INTRODUCTION TO MICROPYTHON

GETTING STARTED WITH BBC MICRO:BIT

Juliana Karoline de Sousa | @julianaklulo

JULIANA KAROLINE DE SOUSA | @JULIANAKLULO

- ➔ **Bachelor of Computer Science** | UFSCar
- ➔ **PyLadies São Carlos** | co-founder & organizer
- ➔ **Grupy-Sanca** | co-founder & organizer
- ➔ **Omnivector** | software engineer
- ➔ **IoT, robotics, 3D printing & kitties :3**

Disclaimers

1

No sponsors

This tutorial is not sponsored

2

Be careful

Please handle the equipment with care

3

Return

Don’t forget to return the devices before leaving the room

4

Have fun!

Agenda

01. MicroPython

Overview about MicroPython

02. BBC micro:bit

Overview of the device and the specifications

03. Python editor

Using the Python editor and built-in simulator

04. Examples

Experimenting with the device's components

05. Battleship

Build the single player version of the game

06. Challenge

Make the game multiplayer

01.

MicroPython

Python for microcontrollers

What is MicroPython?

Reimplementation of Python 3 targeted to microcontrollers

But what is a microcontroller?

Microcontroller

Integrated Circuit

Processor, memory and peripherals all on a single chip

I/O Capabilities

Built-in input/output ports to interact with sensors and actuators

Programmable

Can store persistently user-defined code in memory

Low power consumption

Suitable for battery powered applications

MicroPython

Key points:

- Re-implementation of Python 3, written in C
- Contains a small subset of the standard library
- Optimized for constrained environments

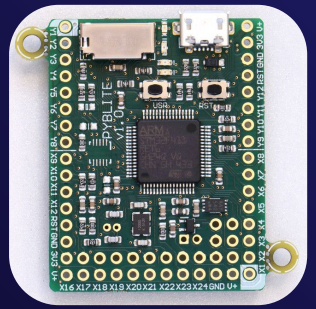
Features:

- Interactive prompt (REPL)
- List comprehensions, generators, closures
- Exception handling
- Access to GPIO, PWM, ADC, UART and more

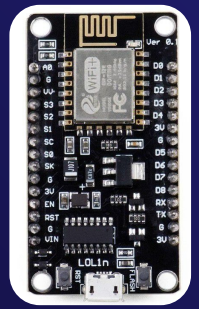
Requirements:

- 256k code space
- 16k RAM

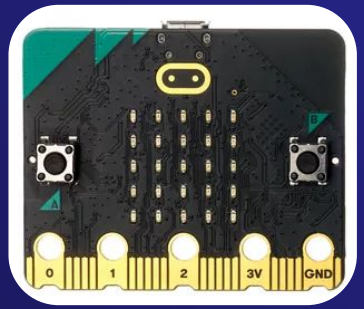
Microcontrollers with MicroPython



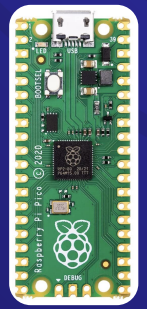
PyBoard



ESP8266 & ESP32



BBC micro:bit



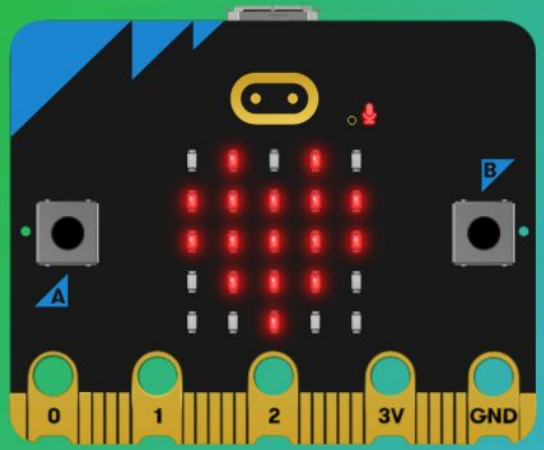
Raspberry Pi Pico

Arduino Nano RP2040

02.

BBC micro:bit

Pocket-sized computer for physical computing



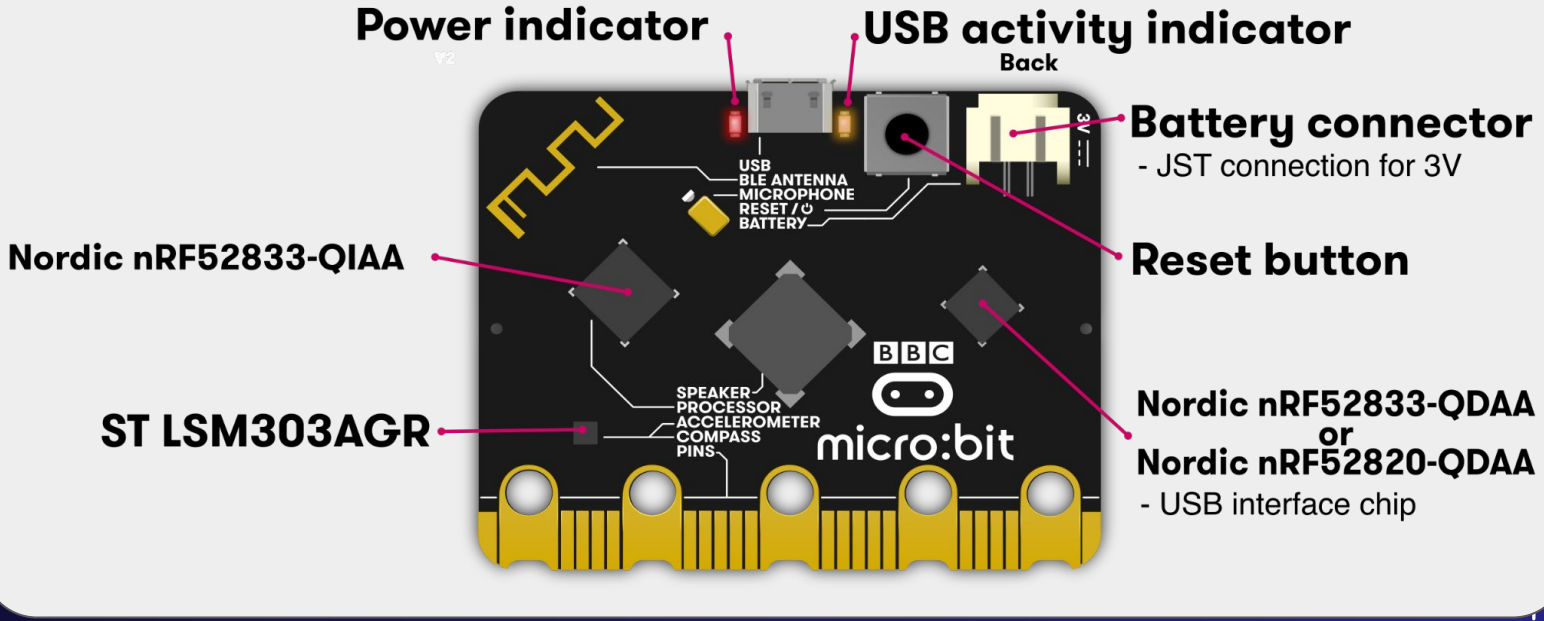
Create | Learn | Code

Get creative, get connected, get coding!

