20	Ground
GPIO9 SPI0_MISO	21	22	GPIO25
GPIO11 SPI0_SCLK	23	24	GPIO8 SPI0_CE0_N
Ground	25	26	GPIO7 SPI0_CE1_N
ID_SD I2C ID EEPROM	27	28	ID_SC I2C ID EEPROM
GPIO5	29	30	Ground
GPIO6	31	32	GPIO12
GPIO13	33	34	Ground
GPIO19	35	36	GPIO16
GPIO26	37	38	GPIO20
Ground	39	40	GPIO21
Pi Model B+			

- Signal -> Pin 7 (GPIO 4)
- Vcc (+) -> Pin 1 (3.3V)
- Ground (-) -> Pin 6 (ground)

Programming Environment

- **Python as Primary Language:**
 - Easy to learn, extensive libraries
 - Great for rapid prototyping

- **Libraries for GPIO & Sensors:**
 - RPi.GPIO (standard)
 - Third-party sensor libraries (Adafruit, etc.)

File Transfer

- Send data using email
- Sync via cloud storage
- Transfer data from your Raspberry Pi with USB
- Swap data from your Raspberry Pi over SSH

File Transfer (SSH)

- Download **MobaXterm**:
https://download.mobatek.net/2502024121622306/MobaXterm_Portable_v25.0.zip

Assignment 3 (group assignment)

- Due on Feb. 7th 11:59 PM, 2025
- Each team only has to submit one report.

Key Takeaways:

- Raspberry Pi is a versatile platform for sensor data acquisition
- GPIO pins and Python libraries make integration straightforward
- Variety of sensors (digital, analog)
- Data logging can be local or cloud-based
- Regular maintenance & calibration ensure reliable data

Next Steps:

- Experiment with more sensors
- Practice writing and optimizing data collection scripts
- Explore advanced IoT and machine learning integration



Thank You!