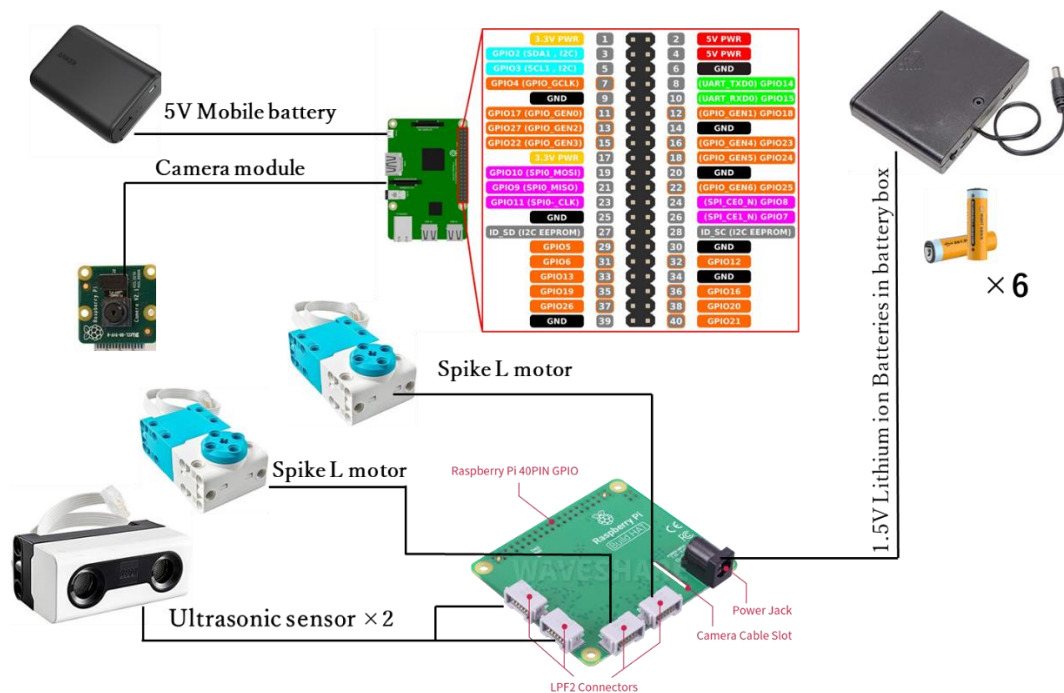


1. system configuration chart

An attempt was made to create a wiring diagram for the robot that included specialized information. However, since detailed electrical schematics for the L and M motors of the Raspberry Pi Build HAT and LEGO Spike used were not available, we created a wiring diagram that would reproduce the wiring of this robot closely as possible.



2. raspberry pi hardware

- Raspberry Pi 4 Model B



(1) Product Information

part	Description
Processor	Broadcom BCM2711 Quad-Core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
Memory	8GB
Connectivity	2.4GHz and 5.0GHz, IEEE 802.11b / g / n / ac wireless LAN, Bluetooth 5.0, BLE Gigabit Ethernet 2 x USB 3.0 ports 2 x USB 2.0 ports.
GPIO	Standard 40-pin GPIO header
Video sound	2 x micro HDMI ports (supports up to 4Kp60) 2 lane MIPI DSI display port 2 lane MIPI CSI camera port 4-pole stereo audio and composite video port
Multimedia	H.265 (4Kp60 decoding); H.264 (1080p60 decoding, 1080p30 encoding) H.264 (1080p60 decode, 1080p30 encode) OpenGL ES, 3.0 graphics
SD card	Micro SD card slot for loading operating system and data storage
Input power	5V DC (min. 3A1) via USB-C connector 5V DC via GPIO header (min. 3A1) Power over Ethernet (PoE) support (PoE HAT required separately)

(2) Reasons for choosing the Raspberry Pi 4 Model B

Lightweight and fast, it is the easiest single-board computer to use. It is highly flexible and can use a variety of sensors. It is also the most widely used single board computer by many people and is widely used in the field of electronic engineering, providing a wealth of information necessary for development.