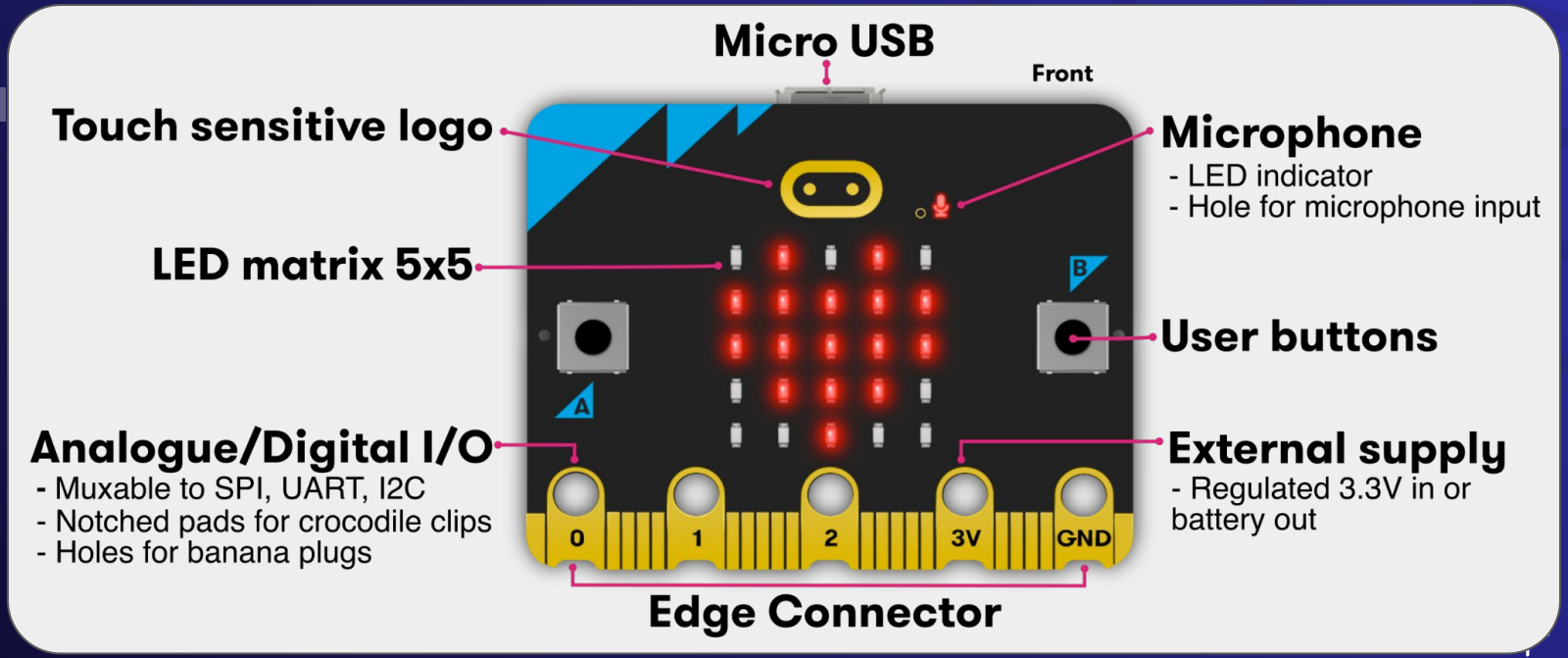
What is the BBC micro:bit?

Pocket-sized computer that introduces you to how software and hardware work together

Which components are included?



Which components are included?

