WRO®
WORLD ROBOT OLYMPIAD ™

KMATRIX FUTURE INNOVATORS SET

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Table of Contents

1. Introduction

In an exciting collaboration, MATRIX Robotics System and the World Robot Olympiad (WRO) have developed a specialized robotics set crafted for the Future Innovators category.This advanced set features the MATRIX Mini R4 controller, powered by the Arduino UNO R4 Wi-Fi, providing seamless connectivity for enhanced projects. Paired with MATRIXBlock software, a new graphical programming tool based on Scratch, students can transition smoothly from block-based coding to C++, aided by a serial port monitor for easy data debugging. The set includes MATRIX sensors and the MATRIX M-Vision Camera, providing students with the tools to create smart, interactive robotics projects that bring ideas to life.These components enable robots to recognize objects, track movement, and respond to their environment, making them ideal for exploring AI and IoT connectivity. Perfect for both beginners and experienced coders, the set offers a hands-on way to learn about smart technologies, automation, and more. Whether for classroom learning or WRO Future Innovators competition, this versatile set empowers students to unleash their creativity and build the robots of tomorrow!

1.1 Overview

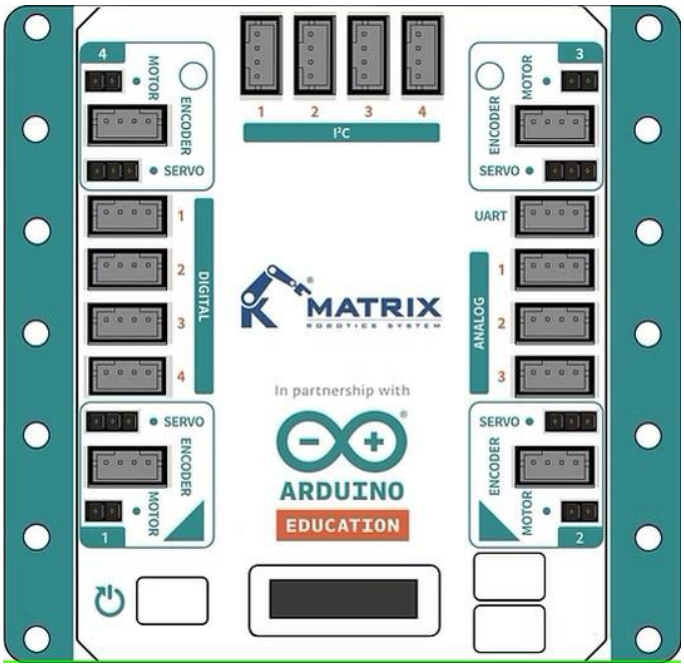
- Arduino® Powered
- Third Party Sensor Support
- Compatible with Easy Assembly
- Dual Programming Platforms
- Industrial Standards
- Ideal for Competitions

2. MATRIX Mini R4 (MA000)

MATRIX Mini R4 is an Arduino UNO R4 WiFi based robot controller. With the MATRIX building system, you can make tons of projects. From basic tracking car to omni-directional mobile platform, you can make any ideas comes out of your mind.

2.1 Feature

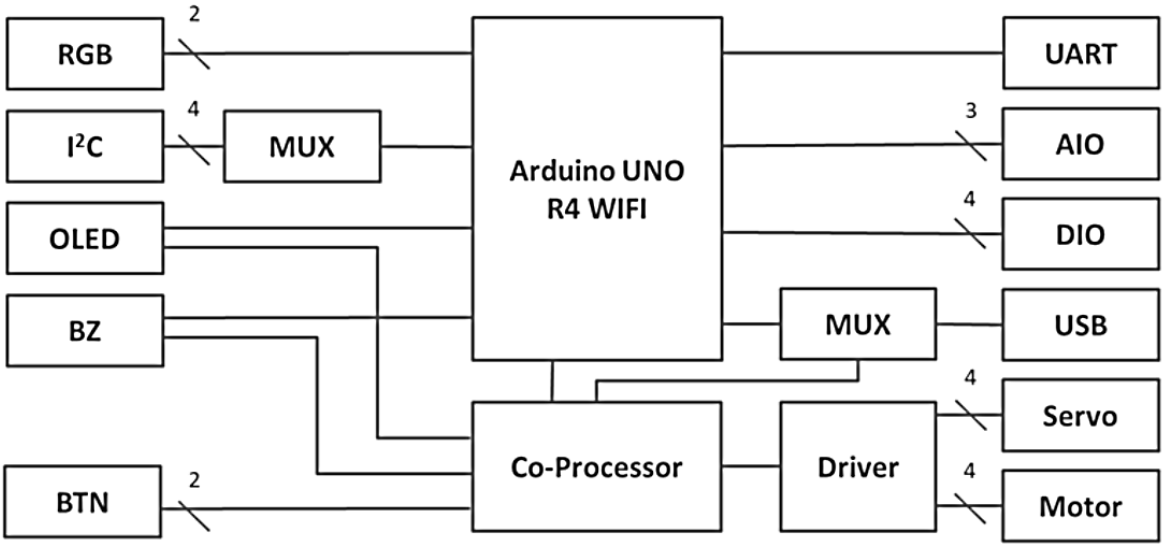
- Support 4 channel RC Servo control.
- Support 4 channel DC Motor with encoder.
- Support 4 channel I2C Interface.
- Support 8 channel GPIO.
- Arduino UNO R4 WiFi built-in.
- OLED, Buttons, RGB LED, Buzzer built-in.
- Co-processor for motor control and IMU.



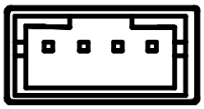
2.2 Application

- Autonomous/TelOp Robotics
- IoT Projects Gateway
- Automatic Device

2.3 Block Diagram



2.4 Matrix Mini R4 Pinout



1 4

Pinout-I2C

NO.	Name	I/O	Description
1	SDA	I/O	Serial data line.
2	SCL	I	Serial clock line.
3	VCC	O	Supply voltage.
4	GND	-	Supply ground.

Pinout-UART

NO.	Name	I/O	Description
1	TX	O	Serial transmit line.
2	RX	I	Serial receive line.
3	VCC	O	Supply voltage.
4	GND	-	Supply ground.

Pinout-Analog In

NO.	Name	I/O	Description
1	AINA	I	Analog input A.
2	AINB	I	Analog input B.
3	A5V	O	Supply voltage.
4	GND	-	Supply ground.

Pinout-Digital I/O

NO.	Name	I/O	Description
1	DIOA	I/O	GPIO A.
2	DIOB	I/O	GPIO B.
3	VCC	O	Supply voltage.
4	GND	-	Supply ground.

Pinout-Encoder

NO.	Name	I/O	Description
1	CHA	I	CH input A.
2	CHB	I	CH input B.
3	M5V	O	Supply voltage.
4	GND	-	Supply ground.

1 2 3

Pinout-Servo Out

NO.	Name	I/O	Description
1	GND	-	Supply ground.
2	5V	O	Supply voltage.
3	PWM	O	PWM out for RC servo.

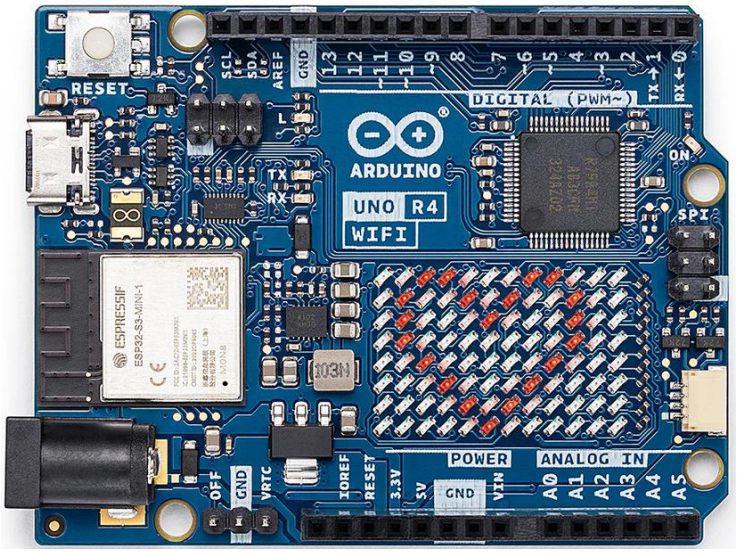
1 2

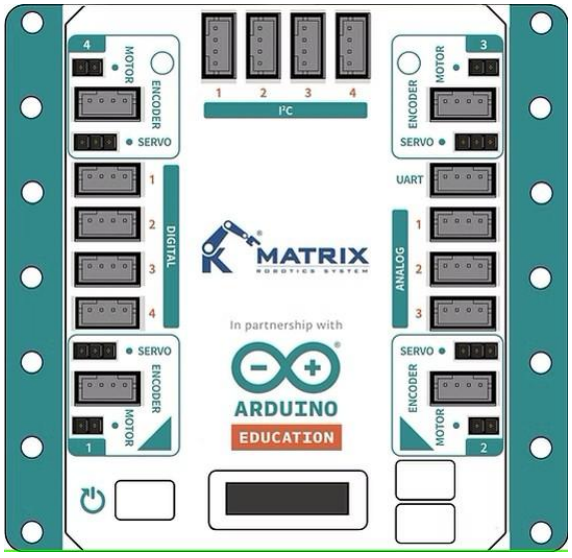
Pinout-Motor Out

NO.	Name	I/O	Description
1	M-	O	H-bridge out M-.
2	M+	O	H-bridge out M+.

Note: *If you are controlling Analog or Digital pins directly with MATRIXBlock*, pin number 1 considered as “Left” pin and pin number 2 considered as “Right” pin.

2.5 Arduino Pin Mapping



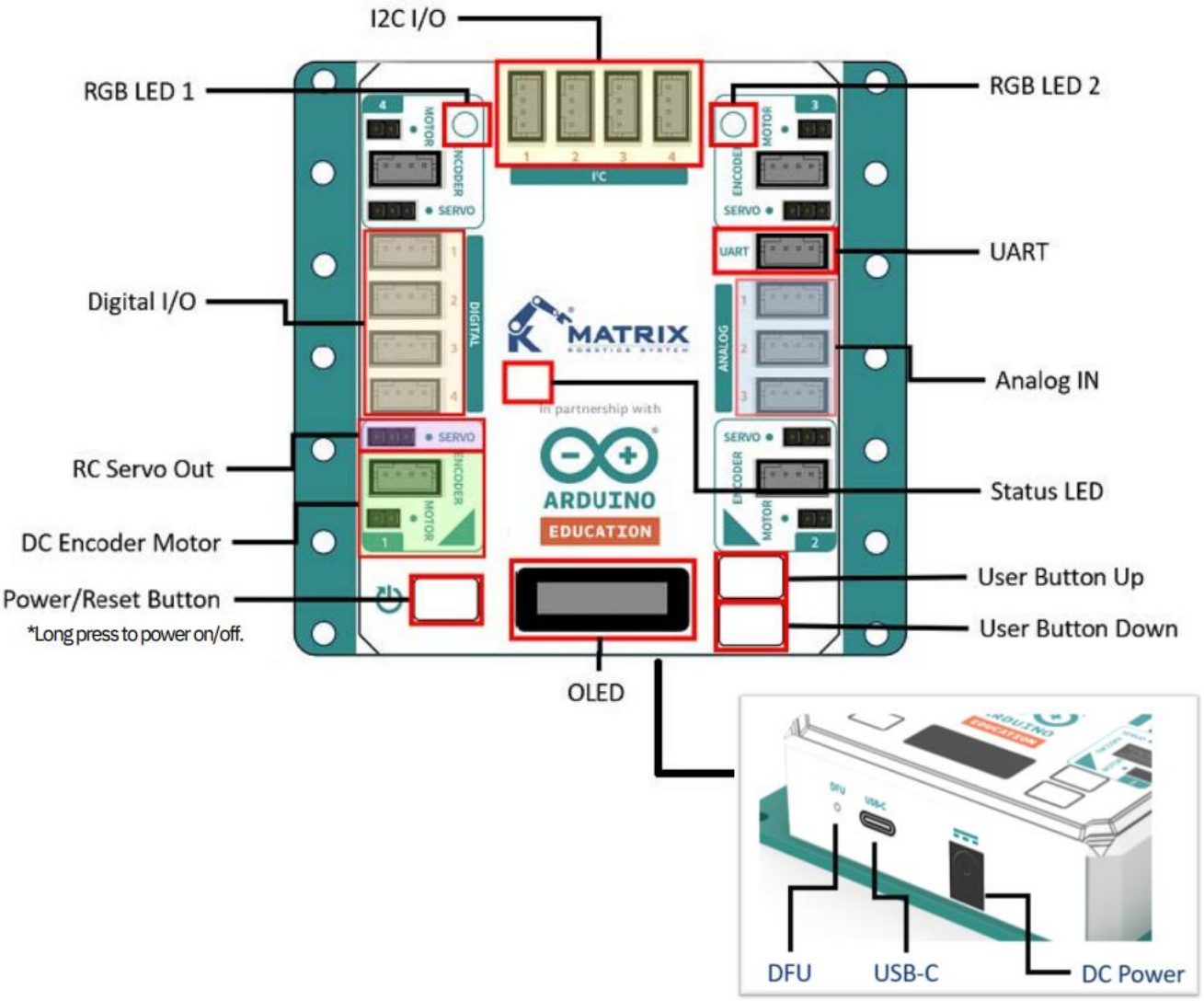


Matrix Mini R4		Arduino Uno R4 WiFi	Peripheral
D1	D1A	3	-
	D1B	2	-
D2	D2A	5	-
	D2B	4	-
D3	D3A	12	-
	D3B	11	-
D4	D4A	13	-
	D4B	10	-
A1	A1A	A1	-
	A1B	A0	-
A2	A2A	A3	-
	A2B	A2	-
A3	A3A	A4	-
	A3B	A5	-
UART	TX	1	-
	RX	0	-
I2C	SDA	-	PCA9548-SDA(0-3)
	SCL	-	PCA9548-SCL(0-3)
Looks	Buzzer	6	
	RGB LED	7	
RC		-	Co-Processor
DC		-	Co-Processor
BTN		-	Co-Processor

2.6 Electrical Characteristics

Parameter	Min	Typ	Max	Units
Input Voltage	6	-	24	V
I/O Voltage	-0.3	5	6.5	V
Digital I/O Pin Current	-	-	8	mA
Analog In Pin Current	-	-	8	mA
RC Servo Output Voltage	-	5	-	V
DC Motor Output Voltage	-	5	-	V
RC Servo Output Current	-	-	1	A
DC Motor Output Current	-	1.5	2	A
UART Buad	300	9600	115200	Bit/s
I2C operating speed	100	-	400	KHz
I2C Low-Level Input Voltage	-0.5V	-	0.33*VCC	-
I2C High-Level Input Voltage	0.7*VCC	-	VCC	-
LED R Wavelength	620	-	625	Nm
LED G Wavelength	522	-	525	Nm
LED B Wavelength	465	-	467	Nm
Operating Temperature	-40	25	85	℃

2.7 Hardware guide

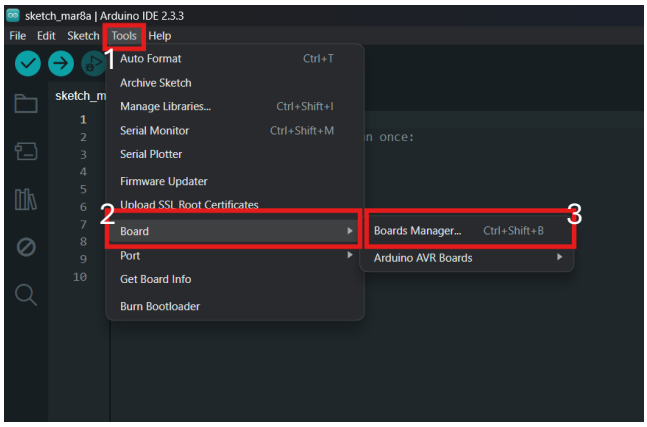


2.8 Software API

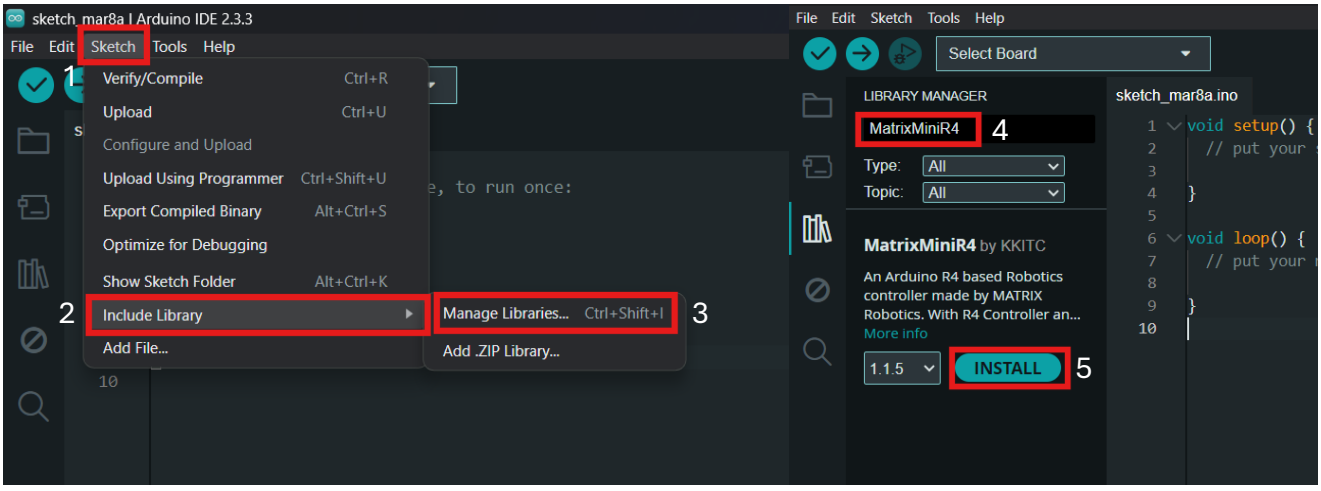
2.8.1 Arduino IDE

1. Download and install Arduino IDE (At least v2.0) from www.arduino.cc/en/software

2. Open Arduino IDE
3. Open the Boards Manager from the Tools -> Board menu and select "Arduino Uno R4 WiFi"



4. Open the Library Manager from the Sketch-> Include Library -> Manage Libraries and search "MatrixMiniR4"

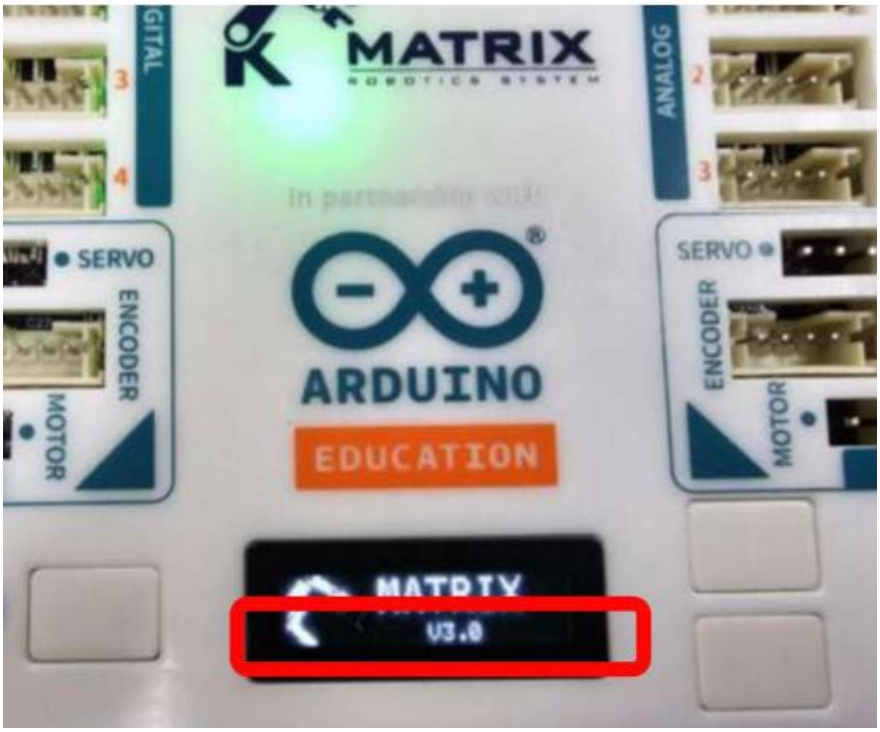


2.8.2 MATRIXBlock

1. Download and install MATRIXBlock from www.matrixrobotics.com/matrixblock-software

2.8.3 Firmware Update

1. While Power On/Reset the Mini R4 Controller, you can see the firmware version on OLED Screen. If firmware is not latest, you might need to upgrade your device to have best experience of Mini R4.