(3) How to use the Raspberry Pi 4 Model B

The Raspberry Pi 4 is a small single board computer. It processes and analyzes images acquired from cameras in real time. The language used is Python and the opencv library is used for image processing.

- **Raspberry Pi Build HAT**



(1) Product Information

This product was used

<https://www.switch-science.com/products/7565>

(2) Reasons for choosing the Raspberry Pi Build HAT

The Raspberry Pi Build HAT can control up to four LEGO® Technic motors and sensors from a Raspberry Pi 4. The LEGO® Technic devices can be controlled by the easy-to-use Python libraries included in the LEGO® Education SPIKE Prime and SPIKE Prime Extension Sets.

(3) How to use the Raspberry Pi Build HAT

The Raspberry Pi Build HAT is not only used as an expansion port for angular motors and ultrasonic sensors, but also has the ability to step down a 9V power supply to 5V with its built-in switching regulator.

3. used battery

3-1 5V mobile battery



(1) Product Information

part	Description
capability	10000mAh
manufacturer	Anker
Model number of the product	A1263
output	5V = 2.4A
input	5V = 2A
size	92 x 60 x 22mm
weight	180g

(2) Reason for selecting this part

To provide a stable power supply to the Raspberry Pi4. and 9V battery box is also used, which also serves as a sub-battery. This allows the autonomous robot to operate for extended periods of time.

(3) How this was used

It is used to supply power to the Raspberry Pi4. This power is further supplied to the hub via a cable.

3-2 1.5V lithium ion Batteries in battery box



(1) Product Information

part	Description
type name	AA Li-ion USB
brand name	MORI SAWA
Battery types	lithium ion
Rated voltage/battery energy	1.5V/2500mWh
Charging voltage/charging current	5V/380mA
Battery weight	34g
size	15 x 15 x 50 mm
Charging time	60 minutes (rapid: 40 minutes)

(2) Reason for selecting this part

It has a USB-C charging port and can be recharged to provide a stable power supply. It can also be recharged for multiple uses, which is good for the environment.

(3) How this was used

Six batteries are placed in a battery box, outputting 9V.

3-3 9V battery box



(1) Product Information

part	Description
style	9V battery box
Manufacturer	KAUMO
size	96 × 75 × 19 mm
weight	55g

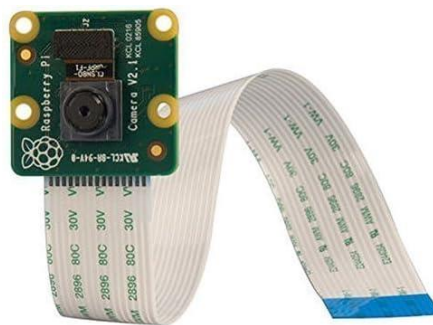
(2) Reason for selecting this part

To provide a stable power supply to the Raspberry Pi Build HAT.

(3) How this was used

Provides power to the Raspberry Pi Build HAT.

4. camera module



• Product Information

part	Description
Product Composition	Raspberry Pi Camera V2
Brands	Raspberry Pi
Video Pixels	480p.x2160p, 1080p
Image Capture Speed	60fps
model number	Raspberry Pi 3B
screen size	2inches

- **Reasons for selecting this part**

This camera module was developed specifically for the Raspberry Pi, so it is optimized for the Raspberry Pi 4 and can capture and record high quality images.

- **How this was used.**

Using a 15cm flexible flat cable, connect the module slot to the camera serial interface port on the Raspberry Pi. It is also used to determine the course environment in competitions.