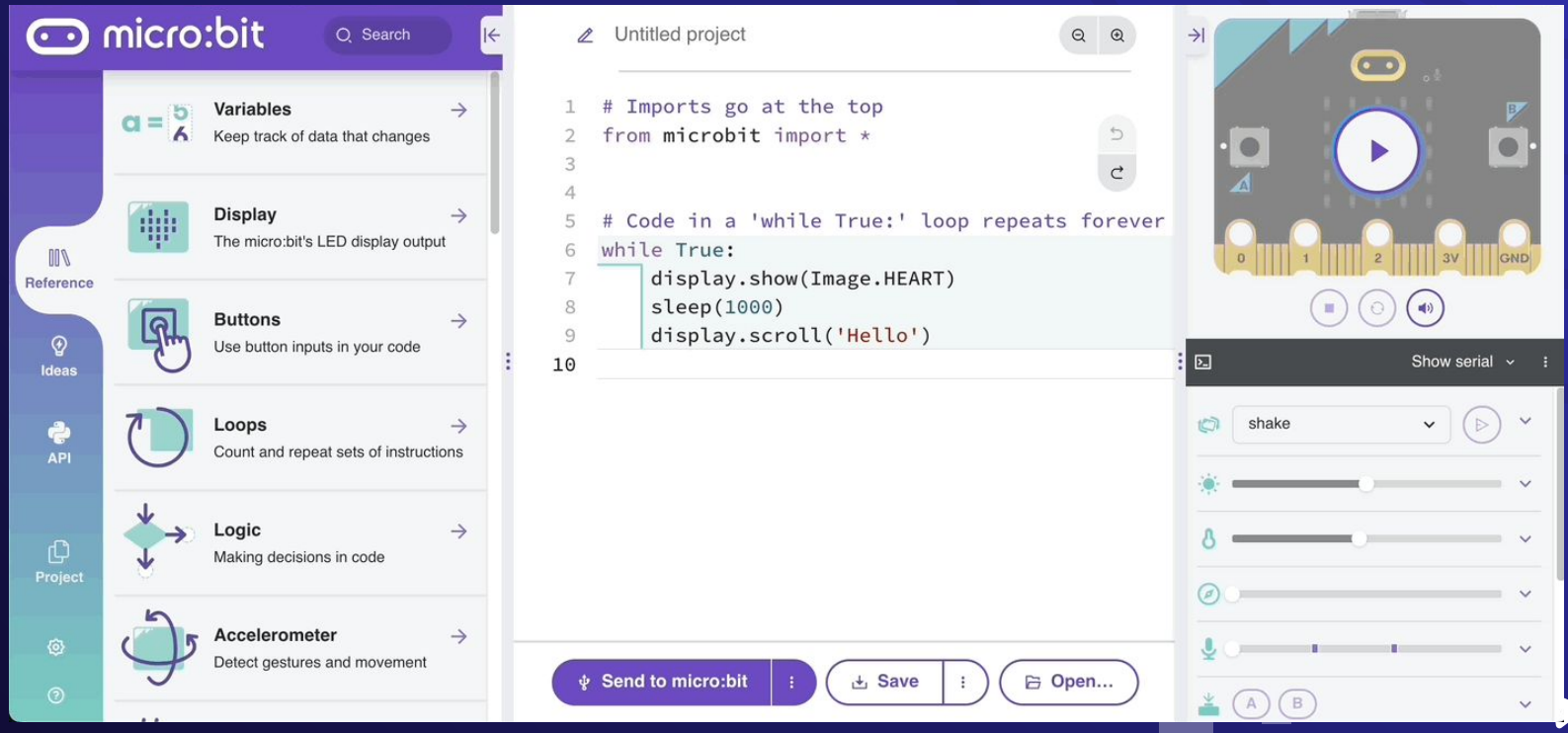


03.

Python editor

Easiest way to program the micro:bit

Online Python editor



https://python.microbit.org

Workflow

Supported browsers (Chrome)

Plug micro:bit into computer

Write **.py** file in the Python editor

Click on **“save to micro:bit”** and select the micro:bit

Automatically flash the **.hex** file to micro:bit

Other browsers (Firefox)

Plug micro:bit into computer

Write **.py** file in the Python editor

Click on “**save to micro:bit**” to download **.hex** file to your machine

Copy **.hex** file to micro:bit flash drive

04.

Examples

Experimenting with the device's components

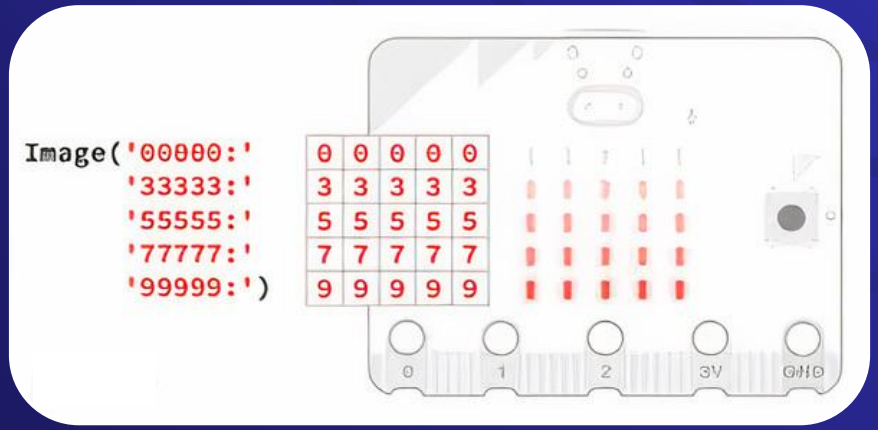
Code Resources

Examples and cheat sheet are available in the repository at
https://github.com/julianaklulo/pycon2024-intro-to-micropython

https://tinyurl.com/micropython-tutorial

Using the Display

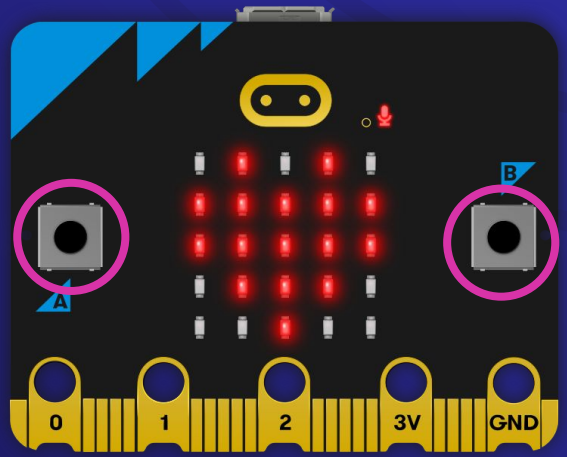
```python
from microbit import *

# Display an image
display.show(Image.HEART)

# Display custom image
display.show(
    Image(
        "00000:"
        "33333:"
        "55555:"
        "77777:"
        "99999"
    )
)

# Scroll text
display.scroll("PyCon US")

# Set pixels
display.set_pixel(0, 0, 9)

# Clear display
display.clear()
```



0-9: Brightness intensity

Using the Push Buttons

```
from microbit import *

# Check if button A was pressed
if button_a.was_pressed():
    pass

# Check if button A is pressed
if button_a.is_pressed():
    pass

# Get how many times button A was pressed
quantity = button_a.get_presses()
```



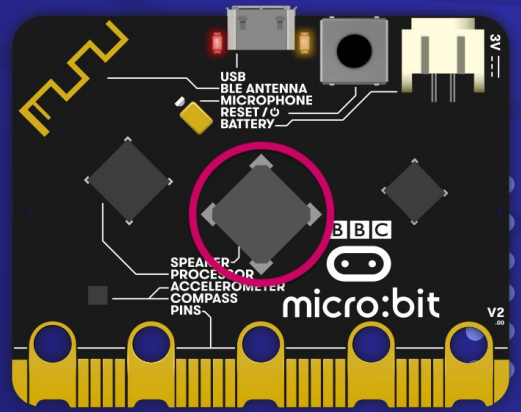
Button A (left) and Button B (right)

Example 1: Buttons and Display

```
"""
Example 1: Buttons and display.

Show an image based on the button pressed:
- If button_a is pressed, show a happy face
- If button_b is pressed, show a sad face
"""
from microbit import *

while True:
    if button_a.is_pressed():
        display.show(Image.HAPPY)
    elif button_b.is_pressed():
        display.show(Image.SAD)

    sleep(100)
    display.clear()
```