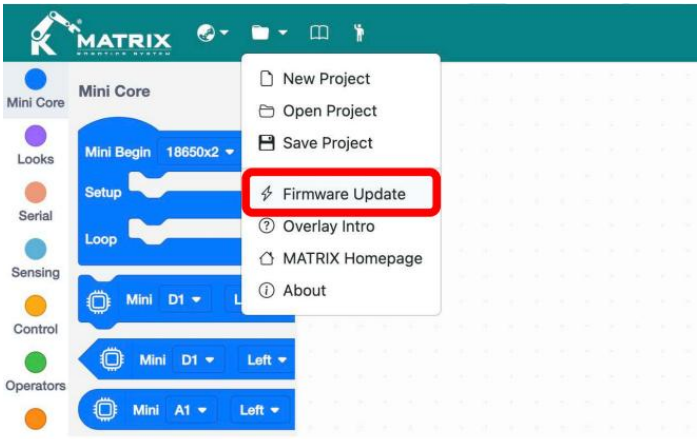


2. Find a paperclip, SIM card pin, small pen or a similar small pin tool.
3. Disconnect the Device from both the battery and USB power.
4. Connect the USB cable to the computer first.

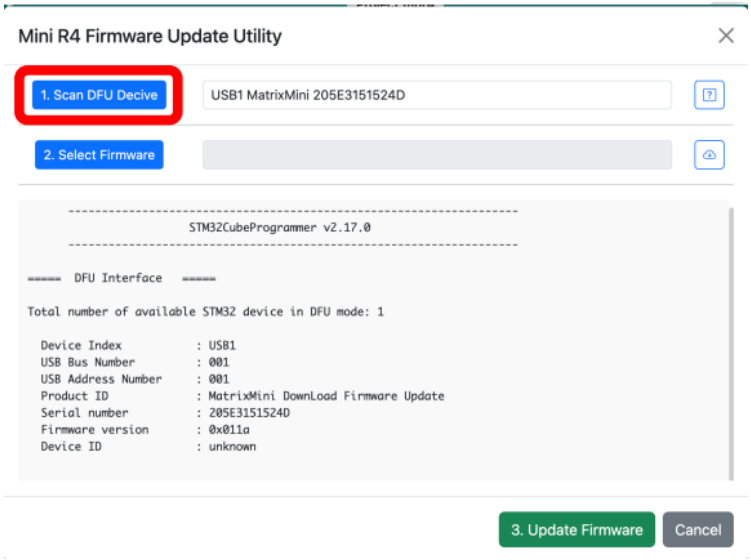
5. Insert the paperclip into the DFU mode pinhole on the Device. (Usually located on the side of the device, nearby USB)

6. While holding the paperclip in the DFU pinhole, plug the other end of the USB cable into the Device.
7. If the blue LED near the pinhole starts flashing, the device has successfully entered DFU mode.

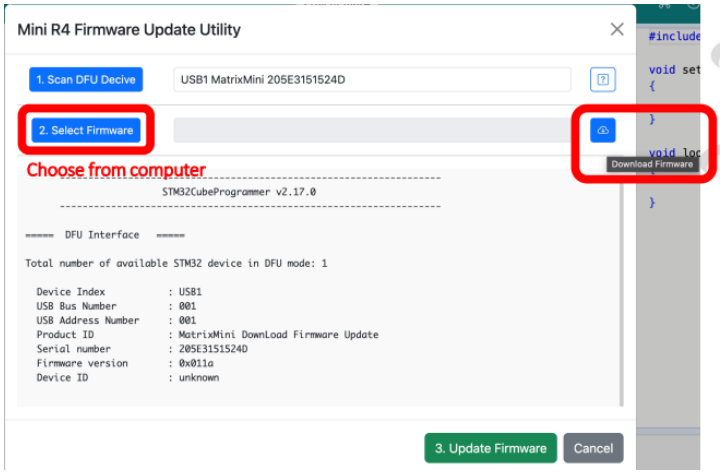
8. Choose the Firmware Update in the MATRIXblock.



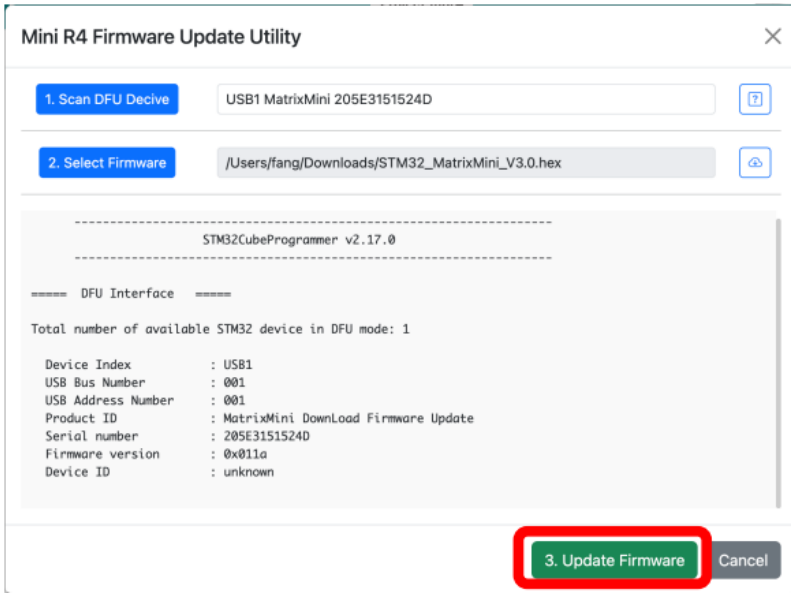
9. Click 1. Scan DFU Device to confirm the device is recognized.



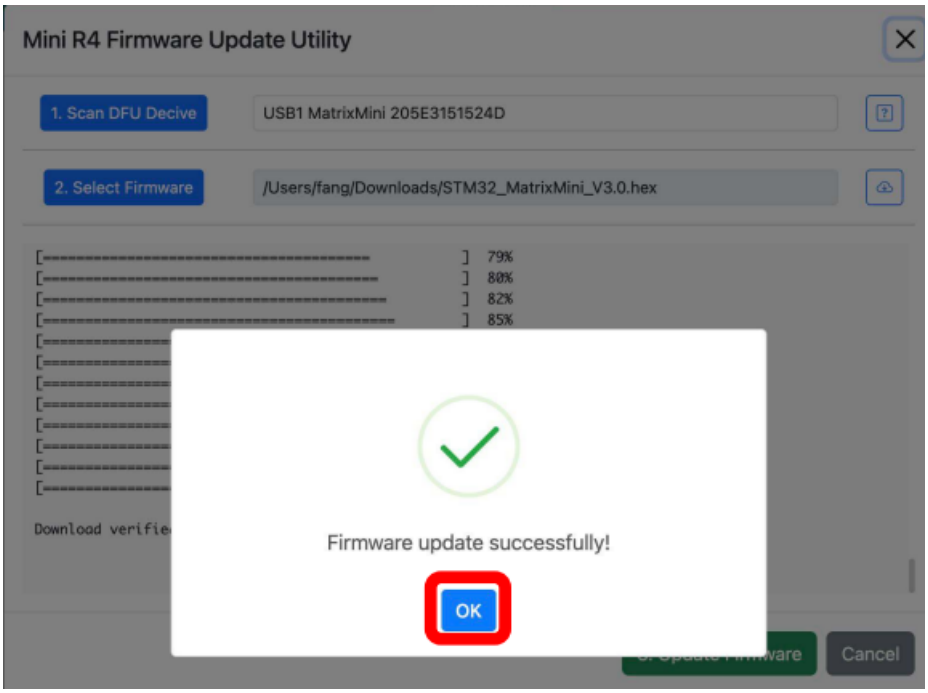
10. Click 2. Select Firmware to select the firmware on your computer or go online to download the latest version.



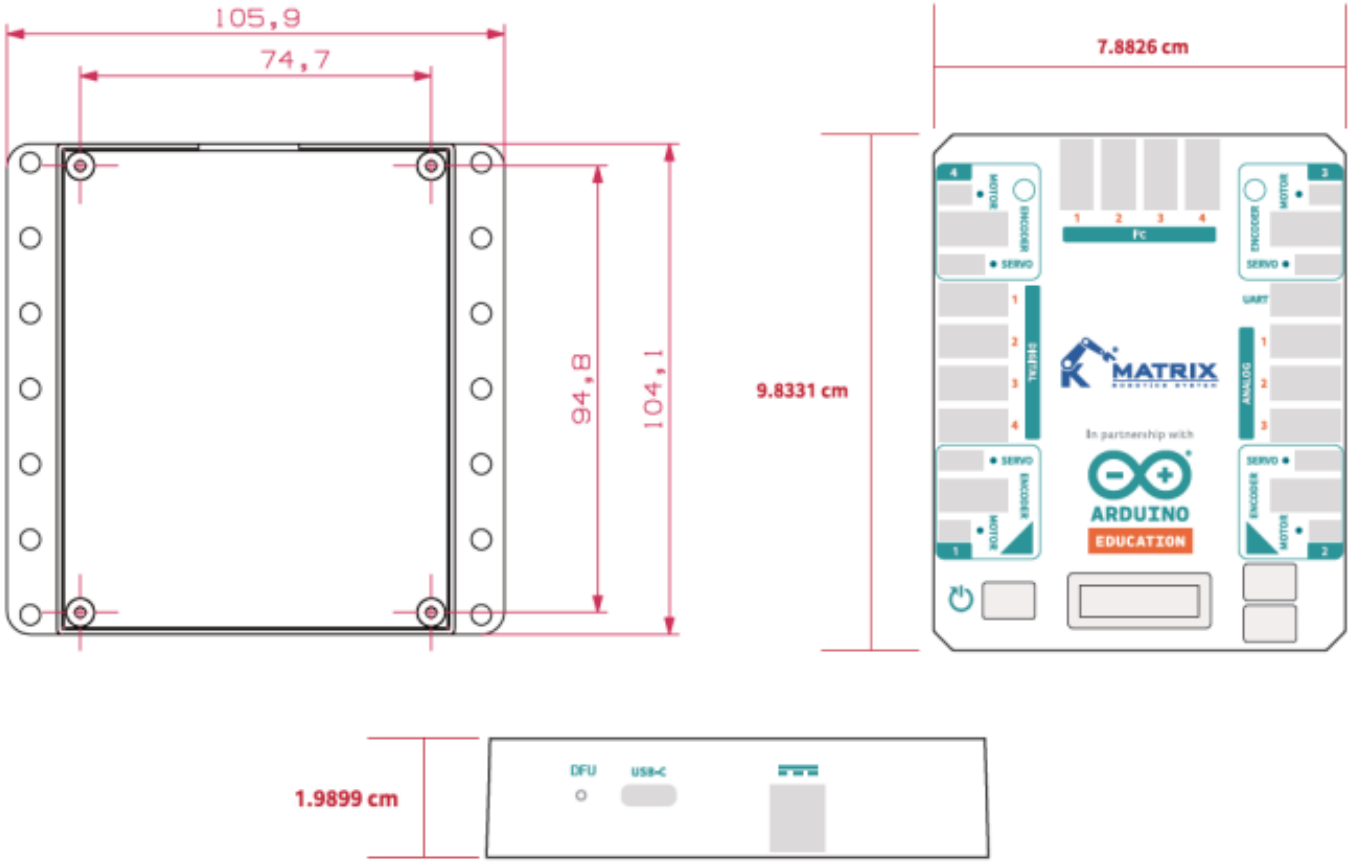
11. After selecting the firmware, click on 3. Update Firmware.



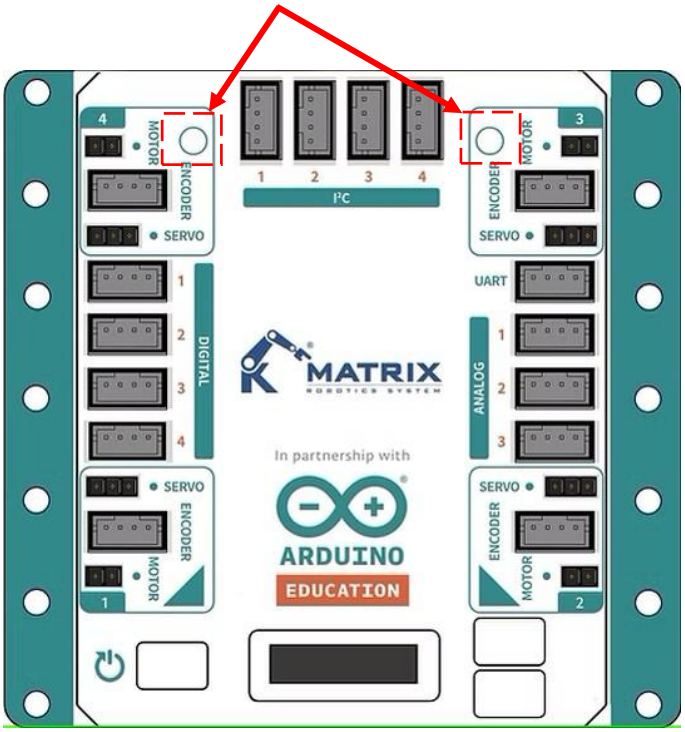
12. After the Firmware update successfully! Dialog comes, Disconnect and reconnect the Mini R4 Controller.



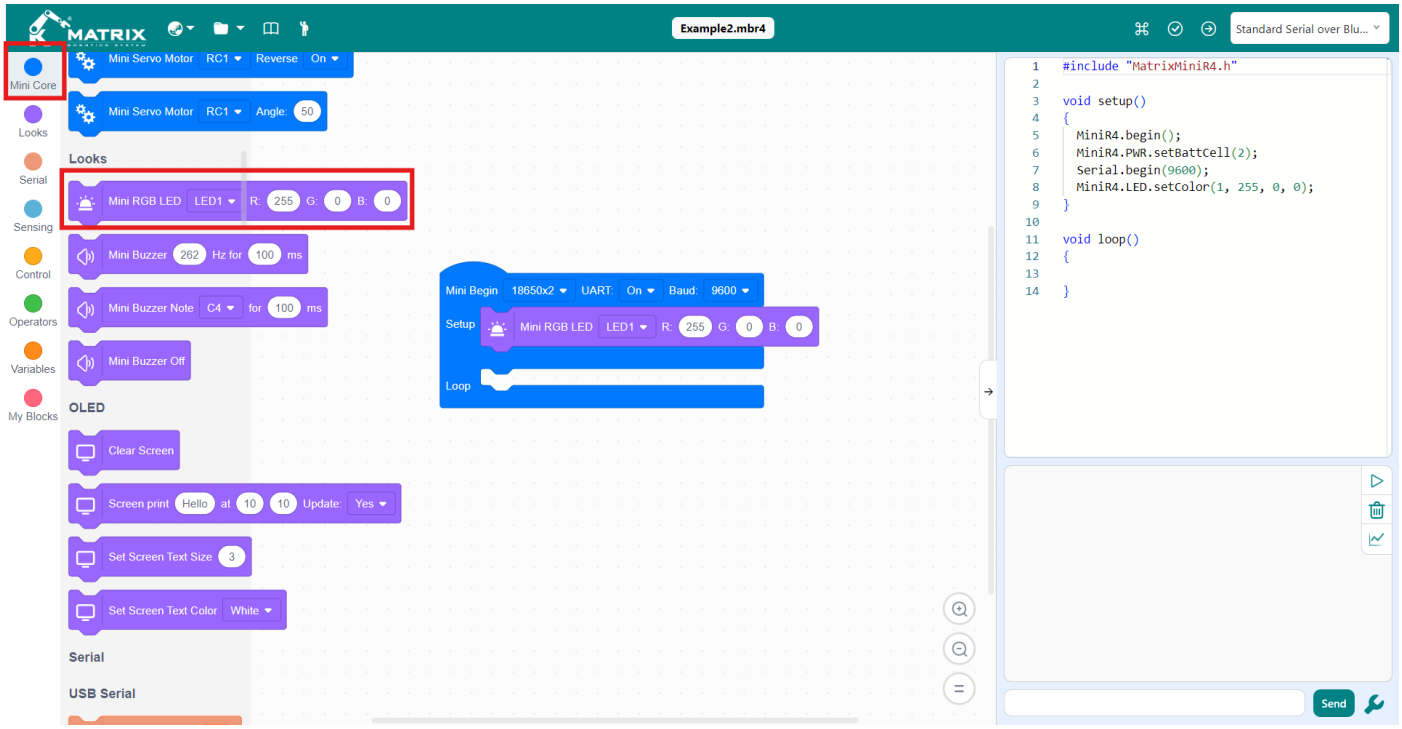
2.9 Dimensions



3. RGBLED

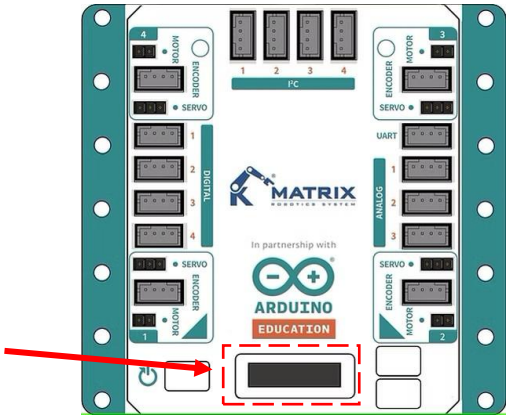


3.1 Sample Code



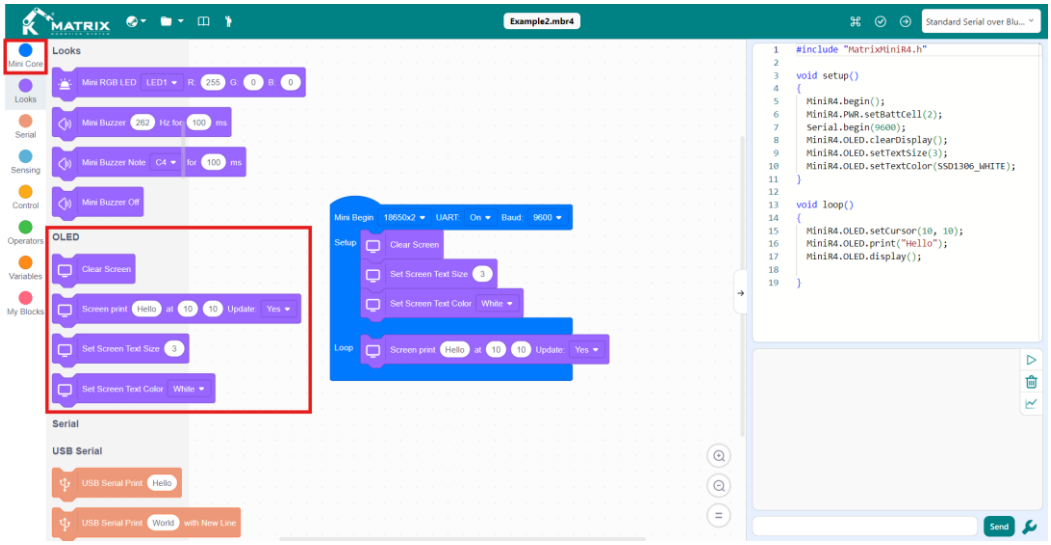
Result: The left LED on the MATRIX Mini R4 goes red.

4. OLED



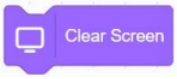
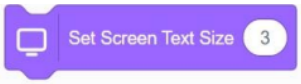
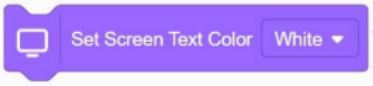
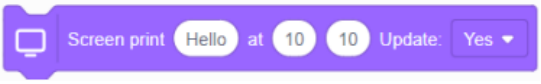
Note: *The OLED display is 128 pixels wide and 32 pixels tall. The two numbers in MatrixBlock simply represent the X (horizontal) and Y (vertical) coordinates on the screen.*

4.1 Sample Code

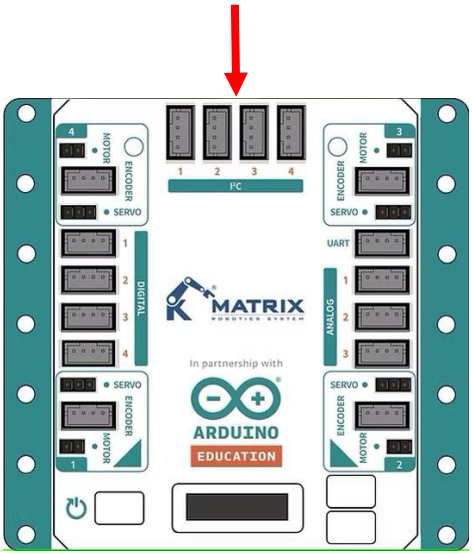


Result: The OLED on MATRIX Mini R4 shows Hello.