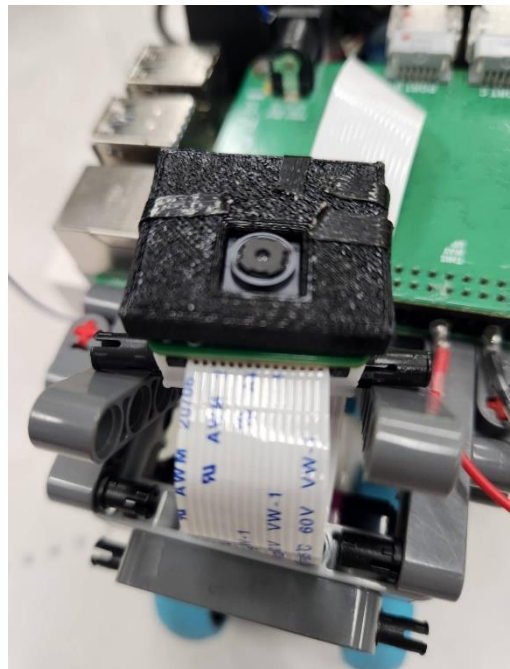
5. flexible flat cable



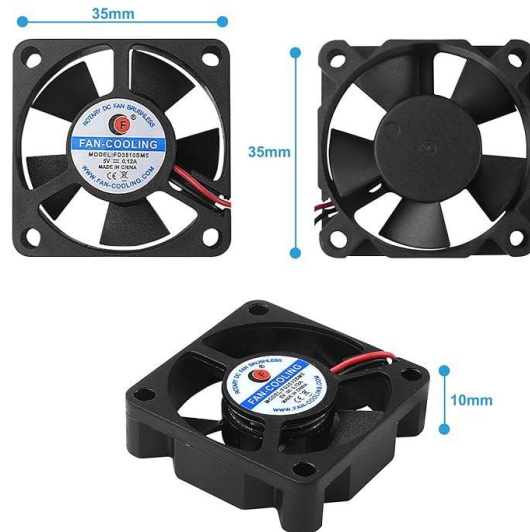
- **How this was used**

This cable is integrated with the camera module and is used to connect the Raspberry Pi. The cable is plugged into the connection on the Raspberry Pi side for connection.

- **connector**



6. cooling fan for RaspberryPi4



(1) Product Information

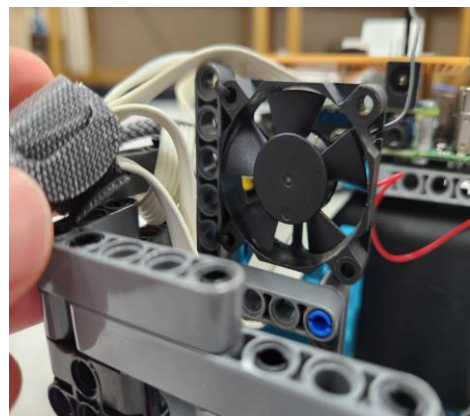
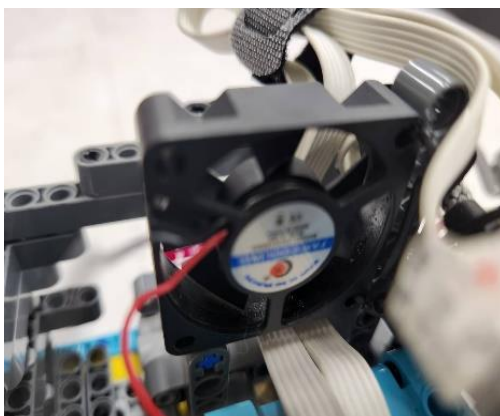
part	Description
Manufacture	Smraza
Voltage/current	5V/0.12A

(2) Reason for selecting this part

The main cause of heat generation is higher performance and higher clock frequencies: in the Raspberry Pi 4 Model B, the temperature around the SoC and PMIC rises when the temperature exceeds 80° C, thermal throttling functions to protect the SoC by gradually lowering the clock frequency to 600 MHz to protect the SoC. Once thermal throttling is functioning, operation becomes unstable. Therefore, cooling fans are used to lower the temperature around the SoC and PMIC.

(3) How this was used.

Used to cool Raspberry Pi4.



7. heatsink for RaspberryPi4



(1) Reason for selecting this part

To prevent excessive heating and stabilize Raspberry Pi4 functionality.

(2) How this was used.

Attaching a heat sink to the SoC increases the surface area that is exposed to cooling fan airflow, resulting in more efficient cooling.