Using the Speaker

```
from microbit import *
import music, speech, audio

# Play pre-defined music
music.play(music.POWER_UP)

# Create your own music - Format: '{note}{octave}:{duration}'
music.play(
    [
        "C4:2", "D4:2", "E4:2", "F4:2",
        "G4:2", "A4:2", "B4:2",
    ]
)

# Text to speech
speech.say("Hello, PyCon!")

# Play expressive sounds
audio.play(Sound.YAWN)
```

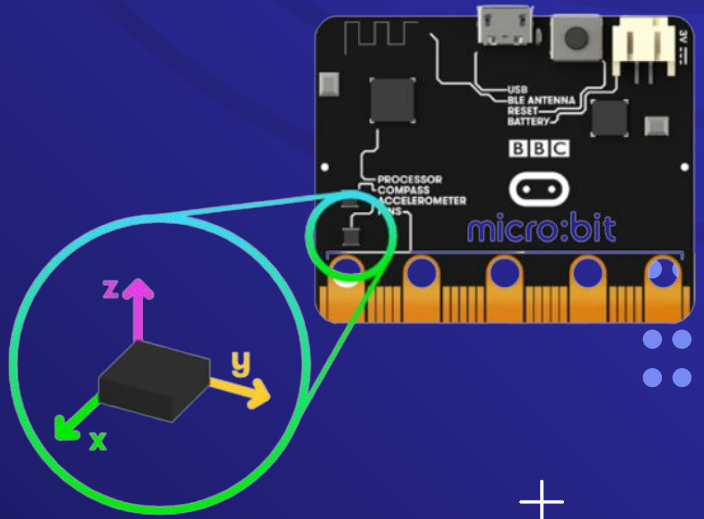


Example 2: Play melody

```
"""
Example 2: Play a melody.

Play a melody using the music module.
"""
import music

music.play(
    [
        "G4:2", "A4:2", "B4:4", "D5:4", "D5:4", "B4:4", "C5:4", "C5:4",
        "r:2", "G4:2", "A4:2", "B4:4", "D5:4", "D5:4", "C5:4", "B4:8",
    ]
)
```

Using the Accelerometer

```
from microbit import *

# Read acceleration in each axis
x = accelerometer.get_x()
y = accelerometer.get_y()
z = accelerometer.get_z()

# Read pre-defined current gesture
gesture = accelerometer.is_gesture("face up")

# Read pre-defined past gesture
gesture = accelerometer.was_gesture("shake")
```



Example 3: Accelerometer Gestures

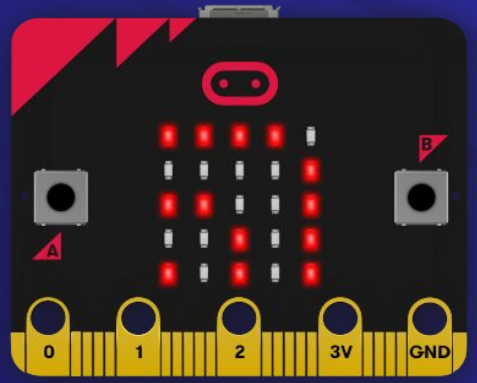
```
"""
Example 3: Accelerometer gestures.

Show an arrow pointing to the direction of the accelerometer gesture.
"""
from microbit import *

while True:
    gesture = accelerometer.current_gesture()

    if gesture == "up":
        display.show(Image.ARROW_N)
    elif gesture == "down":
        display.show(Image.ARROW_S)
    elif gesture == "left":
        display.show(Image.ARROW_W)
    elif gesture == "right":
        display.show(Image.ARROW_E)

    sleep(100)
    display.clear()
```

Example 4: Accelerometer values

```
"""
Example 4: Accelerometer values.

Display a pixel at coordinate (2, 2) and make it move based on
the accelerometer values:
- Read x and y axis
- Increase or decrease the coordinates based on the the values read
- Show the pixel at the new coordinates
"""
from microbit import *

x, y = 2, 2

while True:
    if accelerometer.get_x() > 0:
        x = min(x + 1, 4)
    else:
        x = max(x - 1, 0)
    if accelerometer.get_y() > 0:
        y = min(y + 1, 4)
    else:
        y = max(y - 1, 0)

    display.set_pixel(x, y, 9)

    sleep(100)
    display.set_pixel(x, y, 0)
```

Using the Radio

```
import radio

# Turn on the radio
radio.on()

# Set the radio group and power
# Group: 0-255, Power: 0-7 (signal intensity)
radio.config(group=23, power=7)

# Receive a message from the group
message = radio.receive()

# Send a message to the group
radio.send("PyCon US")
```



Example 5: Teleporting Duck

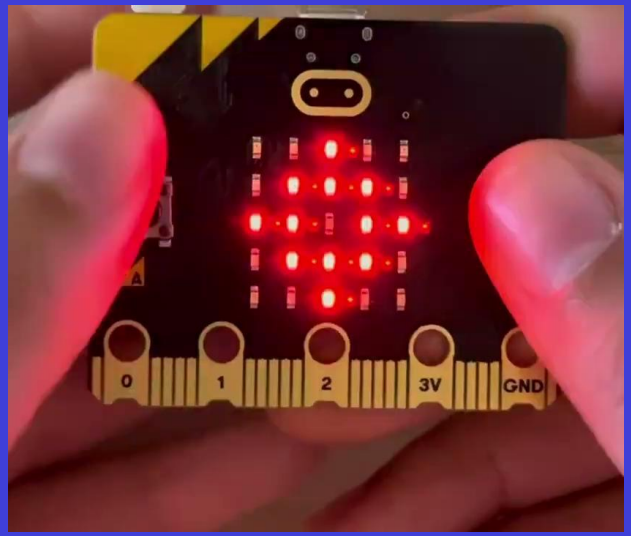
```
"""
Example 5: Teleporting duck.

Create a teleporting duck:
- Choose a partner and define a radio group
- Send “duck” when the device is shaken
- Display a duck when “duck” is received
"""
from microbit import *
import radio

GROUP = 0  # Define a group number with a partner

radio.on()
radio.config(group=GROUP)

while True:
    if accelerometer.was_gesture("shake"):
        display.clear()
        radio.send("duck")
    if radio.receive() == "duck":
        display.show(Image.DUCK)
    sleep(100)
```

05.