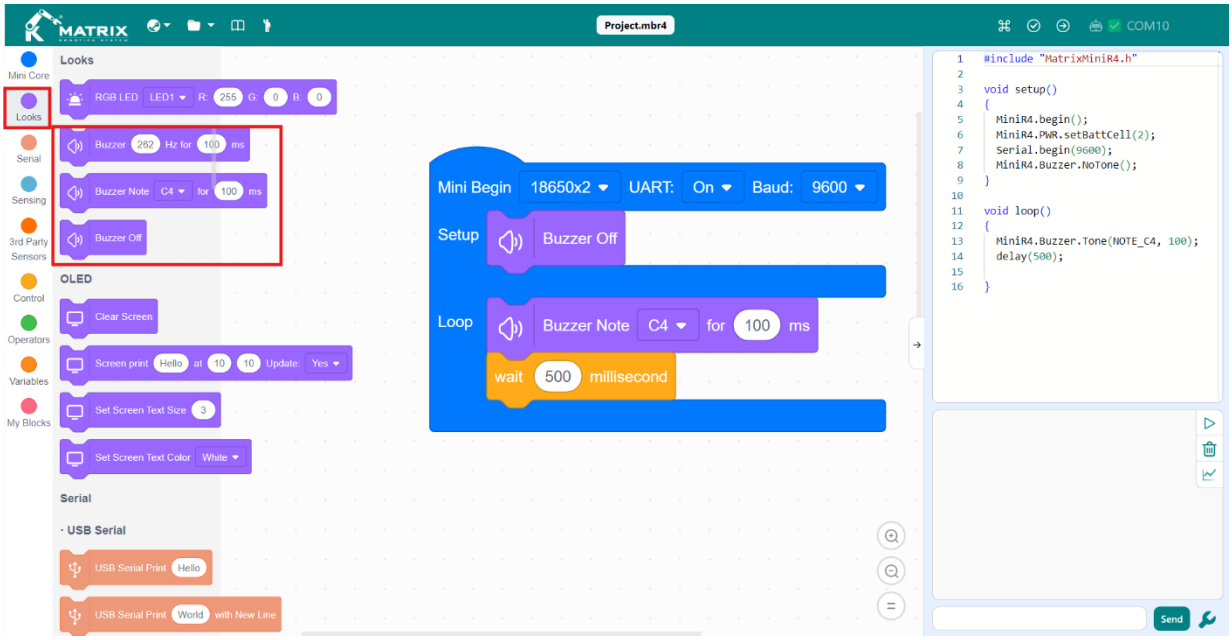
4.2 OLED Blocks Instruction

BLOCK	Instruction
	Clear what is currently displayed on the screen.
	Set the size of the text to be displayed, the smallest is 1, usually placed in the setup. (Default is 1)
	Setting the text colour, usually placed in the setup. (Default is White)
	Print the text to the OLED, you can decide update screen or not for printing multiple content without “flashing”. The screen pixel is 128*32.

5. Buzzer

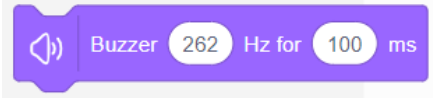
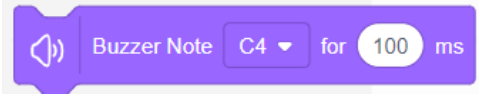


5.1 Sample Code

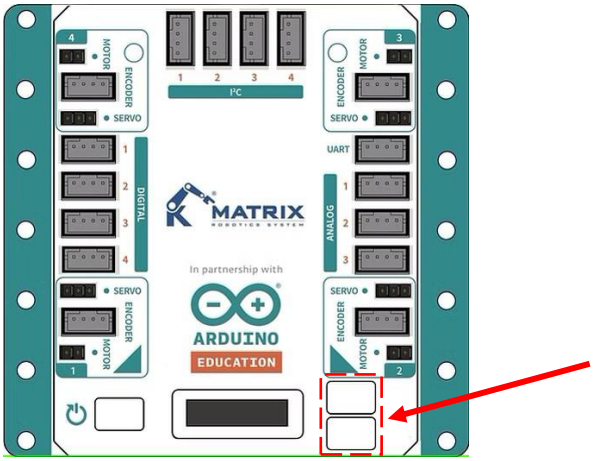


Result: The Buzzer sound goes on.

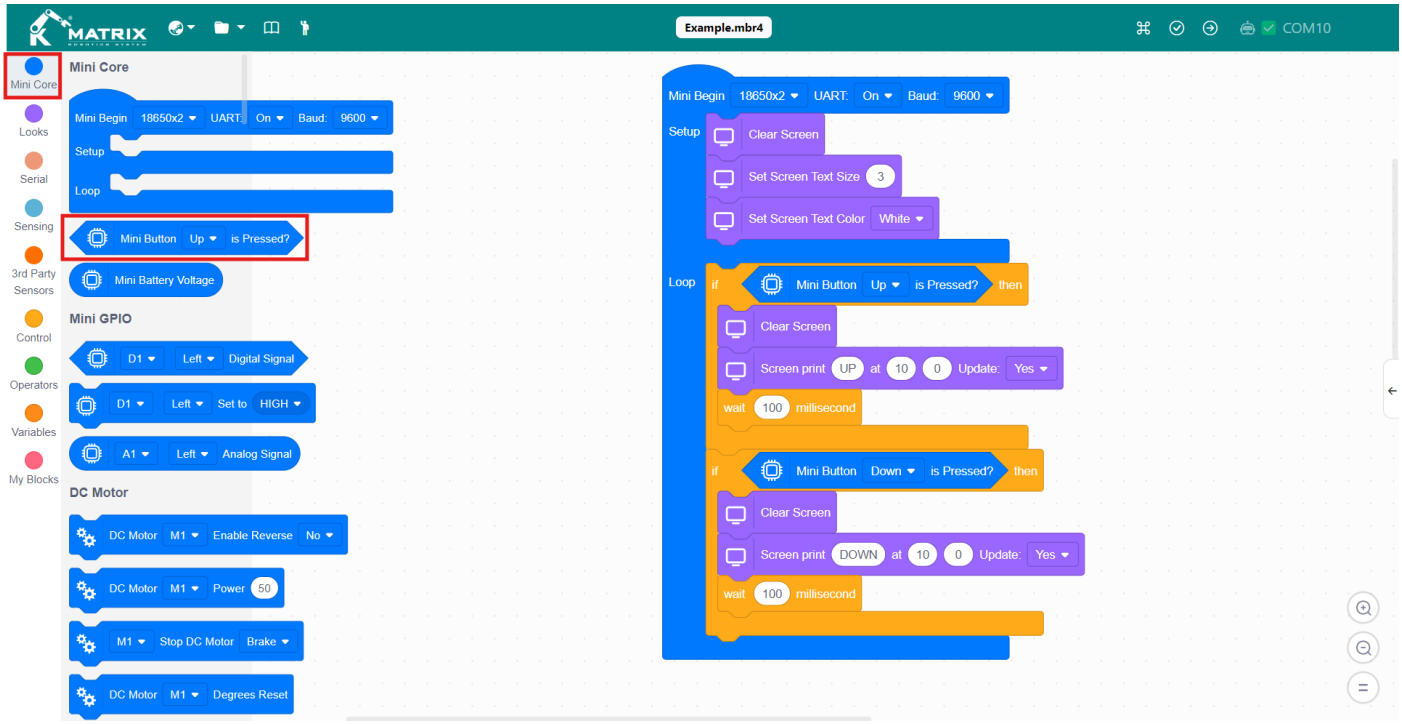
5.2 Buzzer Blocks Instruction

BLOCK	Instruction
	Setting the frequency and playback time of Buzzer, the process will continue in parallel with the program below.
	Setting the chords and playback time of Buzzer, the process will continue in parallel with the program below.
	Stop Playing Sound

6. User Buttons

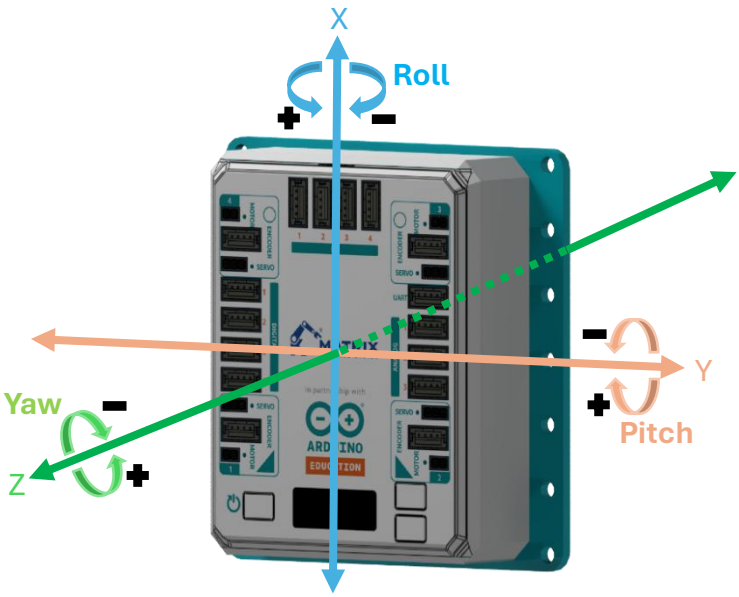


6.1 Sample Code



Result: The OLED will show “UP” and “DOWN” on Button press.

7. IMU



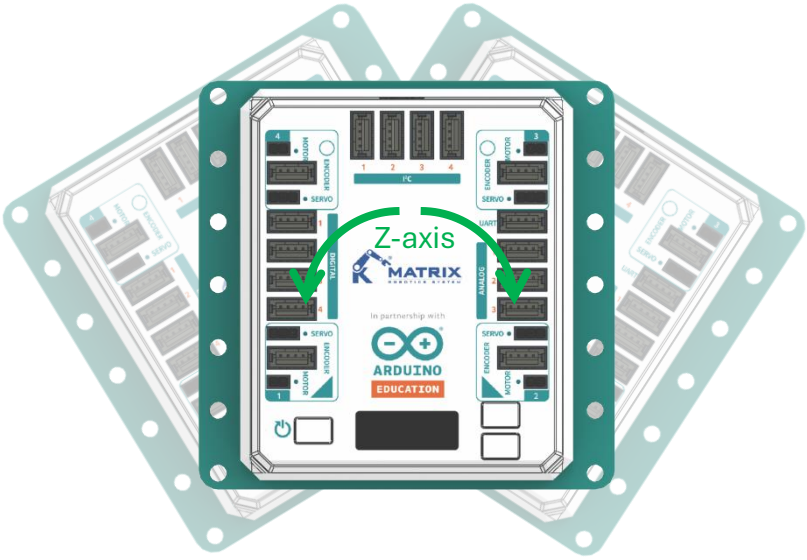
Note: *The MATRIX Mini R4 features a built-in IMU (Inertial Measurement Unit) that tracks both movement and orientation in space. It measures acceleration along the X, Y, and Z axes, as well as angular velocity, how quickly the device is rotating, and calculates the angle of rotation around each axis.*

Using the acceleration data, you can understand how the device is moving along each axis. The gyroscope measures rotation speed in degrees per second, and by combining this data, the IMU provides Euler angles to describe the device's orientation, how it is tilted or turned.

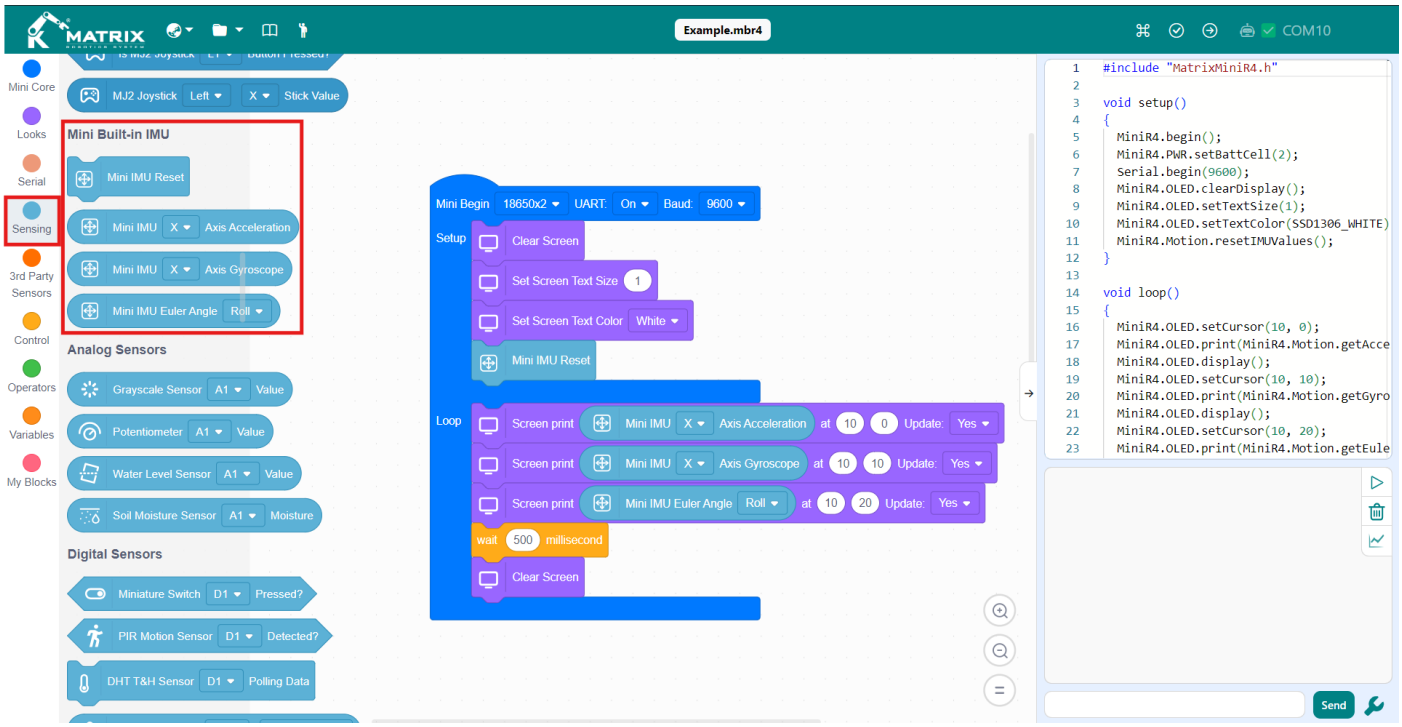
These angles are:

- ***Roll:*** *Rotation around the X-axis*
- ***Pitch:*** *Rotation around the Y-axis*
- ***Yaw:*** *Rotation around the Z-axis*

Below is an example of rotation around the Z-axis, which causes a change in the yaw value.



7.1 Sample Code



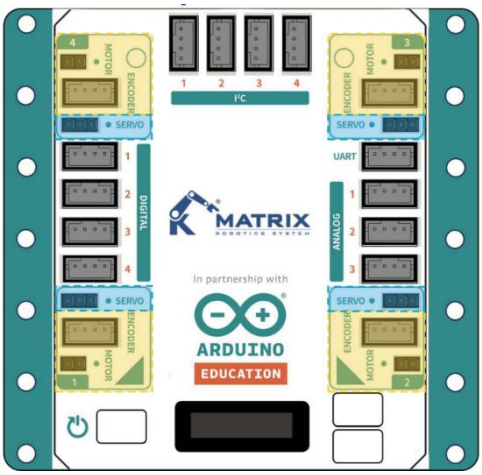
Result: The OLED will display the acceleration on the X-axis, the gyroscope data on the X-axis, and the roll value from the Euler angles.

Note: *in the current firmware, the IMU reset function is set by default to the horizontal position. Otherwise, it cannot be reset.*

7.2 Specifications

Parameter	Min	Typ	Max	Units
Supply voltage (VCC)	3	3.3	5	V
Sample rate	-	100	-	Hz
Acceleration measurement range	-4	-	4	g
Angular rate measurement range	-2000	-	2000	dps

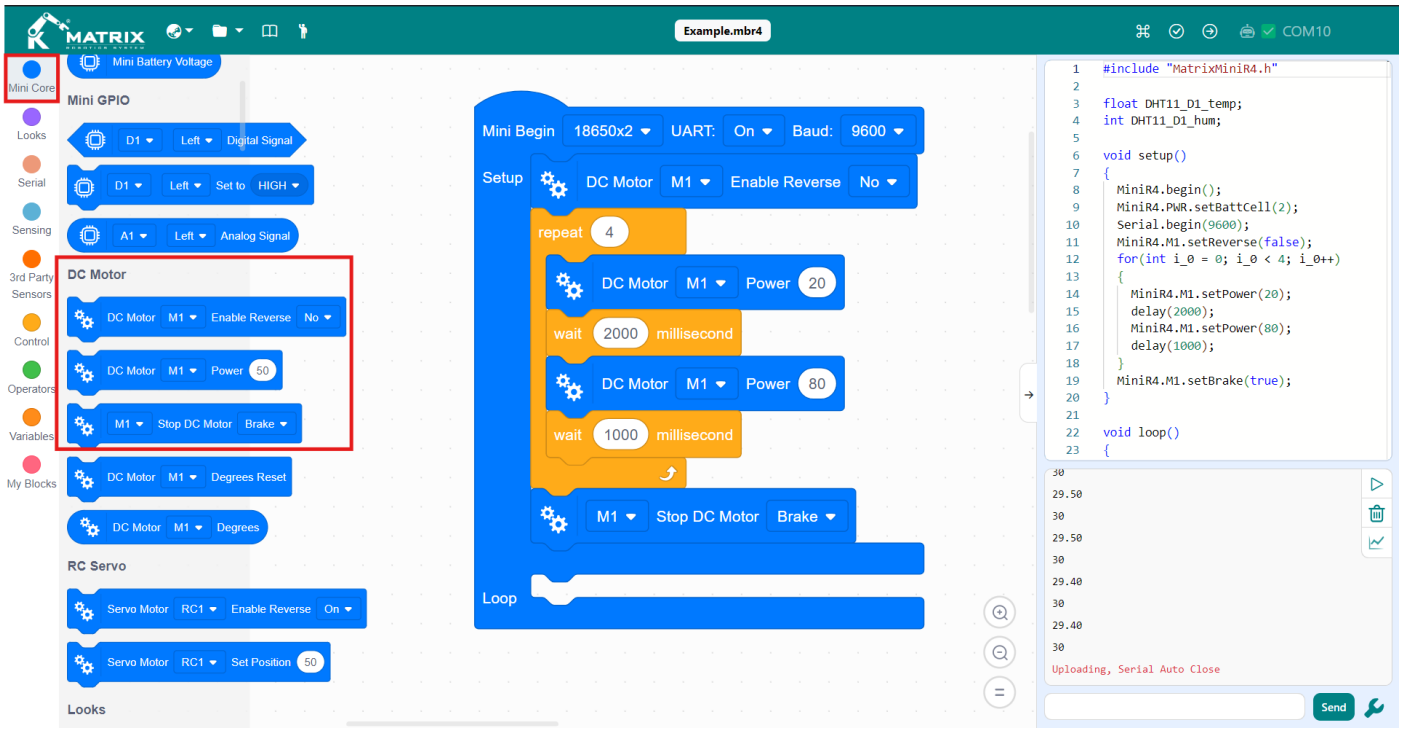
8. DC Motors



Note: *The dot (•) on the motor port indicates the correct side for connecting the ground (GND) wire, which is usually black or sometimes brown in certain motors or servos. Additionally, DC Motors require an external battery power source to function properly.*

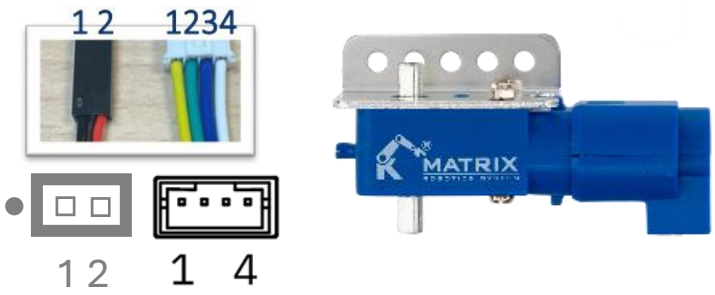
8.1 Sample Code

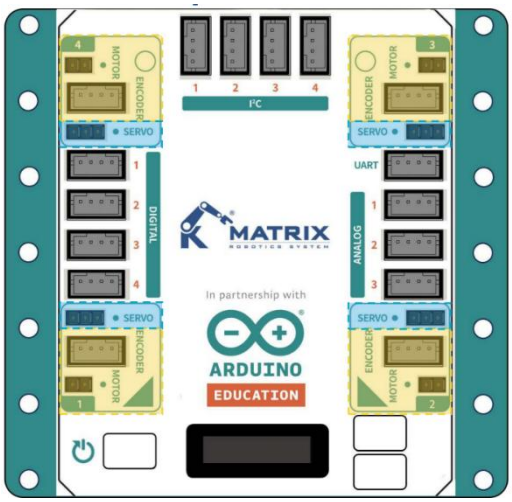
Hardware Connection: Connect the DC Motor to the M1 port of the MATRIX Mini R4.



Result: the motor connected to M1 starts to Move with 50% of speed. After 2 seconds the motor will be move with 80% of speed for 1 second. After 4 times, the motor will be stopped.