8. Cable used

- USB type A to USB type C connector



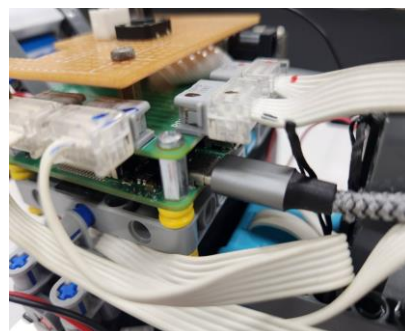
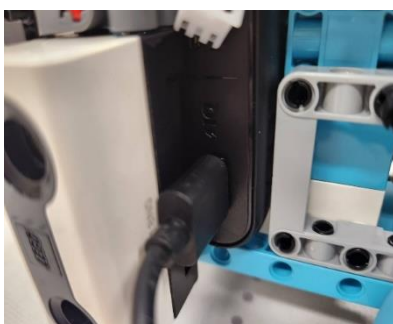
(1) Reason for selecting this part

Used to supply power from a mobile battery to a Raspberry Pi4.

(2) How this was used

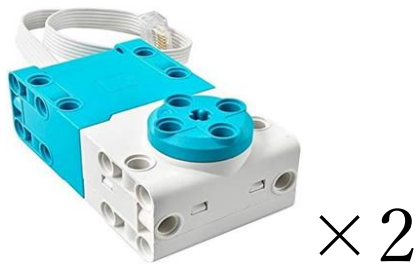
It is connected between the mobile battery and the Raspberry Pi4 and supplies power from the mobile battery to the Raspberry Pi4.

(3) Connections



9. Motor

spike L motor



(1) How this was used.

Click here for details

<https://github.com/Hart1109/TeikyoRobostar-WRO-FE2024/tree/main/schemes/mobility>

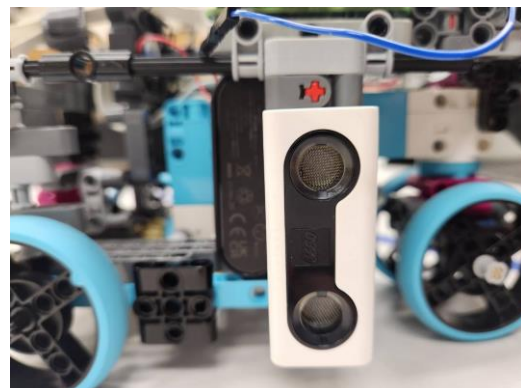
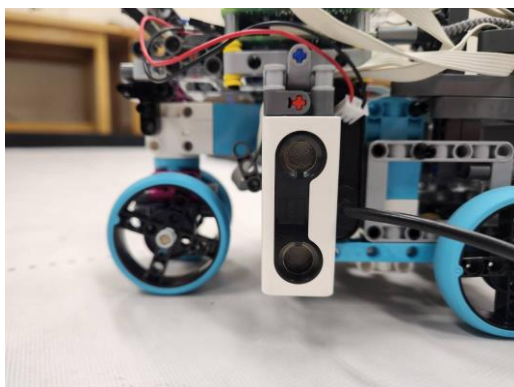
10. ultrasonic sensor



(1) How this was used.

It was connected to a port on the Raspberry Pi Build HAT and used to measure the distance between the inner wall and the expected distance and between the outer wall and the robot.

(2) connector



11. description of power supply method

Power to the Raspberry Pi 4 was supplied from a mobile battery. The procedure is as follows.

(1) Prepare mobile battery



(2) Connect the mobile battery to the Raspberry Pi 4



(3) Supply power to the Raspberry Pi 4

12. description of power supply method

Power to the Raspberry Pi Build HAT was supplied from the 9V battery box. The procedure is as follows

(1) Prepare 9 V battery box.



(2) Connect the 9 V battery box to the Raspberry Pi Build HAT



(3) Supply power to the Raspberry Pi Build HAT



(4) Prepare the 9V battery box and use six 1.5V AA batteries in the battery box to power the Raspberry Pi Build HAT.

13. Power consumption of autonomous robot

The Raspberry Pi Build HAT is powered by 9V, and the built-in switching regulator steps down the 9V to 5V to feed the Raspberry Pi 4. The autonomous robot consumes an average of 2.7W when stopped. When the camera, ultrasonic sensor, and motors are running, the average power consumption is 7.65W.