Battleship

Single-player version of the game

Battleship - Single Player



Battleship Breakdown

Sea

Stores the automatically generated ships and checks if a shot hit a ship

Player

Handles the logic to shoot on the sea and stores the shots fired

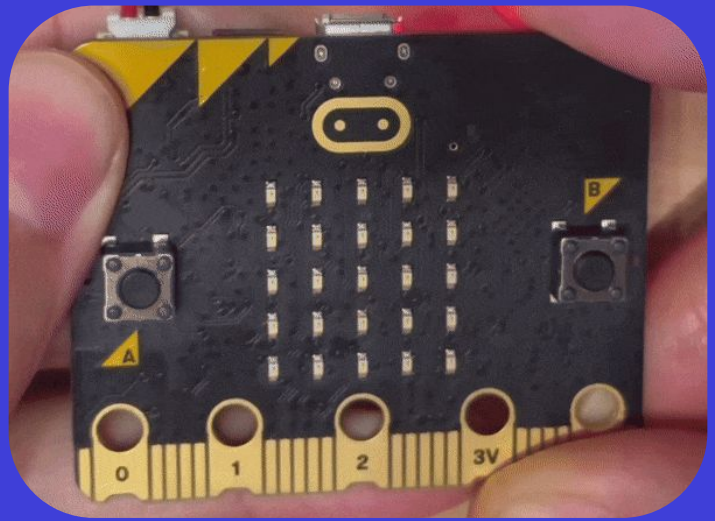
Game

Runs the game until the player hits all the ships

Sea

How to populate the sea with ships?

Examples of Sea boards



Rules to place the ships

1

Size matters

Place the biggest ships first

2

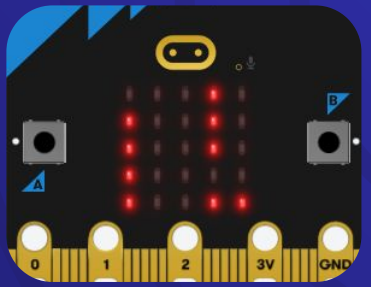
Location matters

The ship can't overflow the board

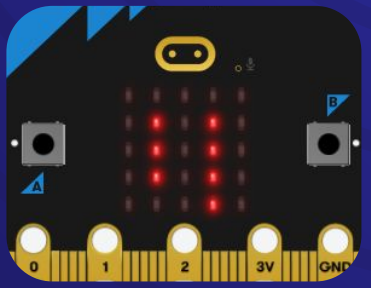
3

No touching

Each boat must be surrounded only by water

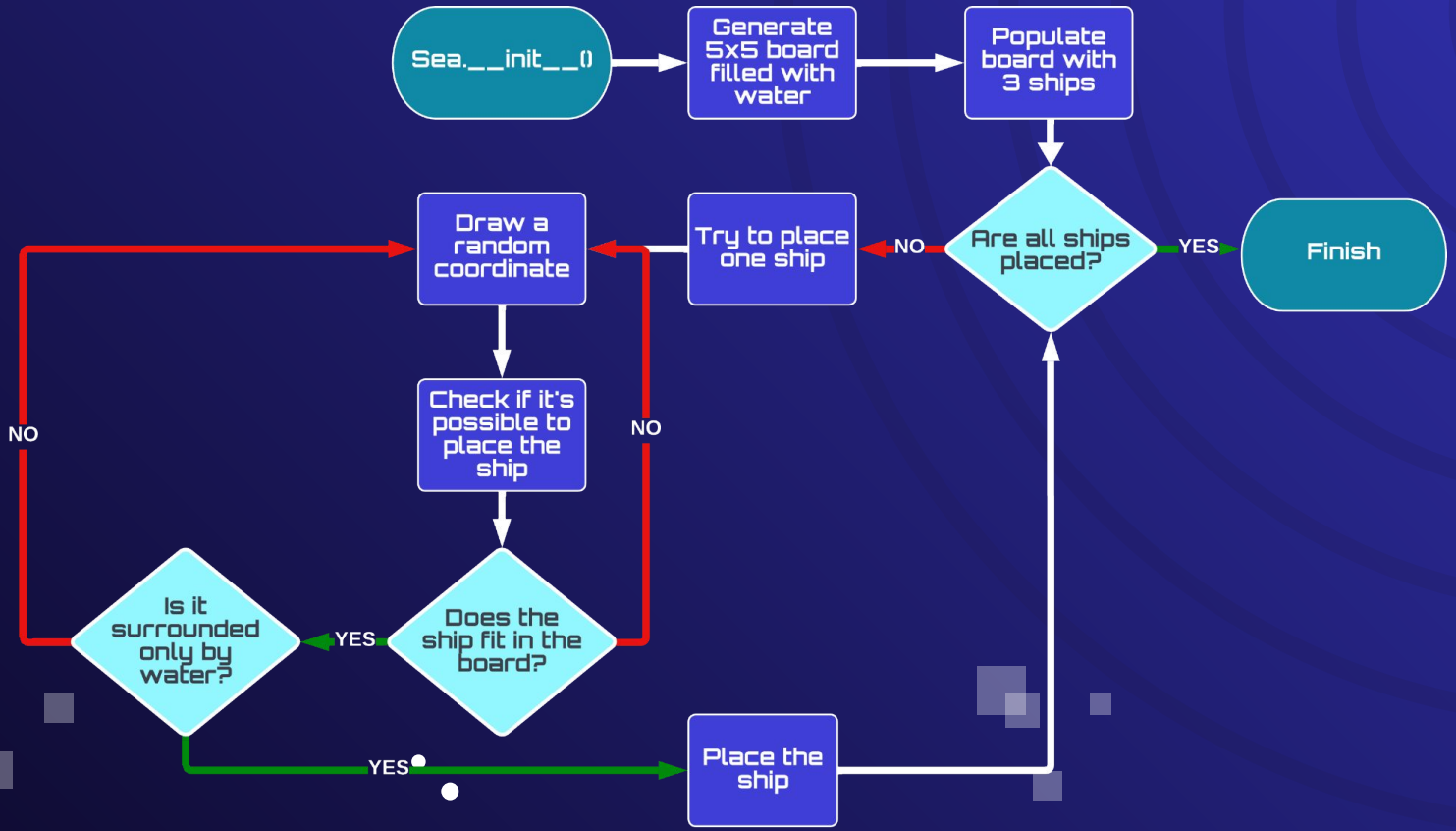


Valid placement



Impossible to place the third ship

Sea Breakdown



Analyzing the code

Open file **battleship-single-player/template_1.py** in the repository

Sea - Generate board

```
class Sea:
    """
    Holds the state of the game board.
    """
    def __init__(self, ships=[4, 3, 2]):
        """
        Initialize the game board with the given ships.
        """
        self.board = [[WATER] * 5 for _ in range(5)]
        self.populate_board(ships)
```

ship sizes

```
SHIP = 9
WATER = 2
```

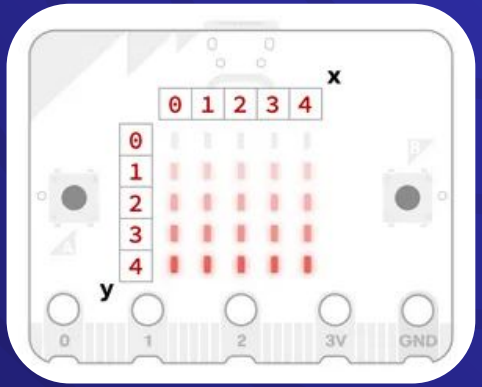
brightness

Sea - Indexing

```
board = [
    [WATER, WATER, WATER, WATER, WATER],
    [WATER, WATER, WATER, WATER, WATER],
    [WATER, WATER, WATER, WATER, WATER],
    [WATER, WATER, WATER, WATER, WATER],
    [WATER, WATER, WATER, WATER, WATER],
]
```