9. DC Motors with Encoder

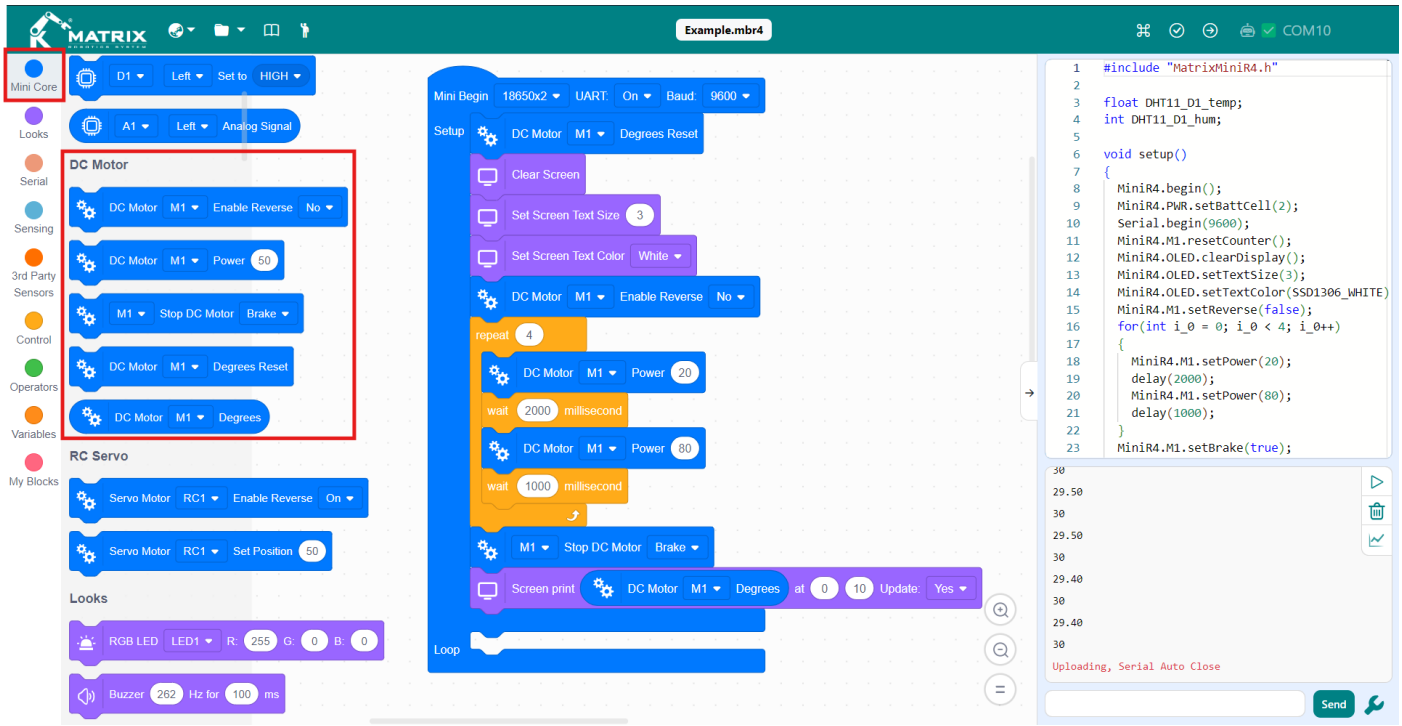




Note: *The dot (•) on the motor port indicates the correct side for connecting the ground (GND) wire, which is usually black or sometimes brown in certain motors or servos. Additionally, DC Motors with Encoders require an external battery power source to function properly.*

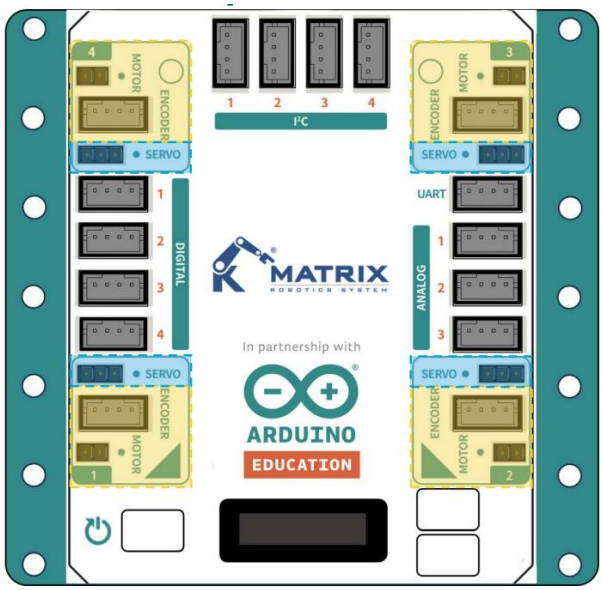
9.1 Sample Code

Hardware Connection: Connect the DC Motor with encoder to the M1 port of the MATRIX Mini R4.



Result: the motor connected to M1 starts to Move with 50% of speed. After 2 seconds the motor will be move with 80% of speed for 1 second. After 4 times, the motor will be stopped and the degrees of rotation will be shown on the OLED.

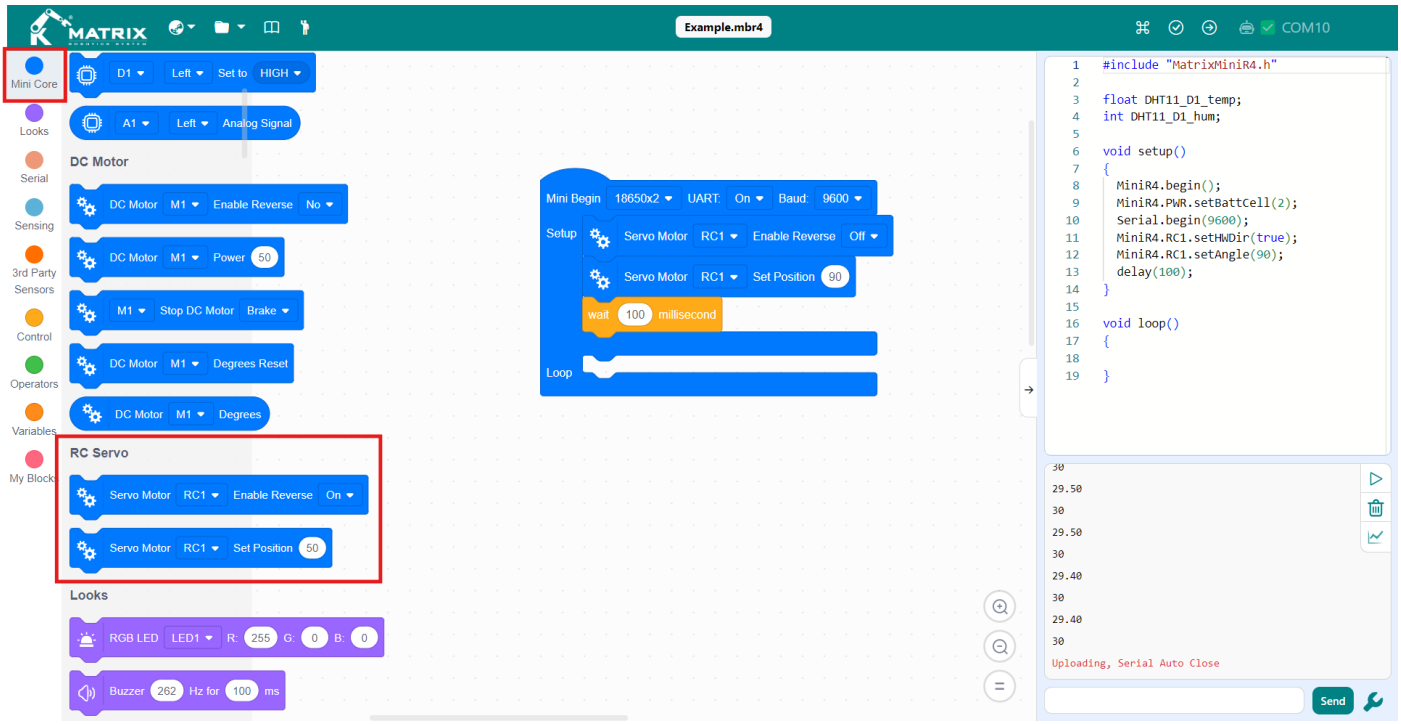
10. RC Servo



Note: *The dot (•) on the motor port indicates the correct side for connecting the ground (GND) wire, which is usually black or sometimes brown in certain motors or servos. Additionally, RC Servos require an external battery power source to function properly.*

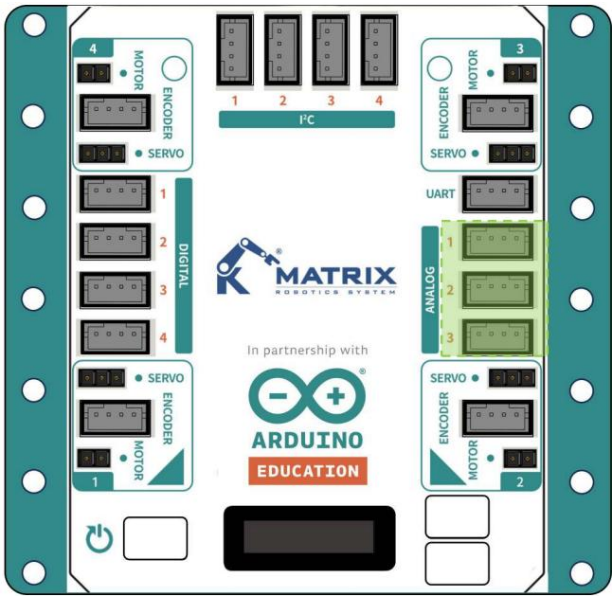
10.1 Sample Code

Hardware Connection: Connect the RC Servo to the M1 port of the MATRIX Mini R4.



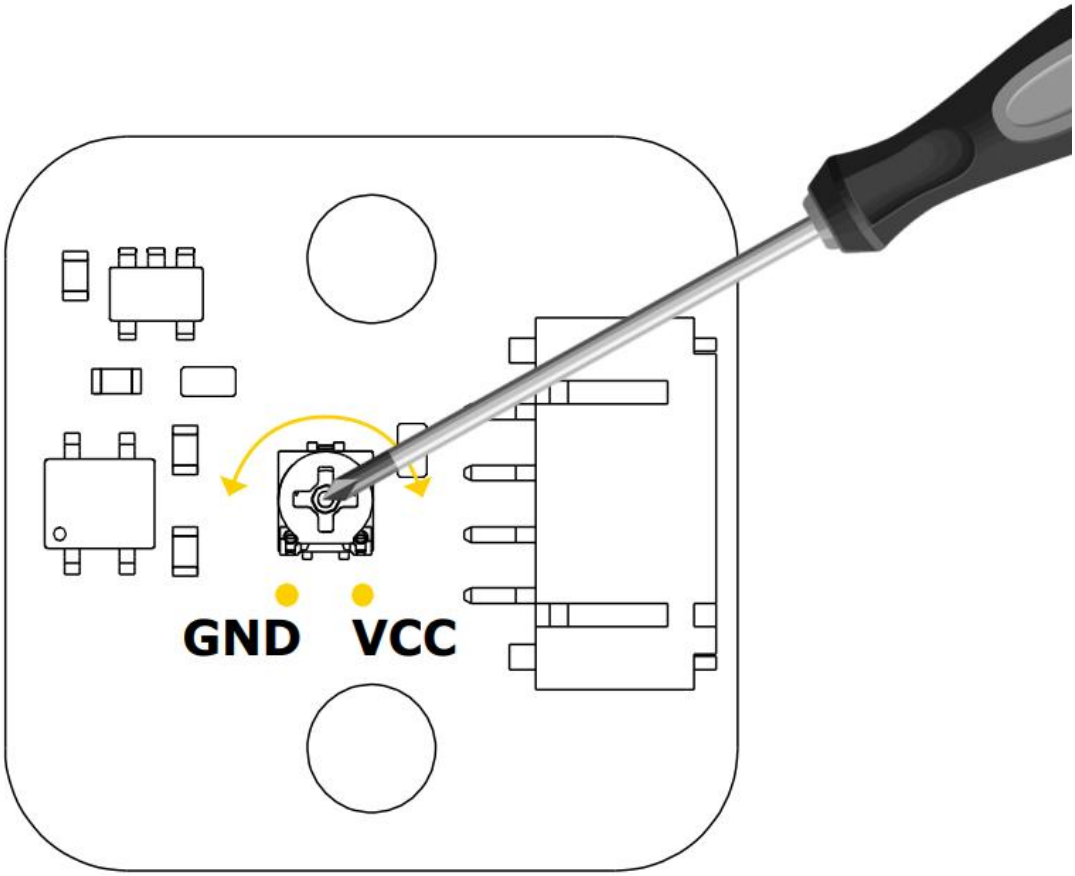
Result: the servo connected to M1 starts to Move and stops on 90°.

11. Gray Scale Sensor



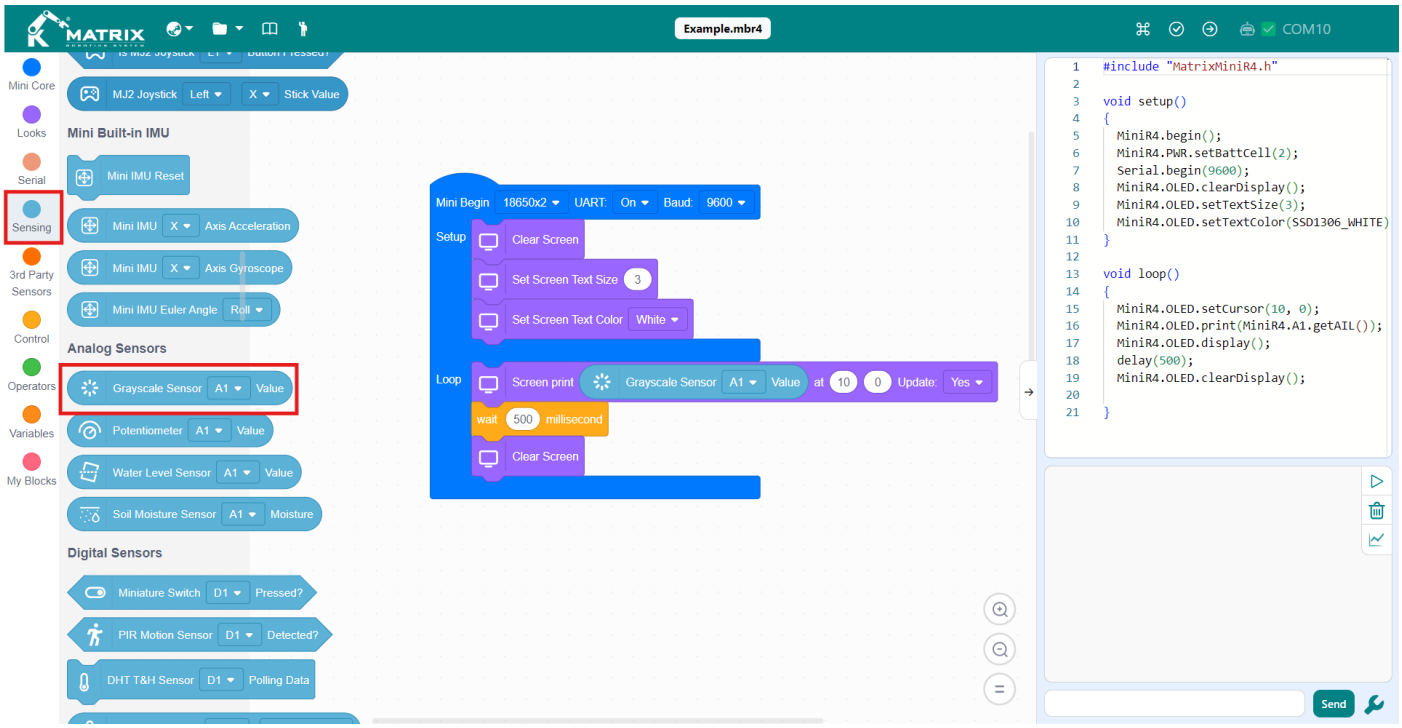
11.1 Usage

AOUT is the IR sensor analog output, the voltage follows IR LED reflection intensity. DOUT only has 0 or 1 state, the changing spot defined by onboard screw. Turn the screw clockwise to bring the gate close to VCC, and turn it counterclockwise to close to GND.



11.2 Sample Code

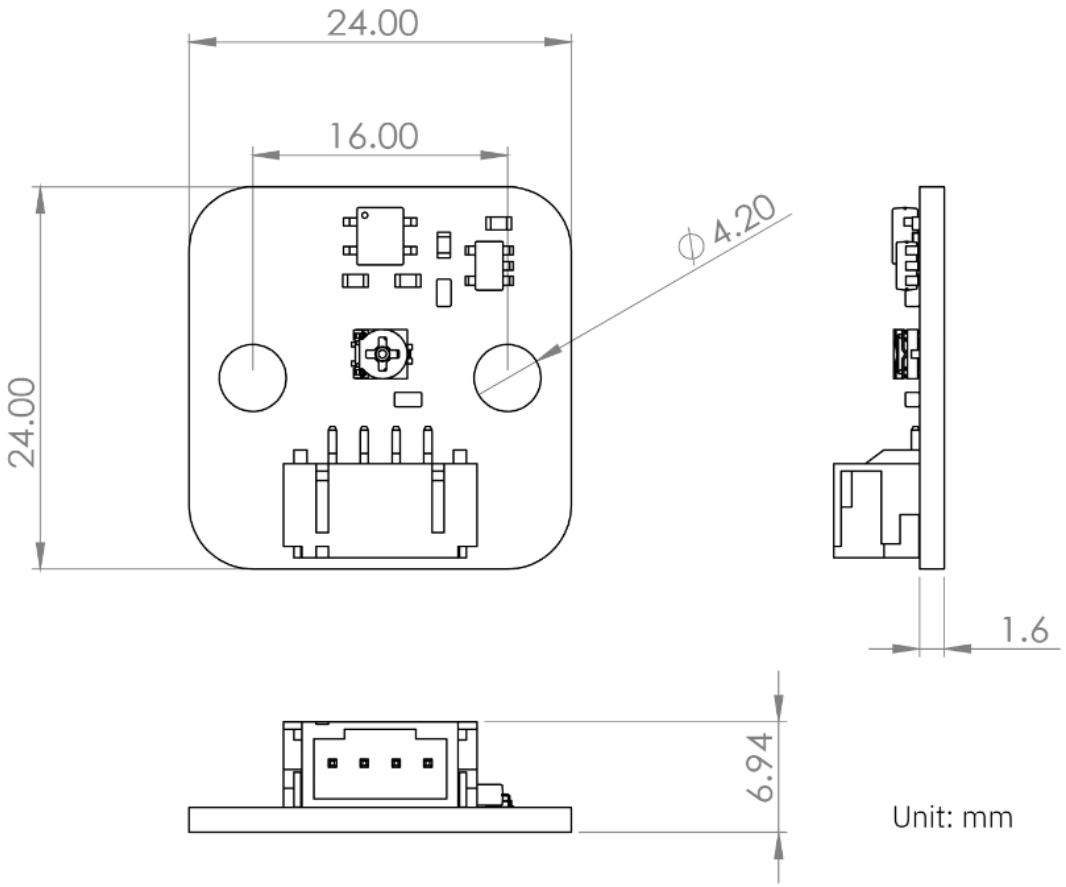
Hardware Connection: Connect the Gray Scale sensor to the Analog1 port of the MATRIX Mini R4.



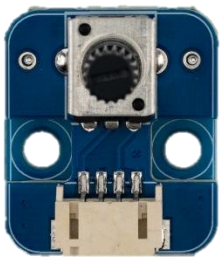
Result: The Gray Scale Sensor value will be shown on the OLED from 0 to 1023. The return value of black is larger and the return value of white is smaller.