Index: `[ROW][COL]`

VS



Index: `[COL][ROW]`

Sea - Populate board

```
def populate_board(self, ships):
    """
    Place all the ships on the board.

    If it is not possible to place all the ships, try again.
    """
    while True:
        placed_ships = [self.place_ship(ship) for ship in ships]

        if all(placed_ships):
            break

        self.board = [[WATER] * 5 for _ in range(5)]
```

reset the board if the ships don't fit

Sea - Place Ship (part 1)

```python
def place_ship(self, size):
    """
    Place a ship of the given size in the board.

    The ship will be placed in a random candidate coordinate.
    The orientation can be horizontal or vertical.
    """
    candidates_coordinates = [
        (row, col) for row in range(5)
        for col in range(5) if self.board[row][col] == WATER
    ]

    while candidates_coordinates:
        row, col = random.choice(candidates_coordinates)
        candidates_coordinates.remove((row, col))

        orientation = random.choice(["H", "V"])

        if self.possible(row, col, size, orientation):
            break
    else:
        return False
```

select among the candidates coordinates

fails if none of the coordinates work

Each water coordinate is a candidate

Sea - Possible

```
def possible(self, row, col, size, orientation):
    """
    Check if it is possible to place a ship.

    The ship must not be near other ships.
    """
    for i in range(size):
        if orientation == "H":
            if not self.near_ships(row, col + i):
                return False
        elif orientation == "V":
            if not self.near_ships(row + i, col):
                return False
    return True
```

check for each part of the boat

H: hold the row and increase the col

V: increase the row and hold the col

desired placement

Sea - Near Ships

```
def near_ships(self, row, col):
    """
    Check if there are ships surrounding the given coordinates.

    If the coordinates are out of bounds, return False.
    """
    if row > 4 or col > 4:
        return False
                        non-inclusive
    for i in range(row - 1, row + 2):
        for j in range(col - 1, col + 2):          exclude the coordinate
            if 0 <= i < 5 and 0 <= j < 5 and (i != row or j != col):
                if self.board[i][j] == SHIP:
                    return False
    return True
```

Sea - Place Ship (part 2)

```
for i in range(size):
    if orientation == "H":
        self.board[row][col + i] = SHIP
    elif orientation == "V":
        self.board[row + i][col] = SHIP

return True
```

H: hold the row and increase the col

V: increase the row and hold the col

Sea - Hit

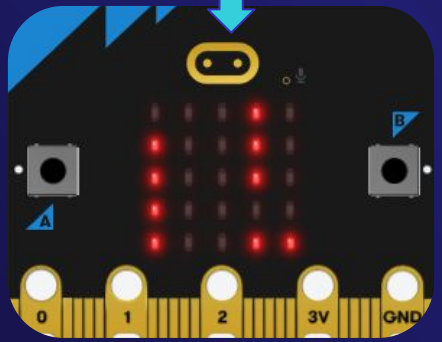
```
def hit(self, row, col):
    """
    Check if there is a ship in the given coordinates.
    """
    return self.board[row][col] == SHIP
```

will be used once the player starts shooting

Sea - Show Board

```
board = [
    [WATER, WATER, WATER, SHIP,  WATER],
    [SHIP,  WATER, WATER, SHIP,  WATER],
    [SHIP,  WATER, WATER, SHIP,  WATER],
    [SHIP,  WATER, WATER, WATER, WATER],
    [SHIP,  WATER, WATER, SHIP,  SHIP],
]
```

```
board = Image("22292:92292:92292:92222:92299")
```



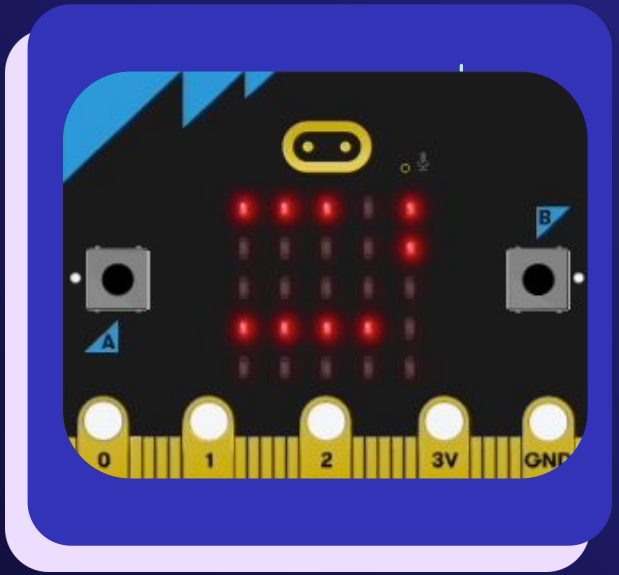

```
SHIP = 9
WATER = 2
```

represents the brightness

Sea - Show Board

```
def show(self):
    """
    Show the game board.
    """
    display.show(
        Image(
            ":".join(
                ["".join(str(point) for point in line) for line in self.board]
            )
        )
    )
```

create one string for each row
then concatenate each string using :



Try it in the simulator

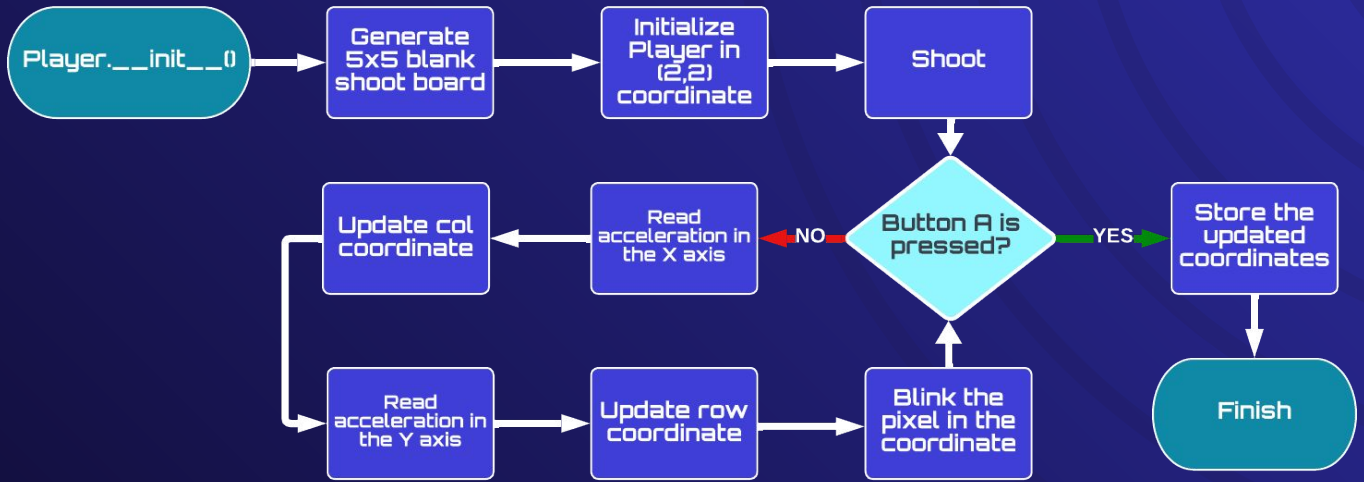
Open **battleship-single-player/template_1.py**, paste it in the simulator and execute the code

https://python.microbit.org

Player

How to shoot the ships?

Player Breakdown



Analyzing the code

Open file **battleship-single-player/template_2.py** in the repository

Player - Generate Shots Board

```
class Player:
    """
    Holds the state of the player board.
    """
    def __init__(self):
        """
        Initialize the player board.
        """
        self.shots = [[0] * 5 for _ in range(5)]

        self.row = 2
        self.col = 2
```

same structure as the sea board

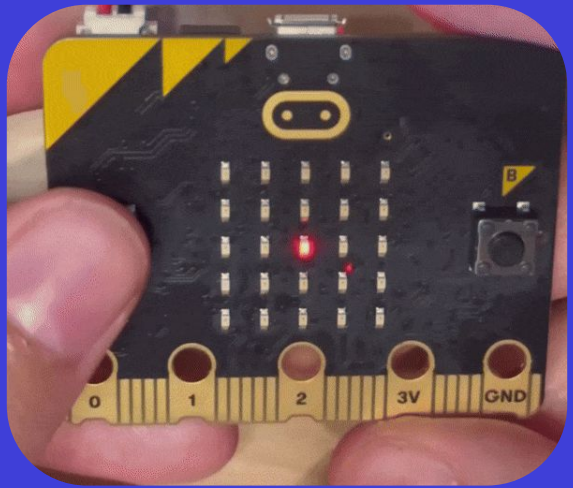
start player in the center of the board

Player - Mark

```
def mark(self, row, col, hit):
    """
    Mark the player board with the result of the shot.
    """
    if hit:
        self.shots[row][col] = SHIP
    else:
        self.shots[row][col] = WATER
```

similar to the hit method

Player - How to Shoot



Player - Shoot

1

While loop

Run until Button A is pressed

2

Show the board

Show the shots board so the user knows where they've already shot

3

Threshold

Value to filter out small movements or noise in the accelerometer readings

4

Update row

Use accelerometer axis Y to update the row

5

Update col

Use accelerometer axis X to update the col

6

Blink

Alternate between the coordinate in the shot board and the current coordinate

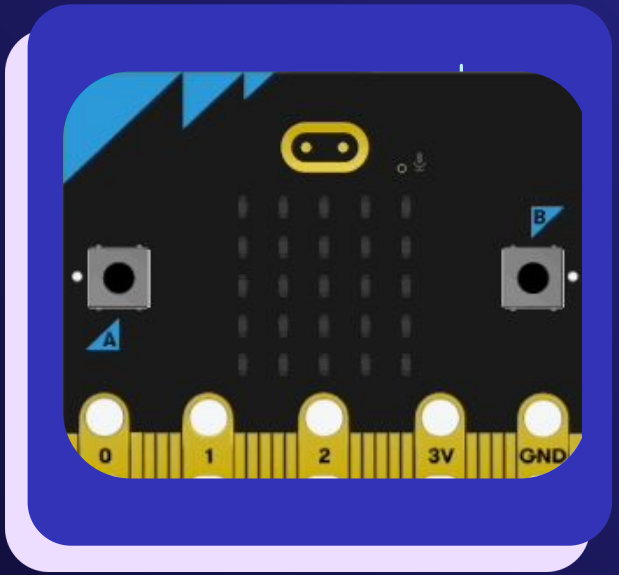
Writing the shoot method

Edit file **battleship-single-player/template_2.py** in the repository

Player - Shoot

```
def shoot(self):
    """
    Shoot the board.

    The player can move the cursor with the accelerometer.
    The player can shoot with the A button.

    The coordinates are stored for future reference.
    """
    while not button_a.is_pressed():
        self.show()
```

```
        if accelerometer.get_x() > THRESHOLD:
            self.col = min(self.col + 1, 4)
        elif accelerometer.get_x() < -THRESHOLD:
            self.col = max(self.col - 1, 0)

        if accelerometer.get_y() > THRESHOLD:
            self.row = min(self.row + 1, 4)
        elif accelerometer.get_y() < -THRESHOLD:
            self.row = max(self.row - 1, 0)

        self.blink(self.row, self.col)

sleep(100)
```