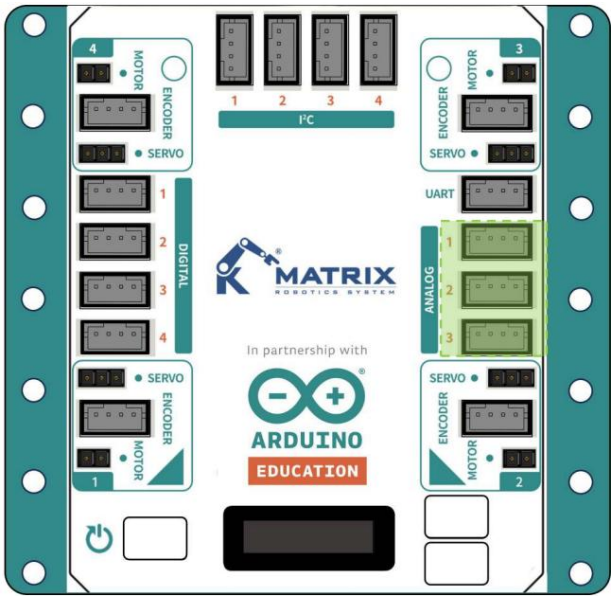
11.2 Specification

Parameter	Min	Typ	Max	Units
Supply voltage (VCC)	3	3.3	5	V
Detection range	-	-	50	mm
IR wavelength	-	940	5	nm
Analog output impedance	-	330	-	KΩ
Digital output impedance	-	10	-	KΩ



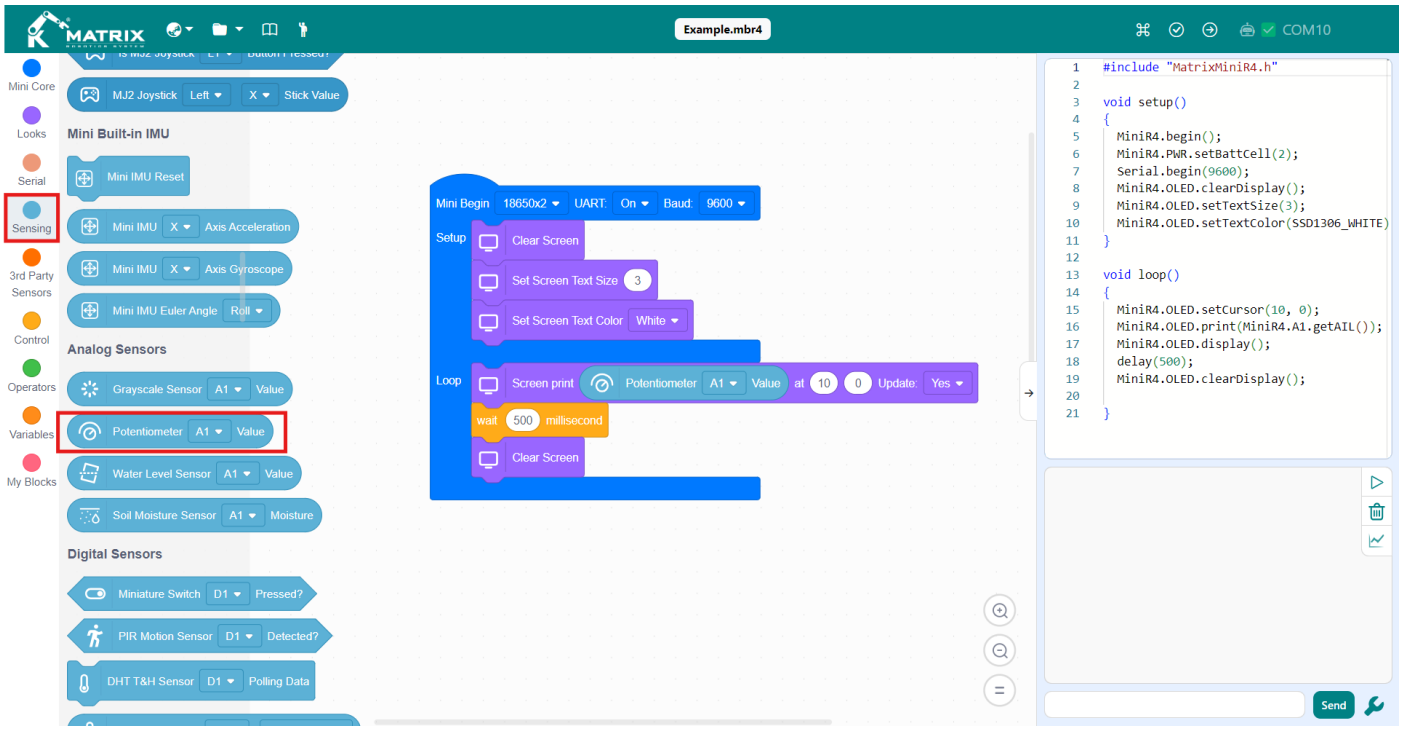
12. Potentiometer





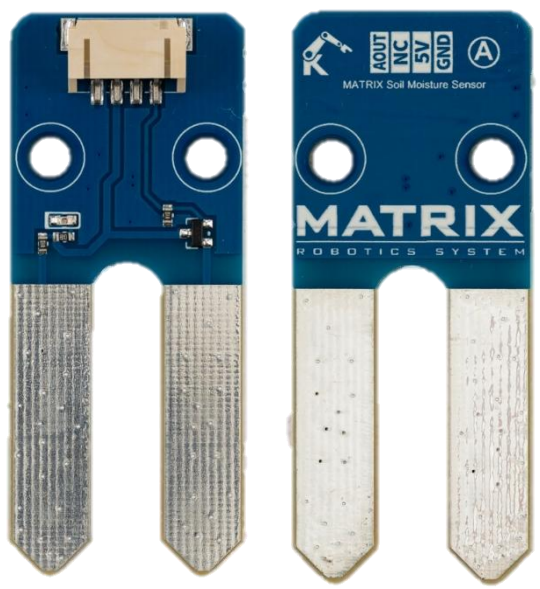
12.1 Sample Code

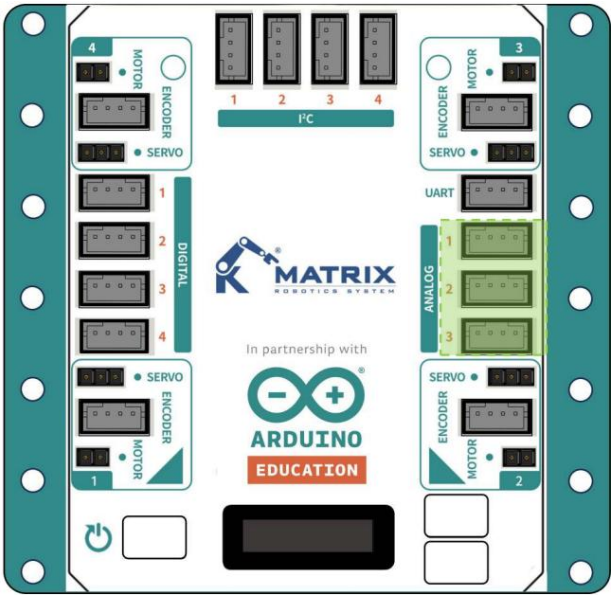
Hardware Connection: Connect the Potentiometer to the Analog1 port of the MATRIX Mini R4.



Result: The Potentiometer value will be shown on the OLED from 0 to 1023.

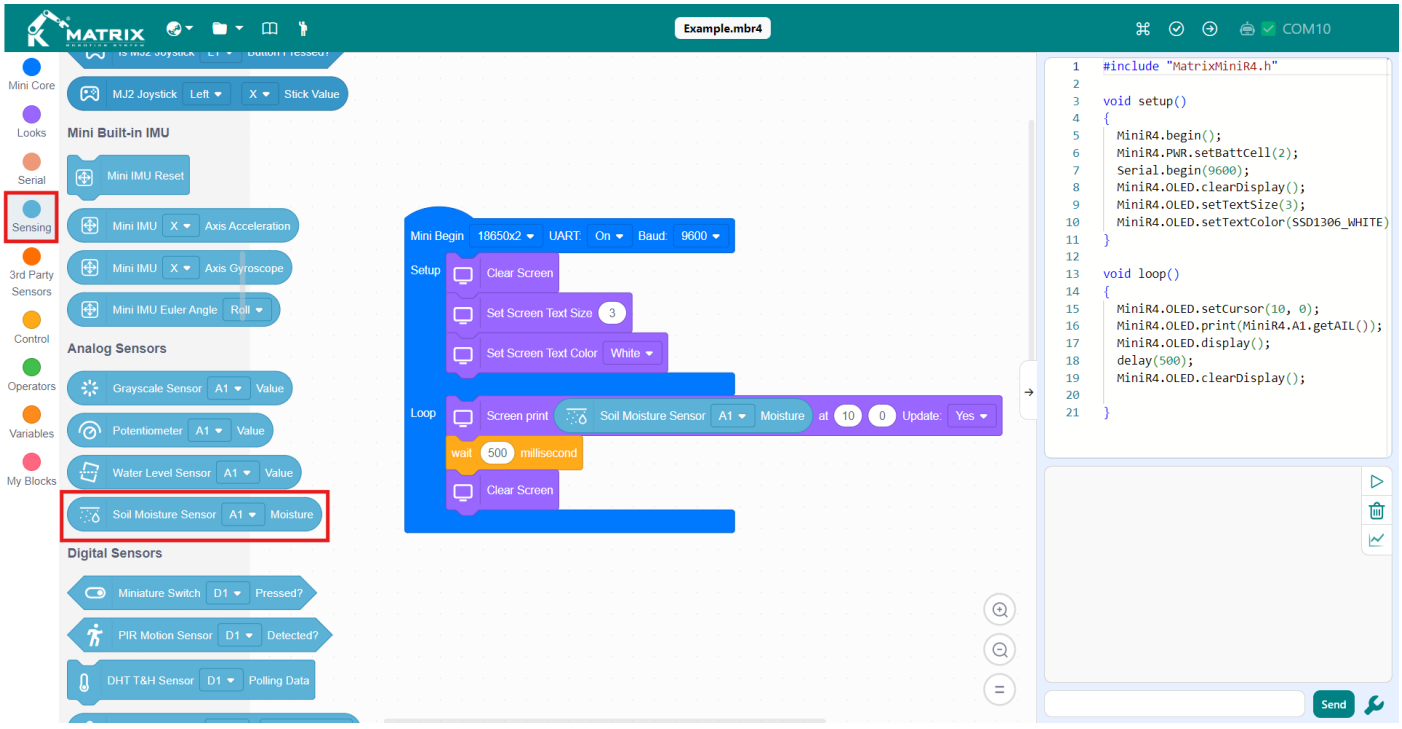
13. Soil Moisture Sensor





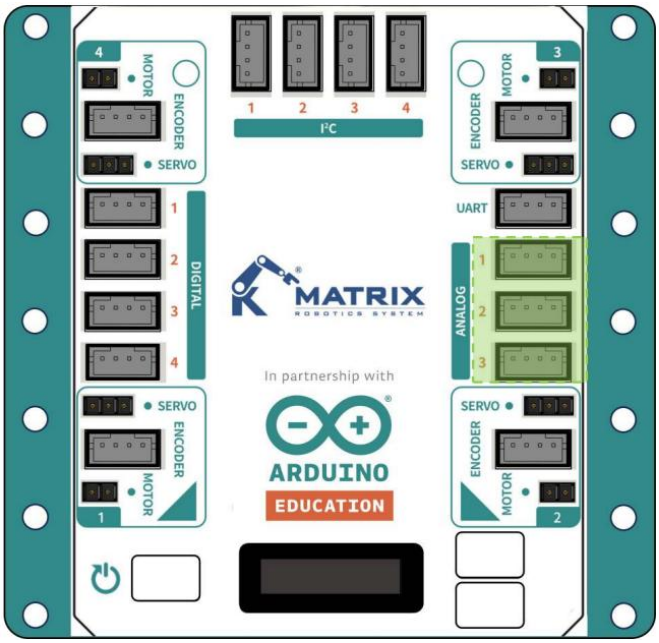
13.1 Sample Code

Hardware Connection: Connect the Soil Moisture Sensor to the Analog1 port of the MATRIX Mini R4.



Result: The Soil Moisture Sensor value will be shown on the OLED from 0 to 1023 (from low moisture to high moisture).

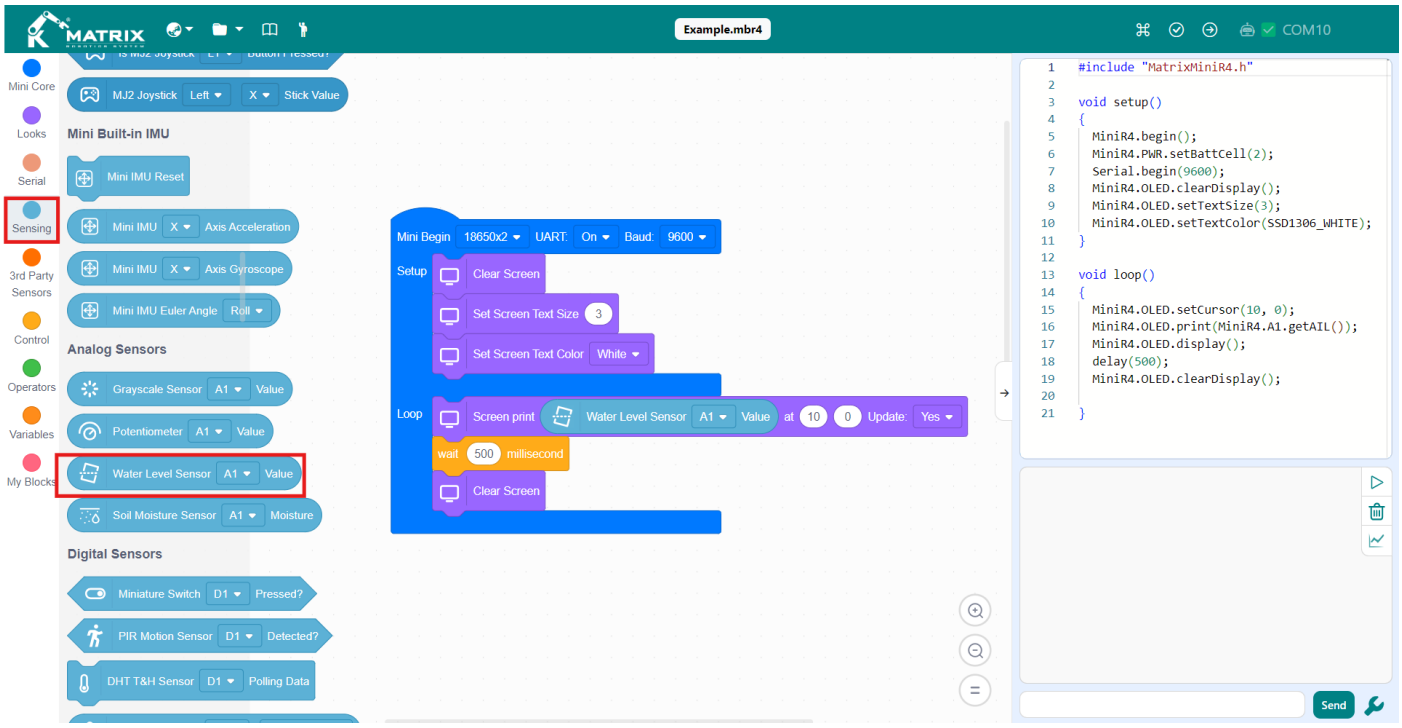
14. Water Level Sensor



Note: *The sensor value is approximately zero when dry, between 300 and 450 when partially submerged, and above 550 when fully submerged.*

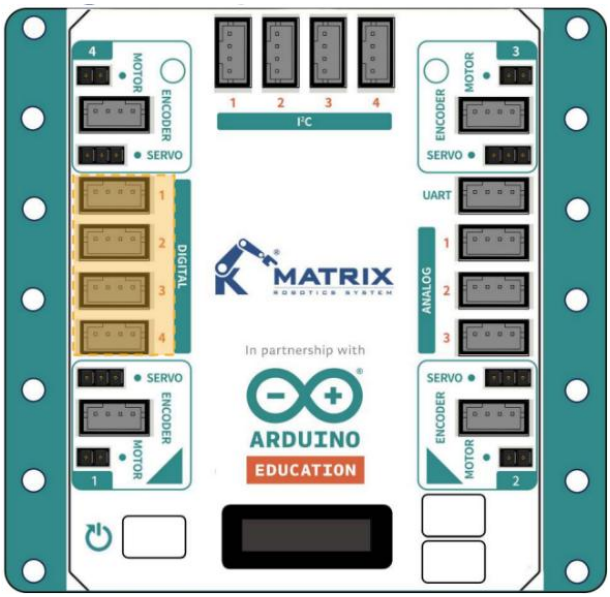
14.1 Sample Code

Hardware Connection: Connect the Water Level Sensor to the Analog1 port of the MATRIX Mini R4.



Result: The Water Level Sensor value will be shown on OLED from 0 to 1023.

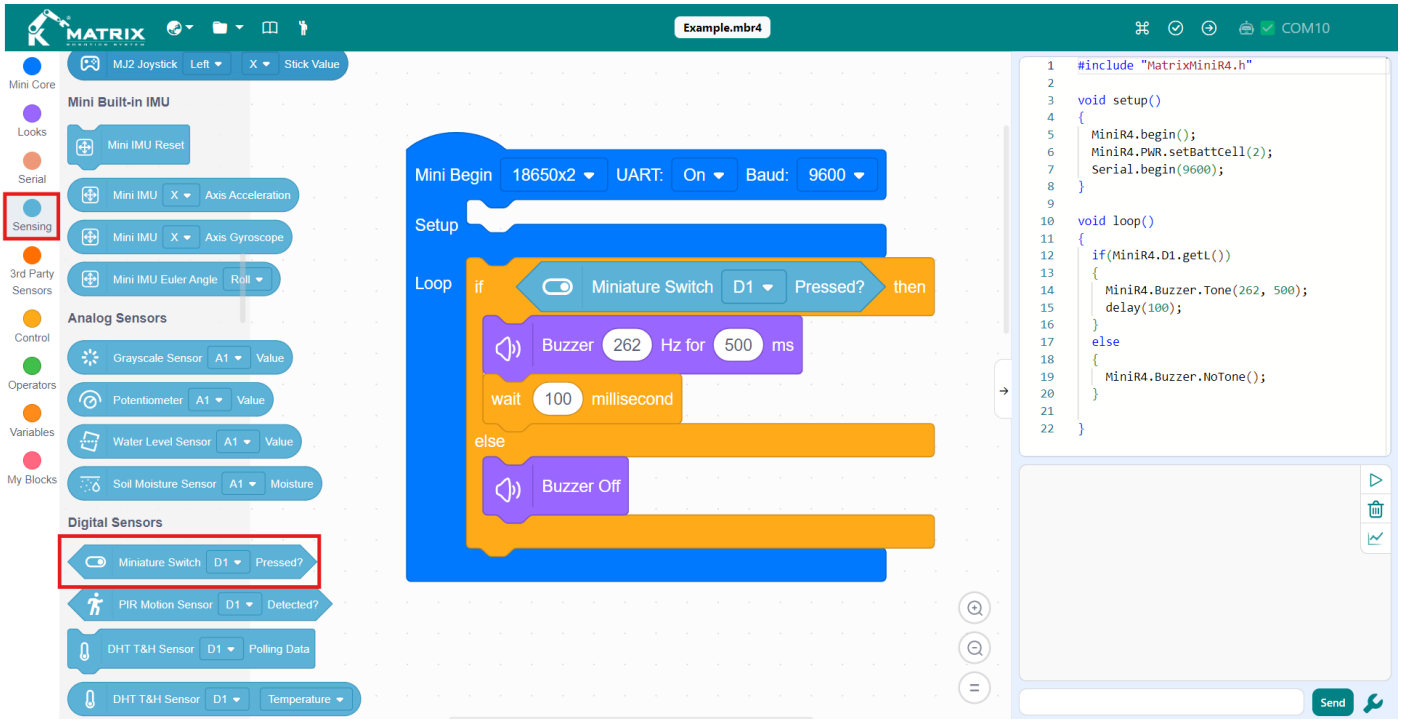
15. Miniature Switch



Note: *the* $\overline{OUT}$ *pin operates in an inverted manner.*

15.1 Sample Code

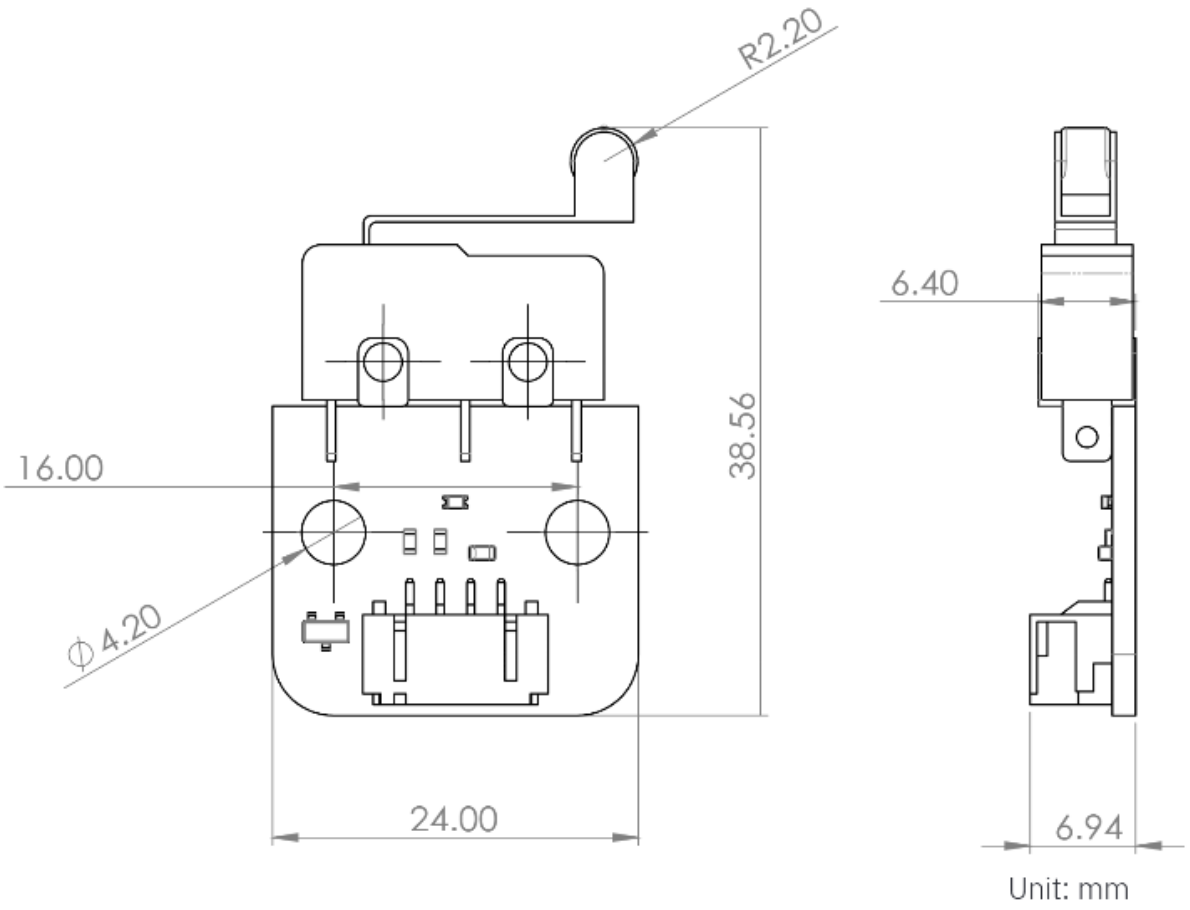
Hardware Connection: Connect the Miniature Switch to the Digital1 port of the MATRIX Mini R4.



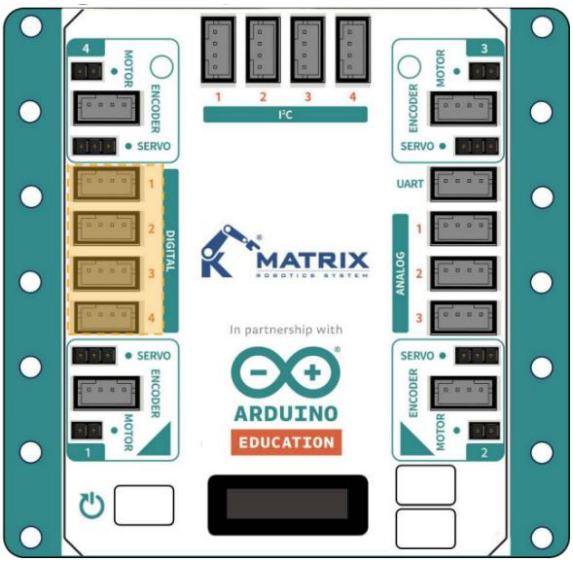
Result: The sound will be played on switch press and will be turned off on switch release.

15.2 Specification

Parameter	Min	Typ	Max	Units
Supply voltage (VCC)	3.3	-	5	V
Operating force	-	-	0.49	N
Switch bounce time	-	-	5	ms



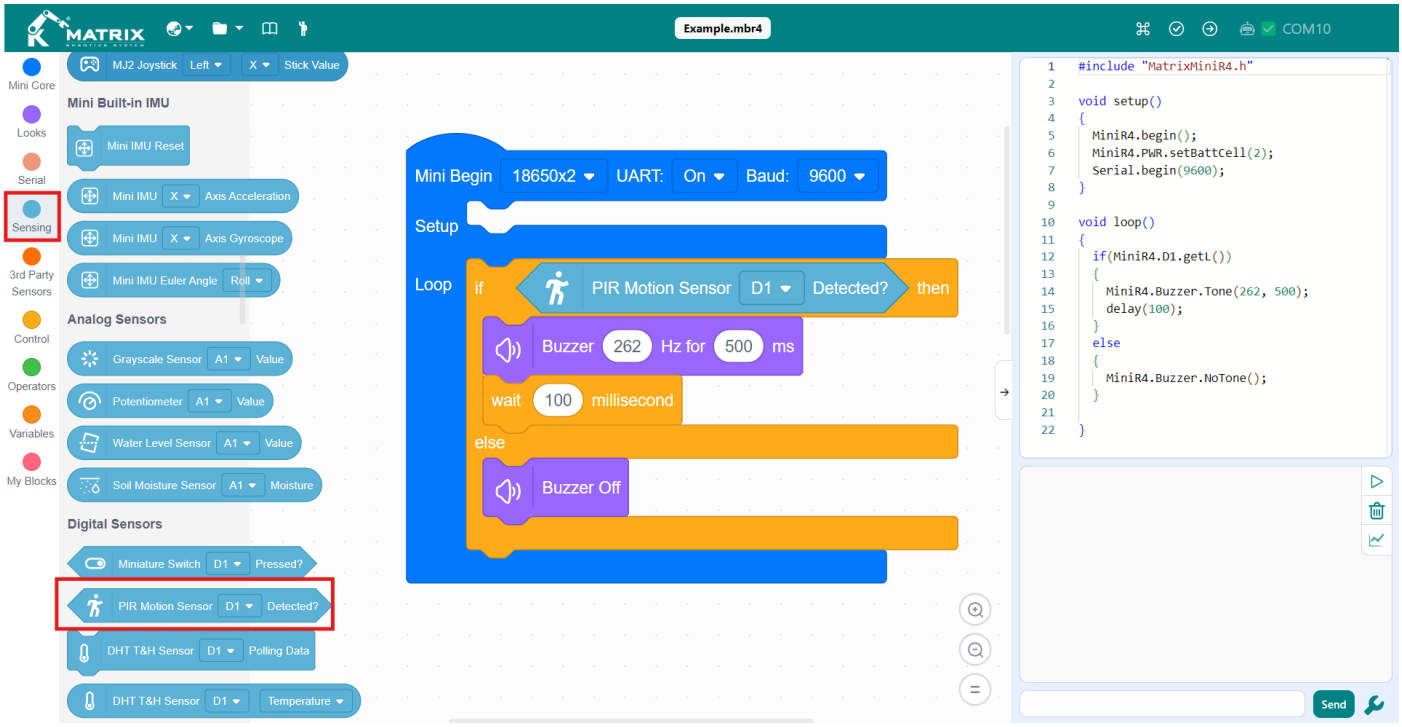
16. PIR Sensor



Note: *The sensor detects heat signature changes from a distance of up to 7 meters within a 100-degree field of view.*

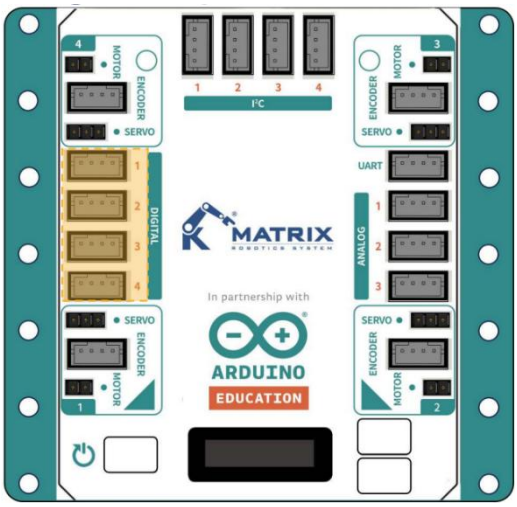
16.1 Sample Code

Hardware Connection: Connect the Miniature Switch to the Digital1 port of the MATRIX Mini R4.



Result: The sound will be played on motion and will be turned off after no motion.

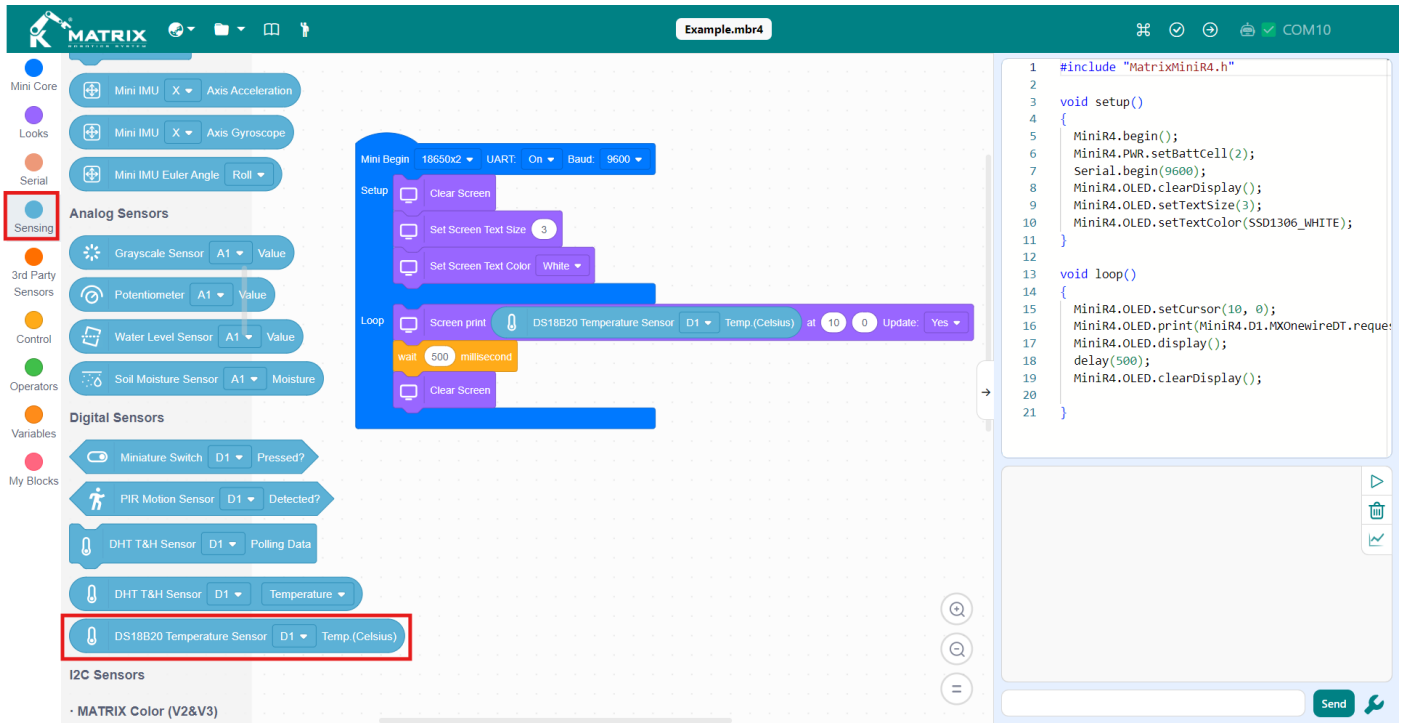
17. Temperature Sensor (one wire)



Note: *The DS18B20 one-wire sensor can measure temperatures from -55°C to +125°C.*

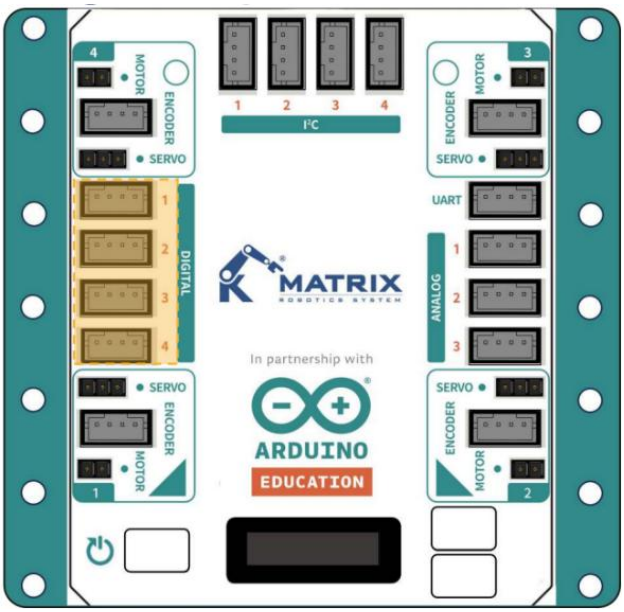
17.1 Sample Code

Hardware Connection: Connect the Temperature Sensor (one wire) to the Digital1 port of the MATRIX Mini R4.



Result: The temperature will be shown on OLED.

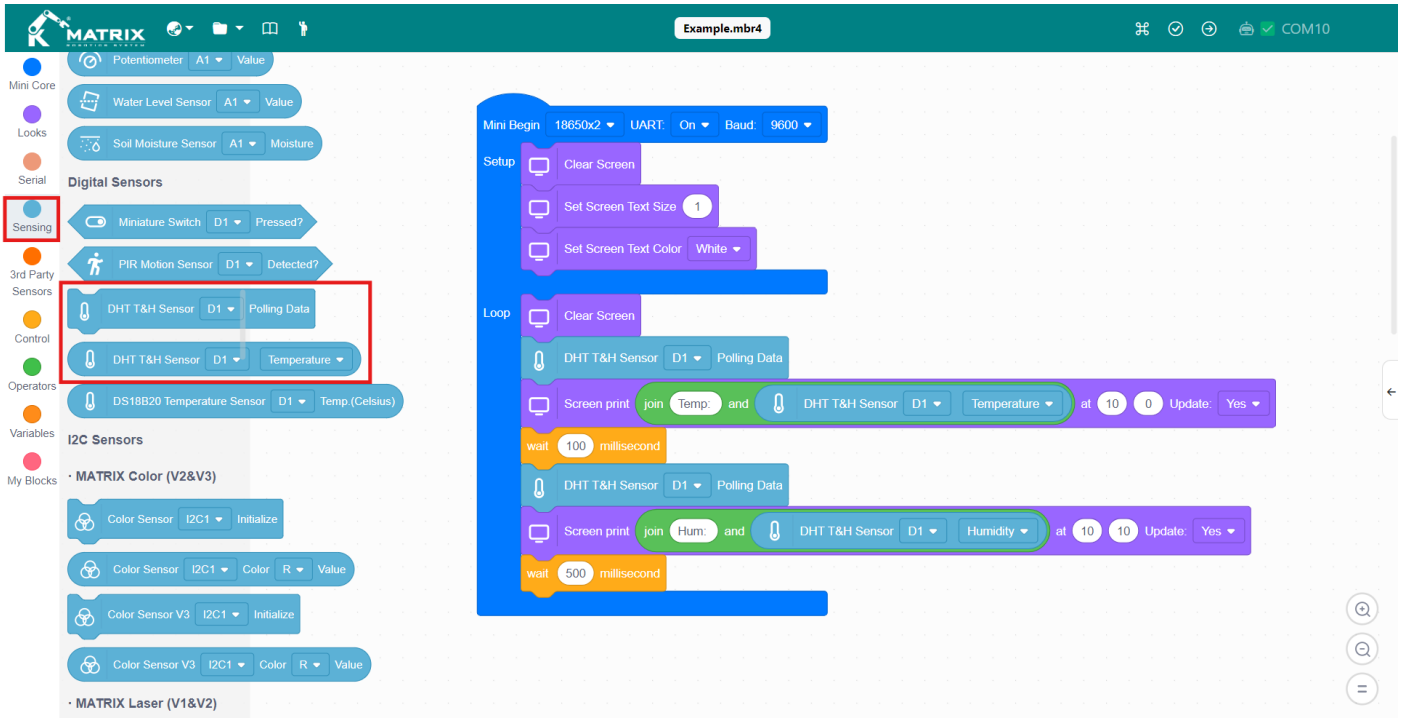
18. Temperature and Humidity Sensor



Note: *The DHT11 sensor has a temperature range of 0°C to 50°C and a humidity range of 20% to 90%.*

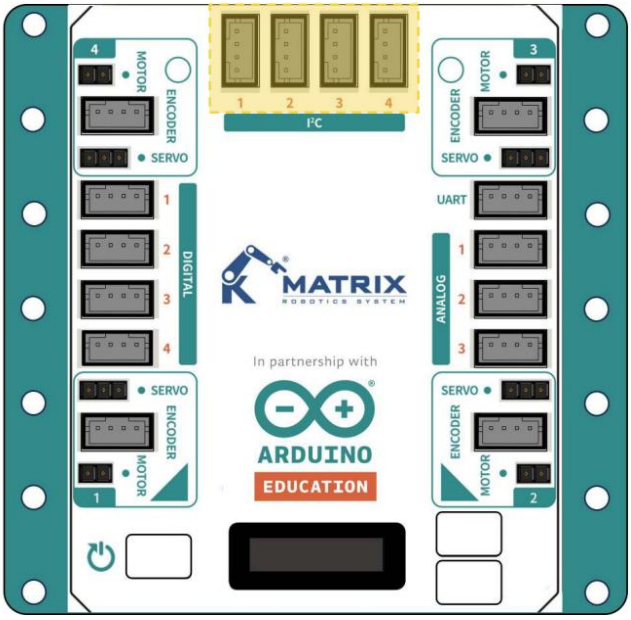
18.1 Sample Code

Hardware Connection: Connect Temperature and Humidity Sensor to the Digital1 port of the MATRIX Mini R4.



Result: The temperature and humidity will be shown on OLED under each other.

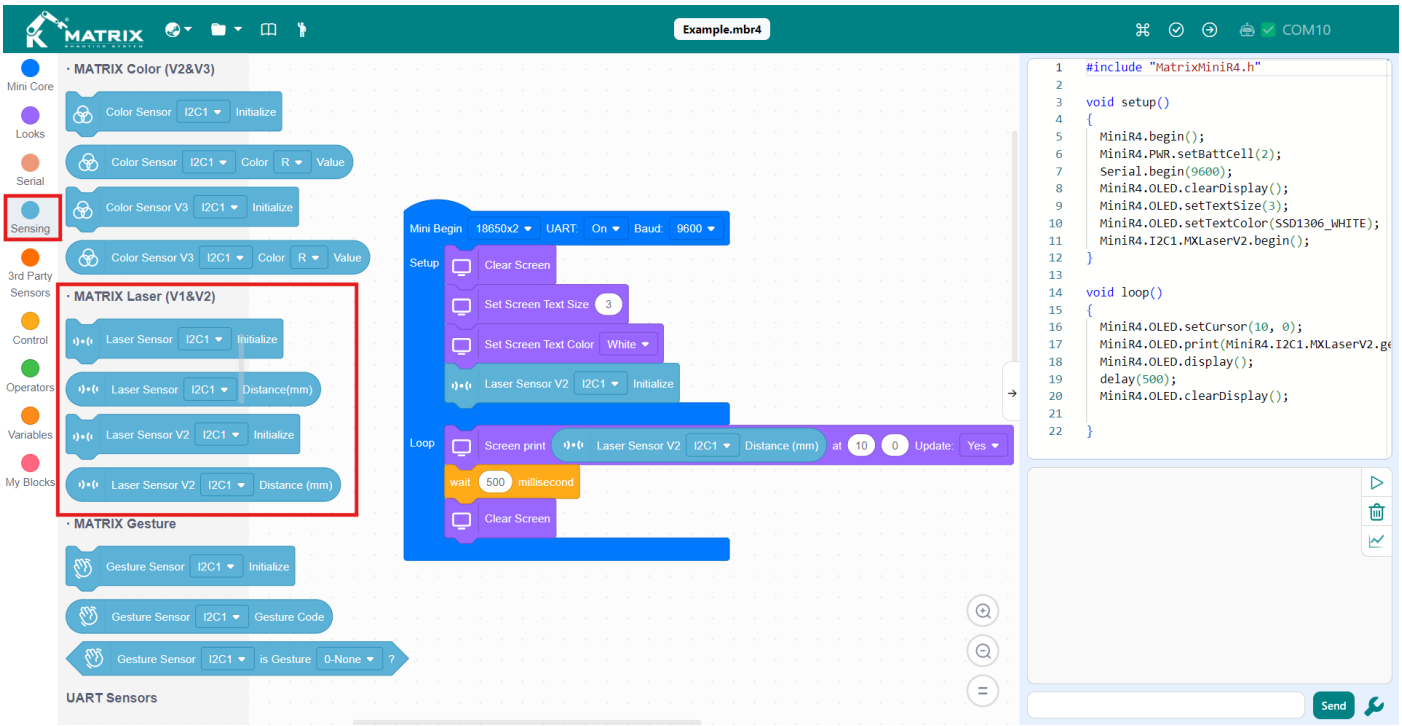
19. Laser Sensor



Note: *The laser sensor that comes with the MATRIX Future Innovators Set is version 2 (V2). If you're using the older version (V1), just make sure to use the block that's made for the V1 laser sensor so everything works correctly. The V2 can measure up to 2 metres.*

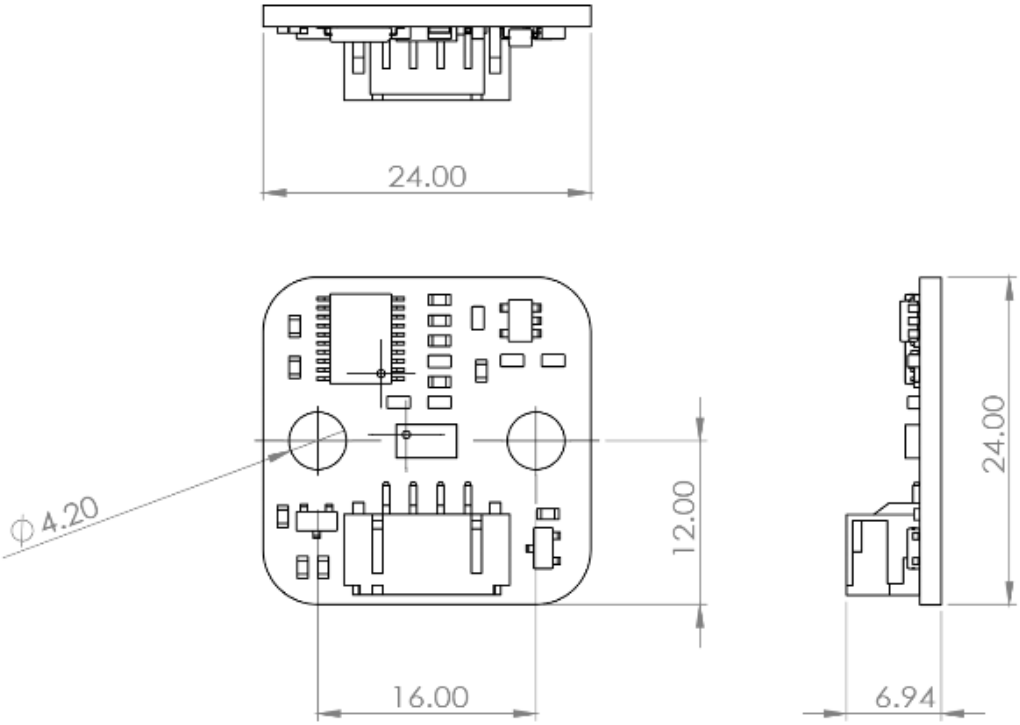
19.1 Sample Code

Hardware Connection: Connect Laser Sensor to the I2C1 port of the MATRIX Mini R4.



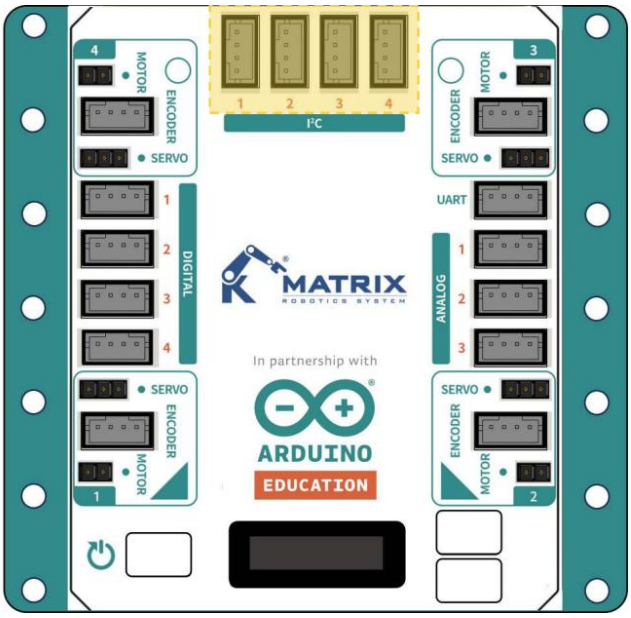
Result: The Laser Sensor value will be shown on the OLED from 50mm to 1200mm.

19.2 Specification



Unit: mm

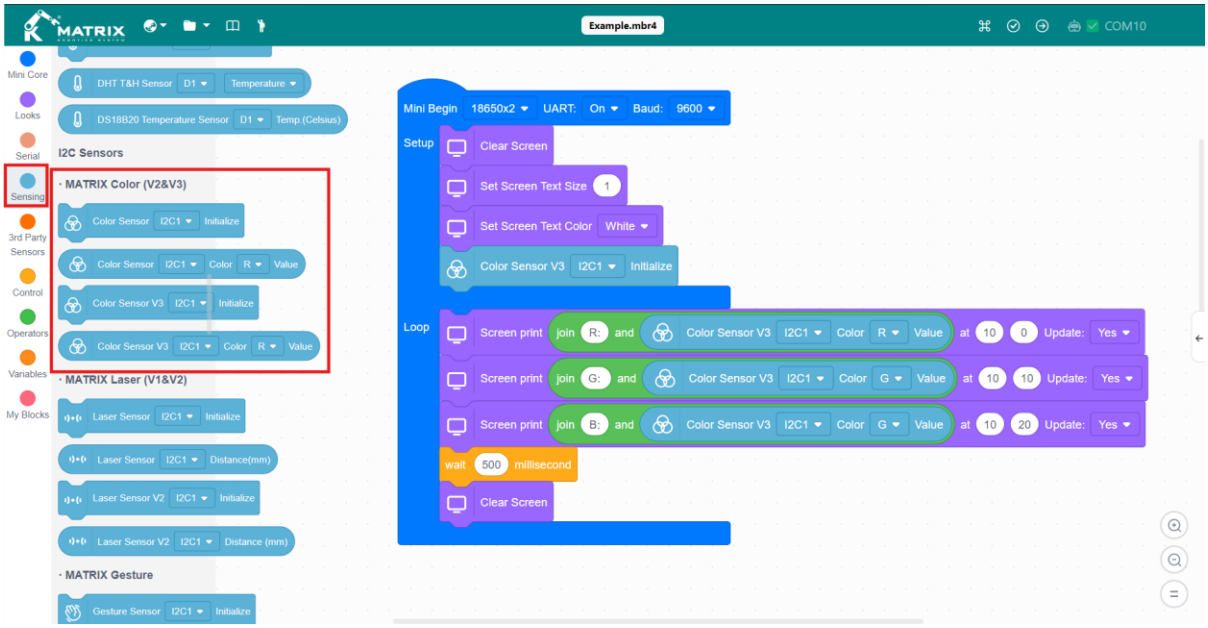
20. Color Sensor



Note: *The colour sensor provided in the Matrix Future Innovators Set is V3, which works with RGBC values. The C in RGBC stands for clear, a no-filter-channel that captures the combined intensity of all visible light, approximating human-perceived brightness. However, if you're using V2, colours are assigned specific numbers: 0 for Black, 1 for White, 2 for Cyan, 3 for Ocean, 4 for Blue, 5 for Violet, 6 for Magenta, 7 for Raspberry, 8 for Red, 9 for Orange, 10 for Yellow, 11 for Spring Green, 12 for Green, and 13 for Turquoise.*

20.1 Sample Code

Hardware Connection: Connect the Colour Sensor to the I2C1 port of the MATRIX Mini R4.

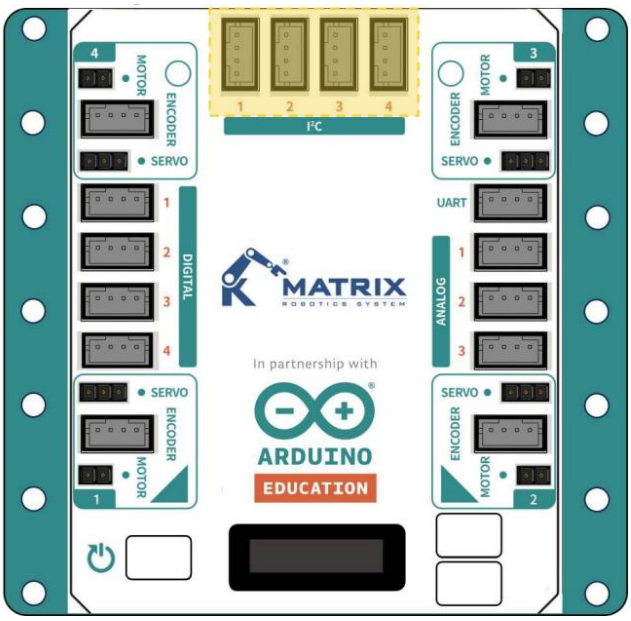


Result: The Colour Sensor RGB value will be shown on the OLED under each other.

20.2 Specification

Parameter	Min	Typ	Max	Units
Supply voltage (VCC)	3	3.3	5	V
Red channel wavelength	-	465	-	Nm
Green channel wavelength	-	525	-	Nm
Blue channel wavelength	-	615	-	Nm
I2C operating speed	100	-	400	KHz
I2C low-level input voltage	-0.5V	-	0.33*VCC	-
I2C high-level input voltage	0.7*VCC	-	VCC	-

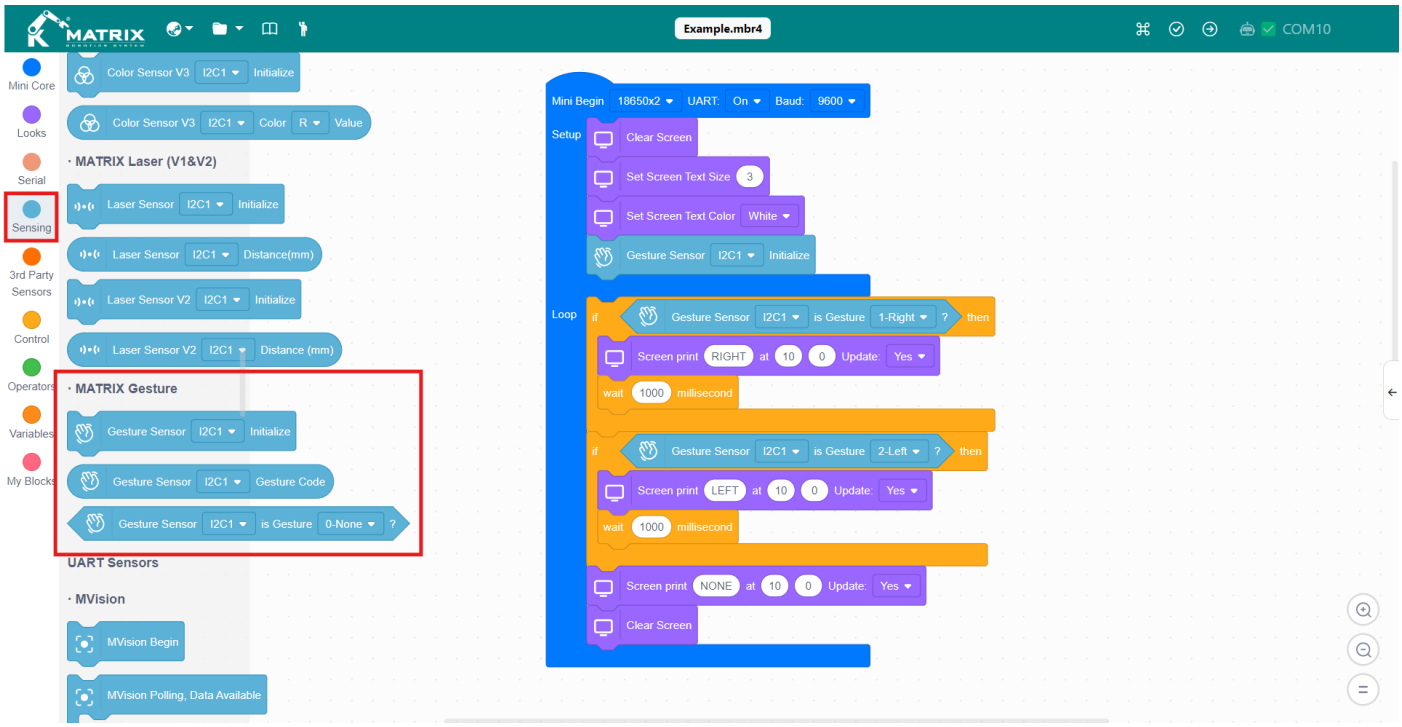
21. Gesture Sensor



Note: *Gesture sensor values are assigned as follows: 0 for None, 1 for Right, 2 for Left, 3 for Up, 4 for Down, 5 for Forward, 6 for Backward, 7 for Clockwise, 8 for Anticlockwise, 9 for Wave. It can detect motion from 5 to 15 centimeters far from sensor.*

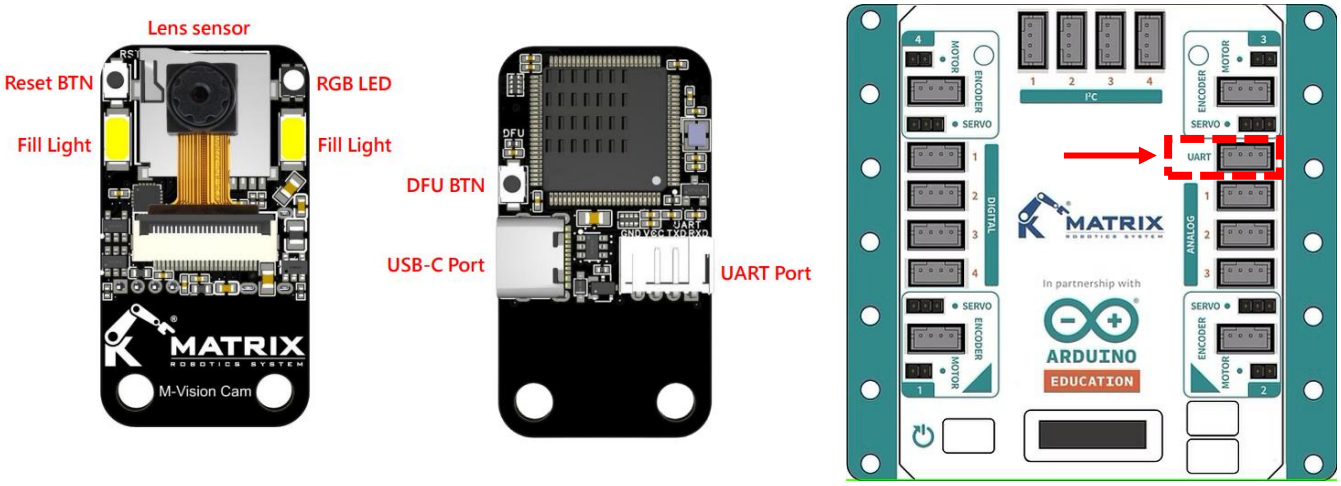
21.1 Sample Code

Hardware Connection: Connect the Gesture Sensor to the I2C1 port of the MATRIX Mini R4.



Result: The OLED will show RIGHT and LEFT on hand gestures.

22. M-Vision Camera

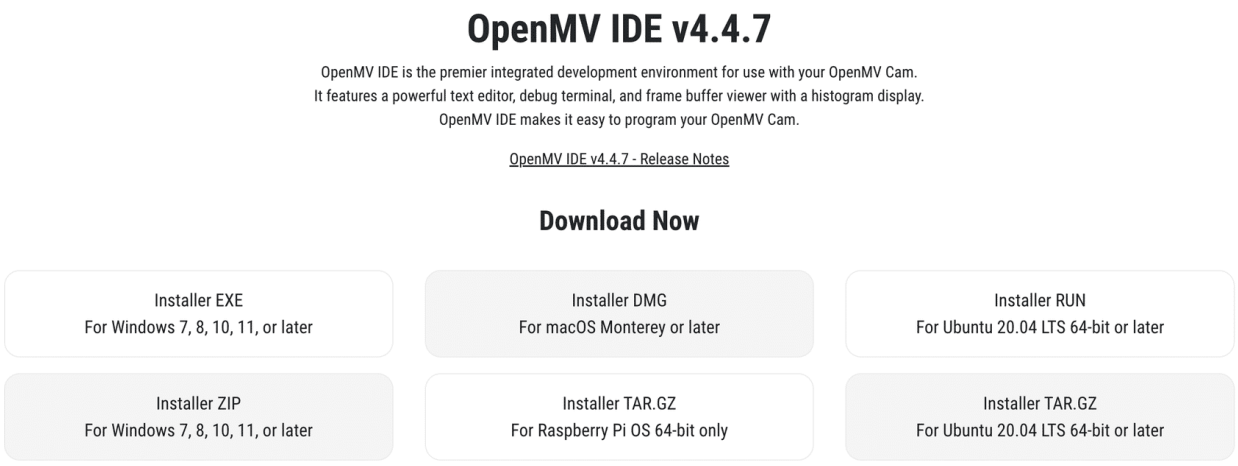


22.1 Overview

- AI camera based on Open MV solutions
- Colour and Object detection
- STM32H7 Processor
- UART and Type- C port

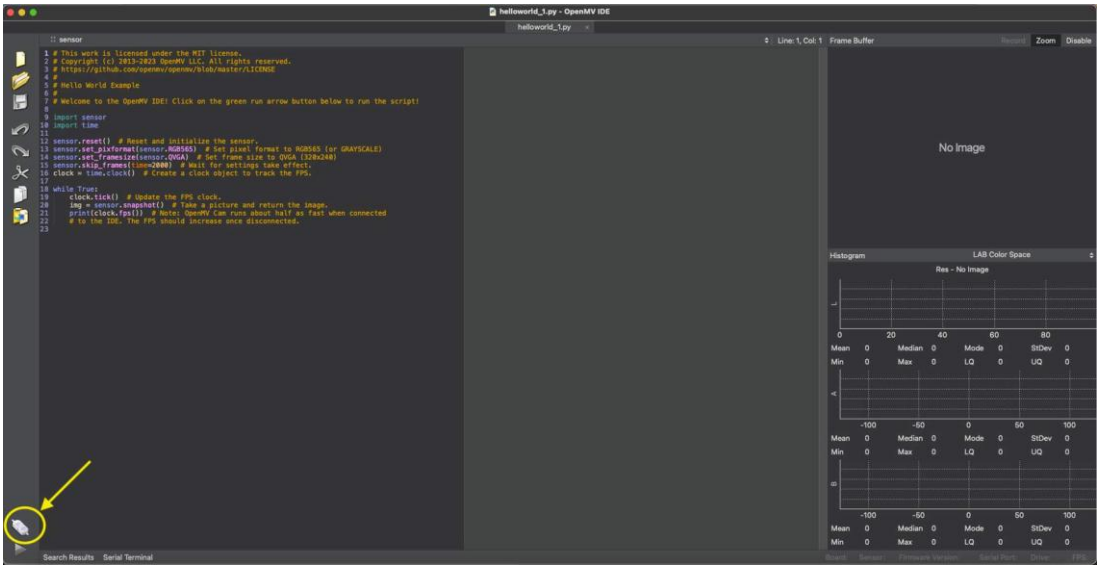
22.2 Setup and Operating Environment for OpenMV IDE

1. Visit the official OpenMV website to download and install the version suitable for your operating system on https://openmv.io/pages/download.

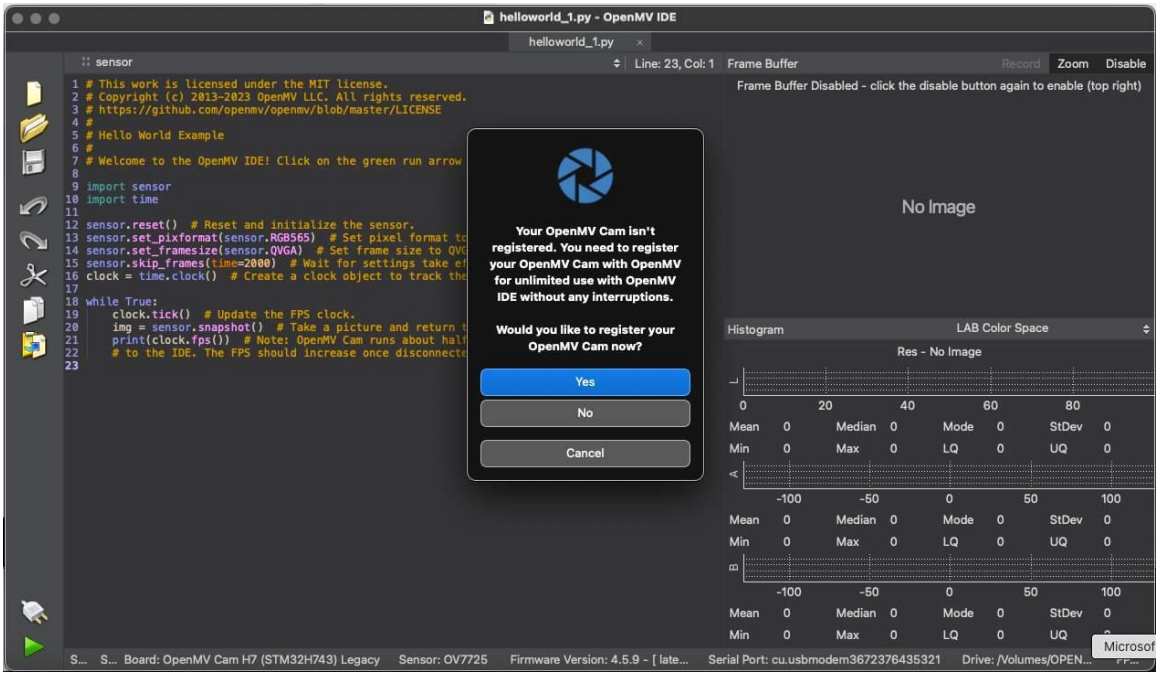


2. After installation is complete, open the OpenMV IDE.
3. Use the USB-A to USB-C cable included in the package to connect your computer to M-Vision Camera. The LED will light up green for a few seconds after the connection is established and then turn off.

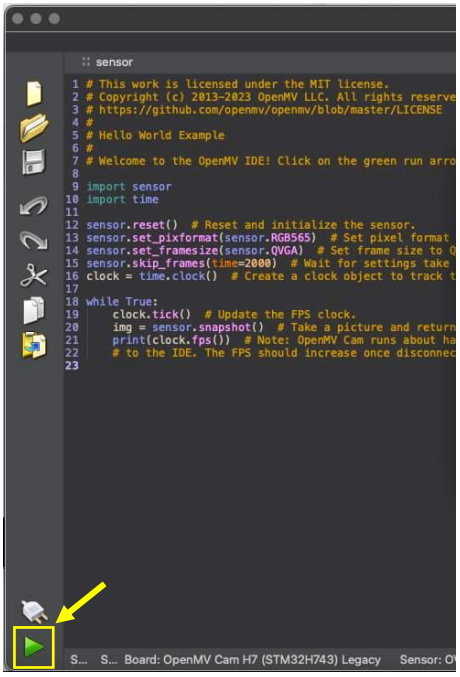
   ***Important Note**: Must use USB-A to USB-C cable to connect M-Vision Camera to the Computer.*
4. Click the connect button in the lower left corner of the OpenMV screen.



5. After successfully connecting M-Vision to the computer, a window will appear asking if you want to register this Camera three times in a row. Just select No or Cancel.

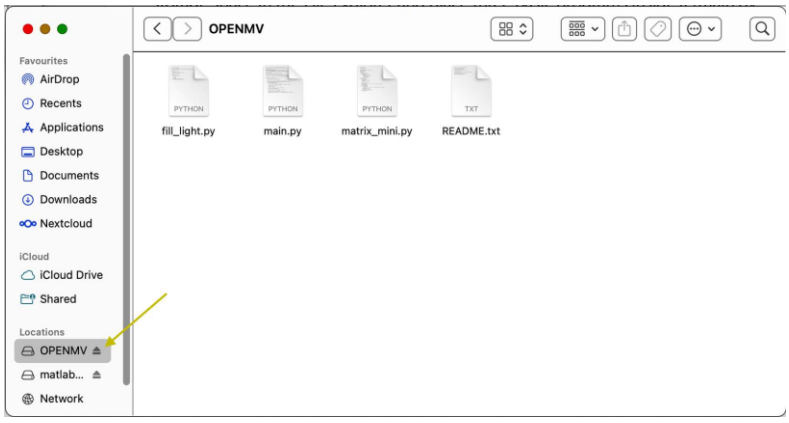


6. When the OpenMV IDE launches, it automatically displays a sample code named “helloworld_1.py”. If it doesn't appear, you can find it under the File > Examples menu. More examples will become accessible once the camera is connected as well.
7. When the camera is connected, the Start (Run Script) button, located in the lower-left corner of the screen, will become active. By clicking it, you can run your first code and view the camera's output. Click the same button again to stop the code.

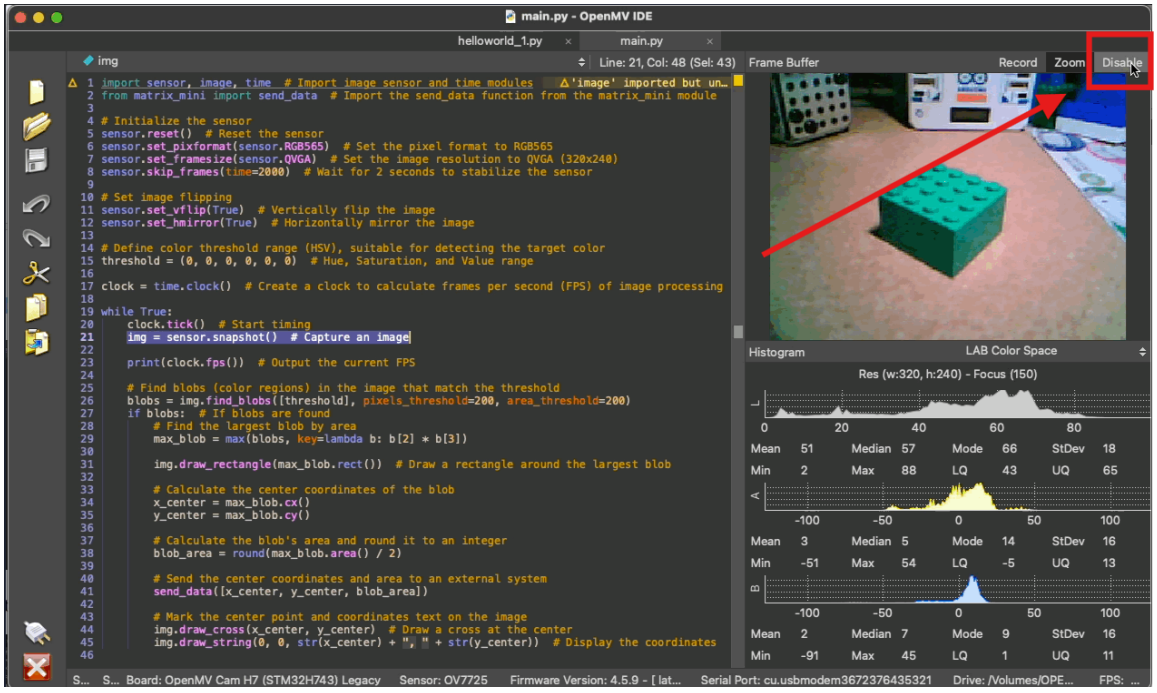


22.3 Getting Started with the Main Code

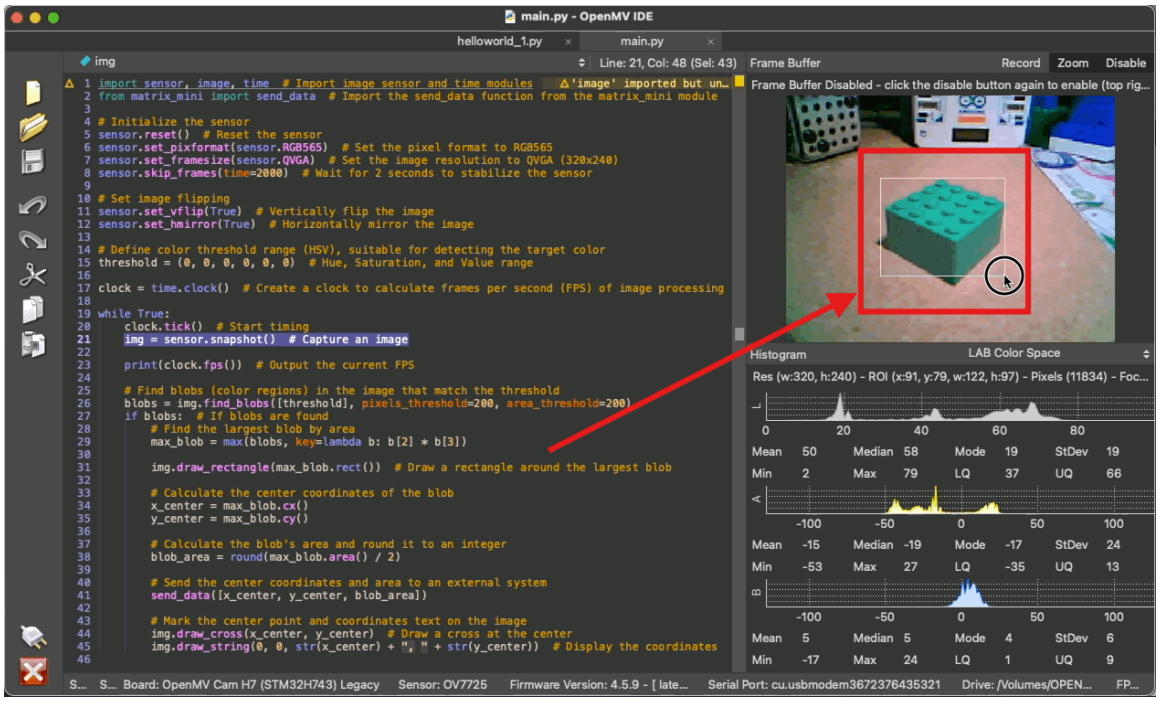
1. Once M-Vision is successfully connected to your computer, its storage space will appear in File Explorer (or Finder on macOS under the Locations section in the left sidebar) with the name "OPENMV". Inside, you will find three basic programs: main.py, matrix_mini.py, and fill_light.py. Alternatively, you can download these files from github.com/Matrix-Robotics/Products-documents/tree/main/Sensors/MVision_Resources/mPython%20Lib(for%20MATRIX%20or%20Arduino) .



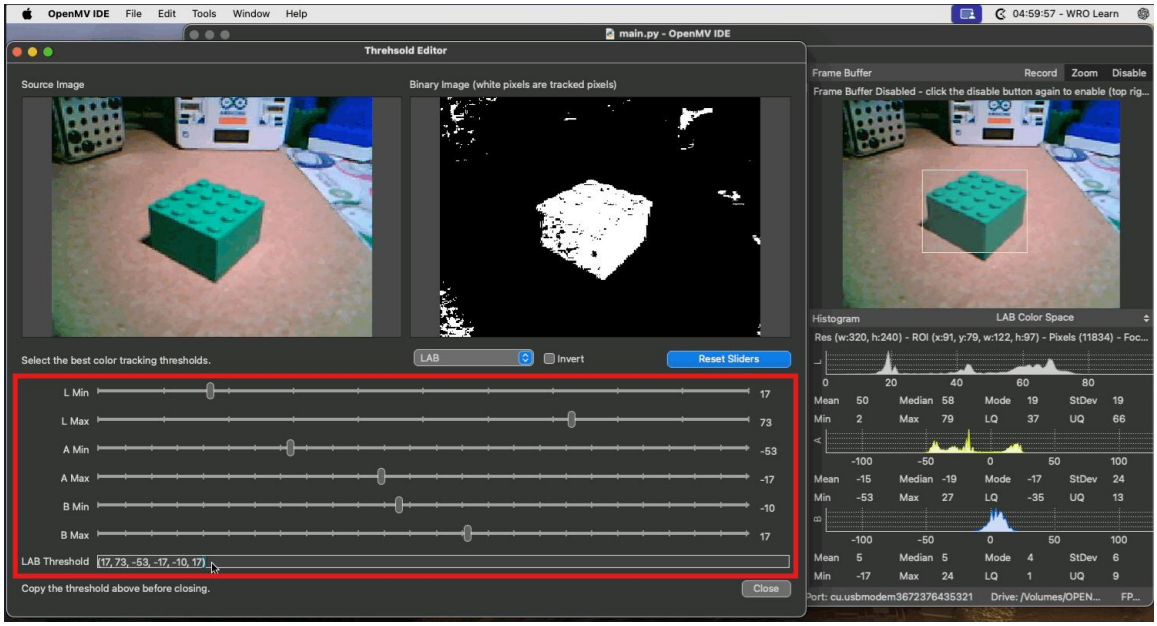
2. Navigate to Files > Open Files in the OpenMV IDE.
3. Select the OPENMV storage space (as explained in the first step) and choose main.py to open it.
4. Run the main.py code.
5. Point the M-Vision Camera at the target and click Disable (located at the top-right corner of the Frame Buffer).



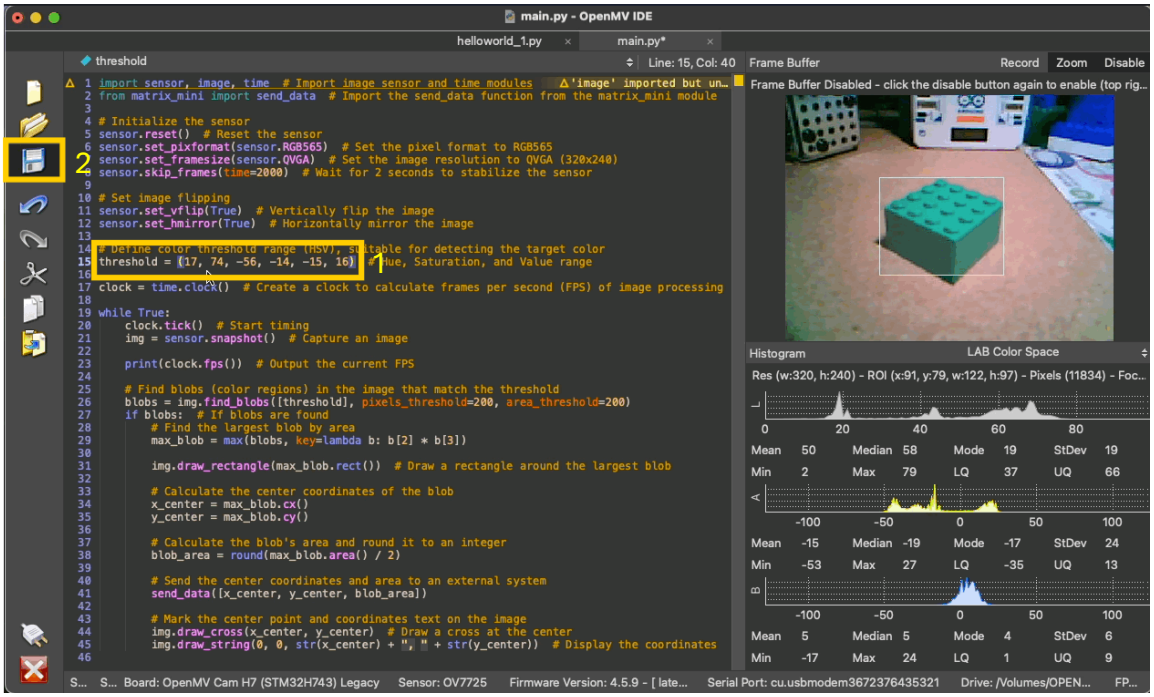
6. Use the mouse to select the target you want the camera to detect.



7. Open the Threshold Editor by navigating to Tools > Machine Vision > Threshold Editor > Frame Buffer.
8. Adjust the LAB threshold to the desired Min and Max values, using the histogram below the Frame Buffer in OpenMV IDE as a reference for the L, A, and B values. Aim to make the desired object appear mostly white while the rest of the area appears black. Once satisfied with the adjustments, copy the threshold values and close the Threshold Editor.

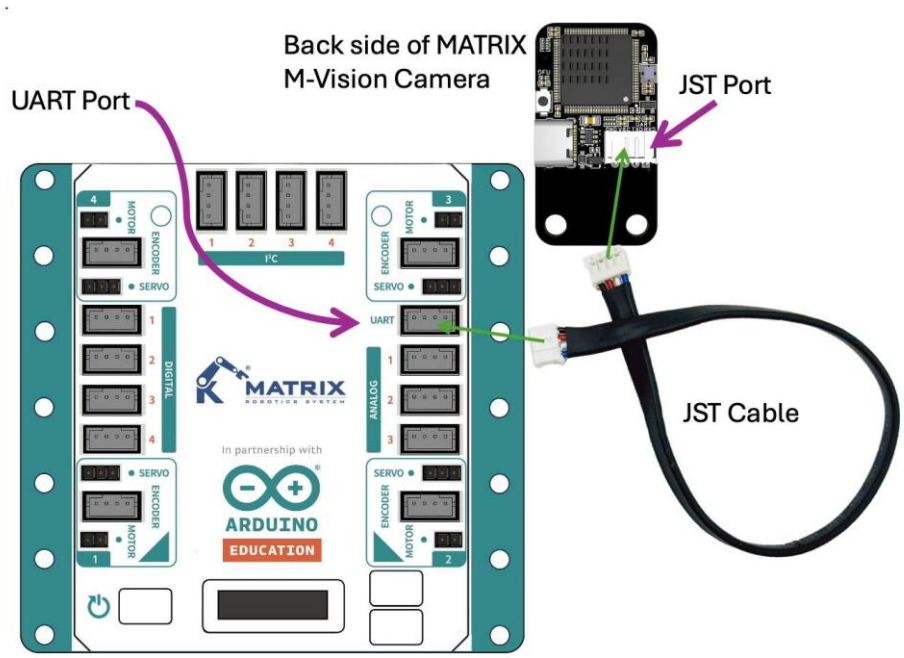


9. After copying the LAB threshold values and closing the Threshold Editor window, replace the threshold values in your main.py code. Make sure to save the changes. When the Red LED light turns off, the data is saved, and the Camera is ready to use.

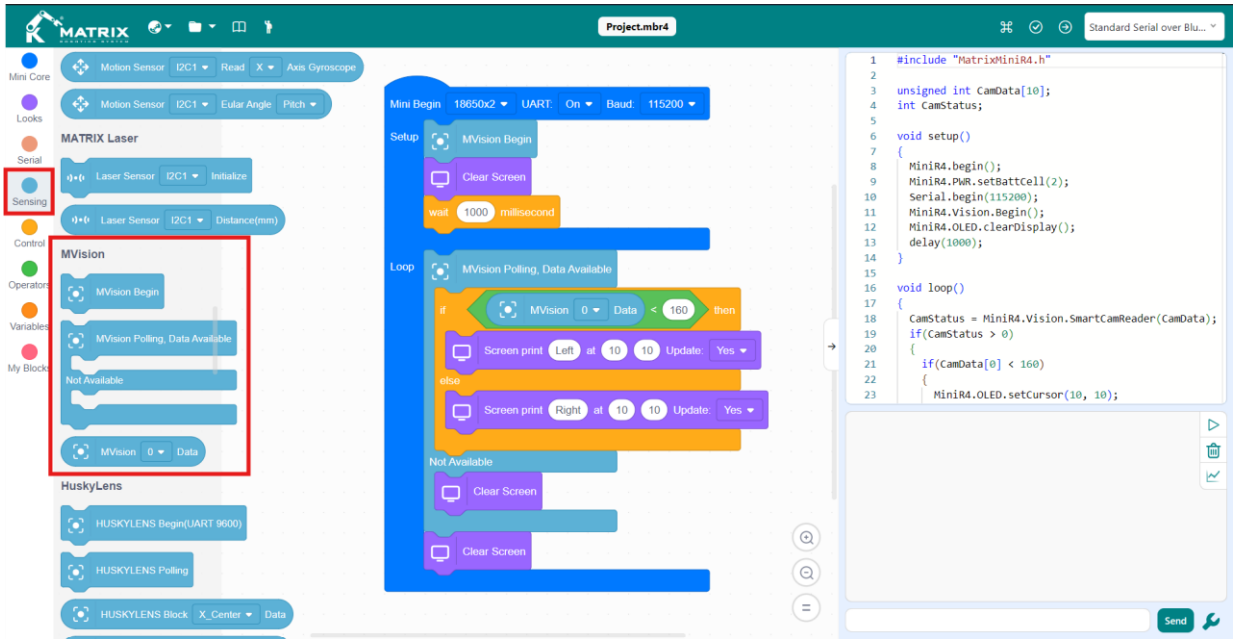


22.4 Connecting and Programming the M-Vision Camera with MATRIXblock

1. Use the USB-C cable to connect the MATRIX Mini R4 microcontroller to the computer.
2. Use JST Cable to connect M-Vision Camera to the UART port of MATRIX Mini R4.



3. Open MATRIXBlock on your computer.
4. Write the following code in MATRIXBlock to detect an object's position and display "Left" or "Right" on the OLED screen:



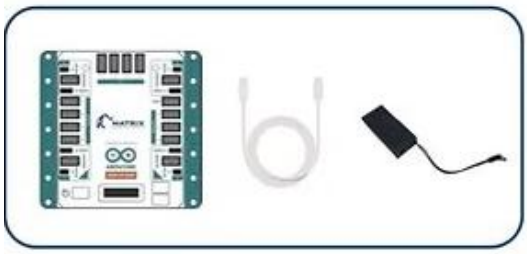
5. **Select the correct device** in MATRIXBlock.
6. Click on the **"Verify and Upload"** button (top right of the screen) to upload the code and test the results

22.5 Specifications

Parameter	Specification
Processor	STM32H7
Clock Speed	480 MHz
Flash Memory	2 MB (User available: ≥100 KB)
SRAM	1 MB
Storage Expandability	Supports up to 32 GB SD card
Max Supported Resolution	640×480 and below
Operating Voltage	5V
Operating Current	200mA (without fill-in light) / 350mA (with fill-in light)
Interfaces	USB Type-C, PH2.0-4P (UART communication)
Mounting Holes	M4 × 2

23. Packing List

23.1 Electrical Components



MATRIX Mini R4 Controller

TT Encoder Motor with metal gear box & Brackets(1 Pair)

TT Motor with metal gear box & Brackets(1 Pair)

2x Micro Servo with metal gear box

PIR Motion Sensor

Water Level Sensor

2x Color Sensor V3

Soil Moister Sensor

Temperature & Humidity Sensor

Grayscale Sensor V3

2x Laser Sensor V2

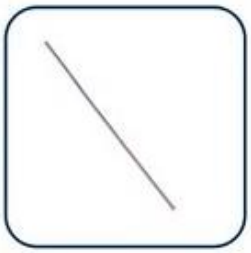
2x Miniature Switch V3

Potentiometer Sensor

Gesture Sensor

One Wire Temperature Sensor

10x JST Cable 200mm



10x JST Cable 400mm

10x JST Cable 600mm

5x JST to Grove Cable

23.2 Construction components

24. Additional Details and References

www.matrixrobotics.com

github.com/Matrix-Robotics/Products-documents/tree/main

www.arduino.cc