Try it in the micro:bit

Upload **battleship-single-player/template_2.py** with your implementation to the micro:bit

https://python.microbit.org

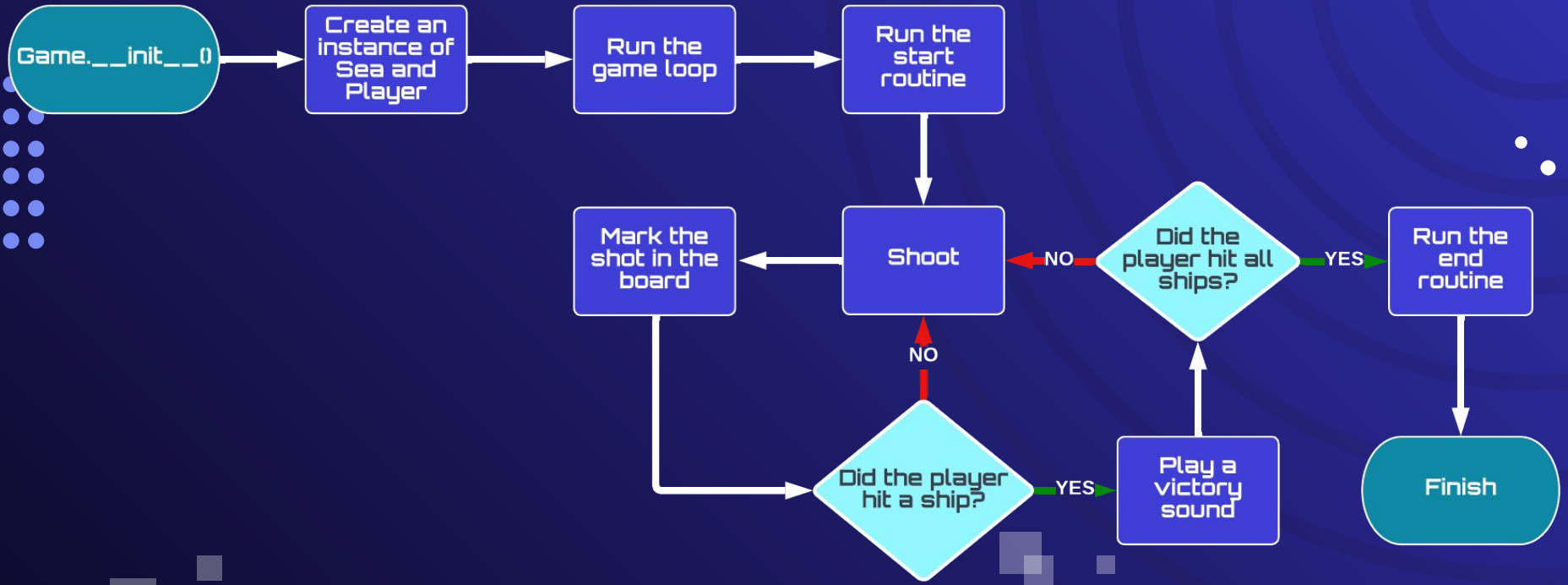
Game

Control the logic of the game

Analyzing the code

Open file **battleship-single-player/template_3.py** in the repository

Game Breakdown



Game - Init Sea and Player

```python
class Game:
    """
    Holds the state of the game.
    """
    def __init__(self):
        """
        Initialize the game.

        The game board is initialized with the ships.
        The player board is initialized.

        The player starts at the top-left corner.
        """
        self.sea = Sea()
        self.player = Player()
```

Game - Win

```
def win(self):
        """
        Check if the player has won the game.

        The player wins the game if they hit all the ships.
        """
        for i in range(5):
            for j in range(5):
                if self.sea.board[i][j] == SHIP and self.player.shots[i][j] != SHIP:
                    return False
        return True
```

Starting the Game

Game - Start and End

1

Greet the player

Play sound and display image

2

Wait for input

Keep blinking the image until the player press both buttons

3

Countdown

Display a countdown to indicate that the game is about to start

4

End game

The game ends when all the ships have been hit

5

Display a positive image

Happy face is a good choice

6

Play an ending sound

Choose an appropriate sound

Writing start and end methods

Edit file **battleship-single-player/template_3.py** in the repository

Game - Start and End

```
def start(self):
    """
    Routine to start the game.
    """
    display.show(Image.TARGET)
    music.play(music.ENTERTAINER)
    while not (button_a.is_pressed() and button_b.is_pressed()):
        display.clear()
        sleep(350)
        display.show(Image.TARGET)
        sleep(350)

    for number in "321":
        display.show(number)
        music.play(music.BA_DING)
        sleep(1000)
    music.play(music.JUMP_UP)
    display.clear()
```

```
def end(self):
    """
    Routine to end the game.
    """
    display.show(Image.HAPPY)
    music.play(music.CHASE)
```

Game - Run

1

Start the game

Run the start routine

2

Loop until end

Run the loop until the game ends with the player winning

3

Shoot the board

Read the player's shot

4

Check hit and mark

Check in the Sea instance if the shot hit any ships

5

Check win

Check if the player has already hit all the ships and run the end routine if so

6

Display the result

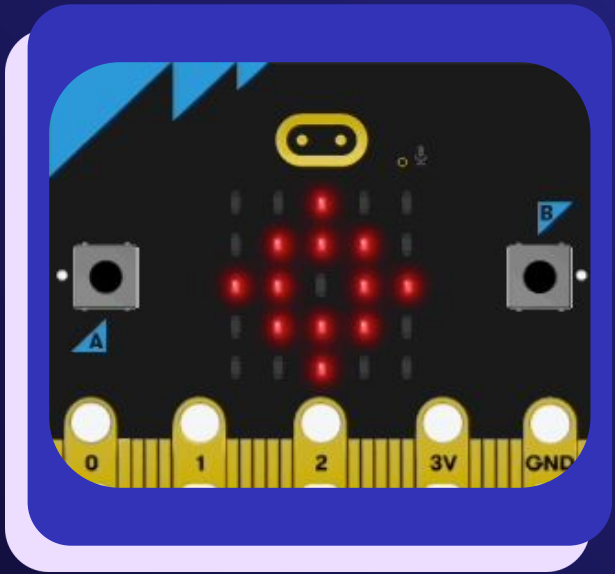
Let the player know if the shot has hit or missed the ships

Writing the Game run method

Continue editing file **battleship-single-player/template_3.py** in the repository

Game - Run

```
def run(self):
    self.start()

    while True:
        self.player.shoot()

        hit = self.sea.hit(self.player.row, self.player.col)
        self.player.mark(self.player.row, self.player.col, hit)

        if hit:
            display.show(Image.TARGET)
            music.play(music.POWER_UP)

            if self.win():
                self.end()
                break
        else:
            display.show(Image.NO)
            music.play(music.POWER_DOWN)
```



Try it in the micro:bit

Upload **battleship-single-player/template_3.py** with your implementation to the micro:bit

https://python.microbit.org

06.

Challenge

Multiplayer version of the game

Battleship - Multiplayer

Multiplayer Breakdown

Sea

No changes needed

Player

No changes needed

Game

Handles the publisher and subscriber logic

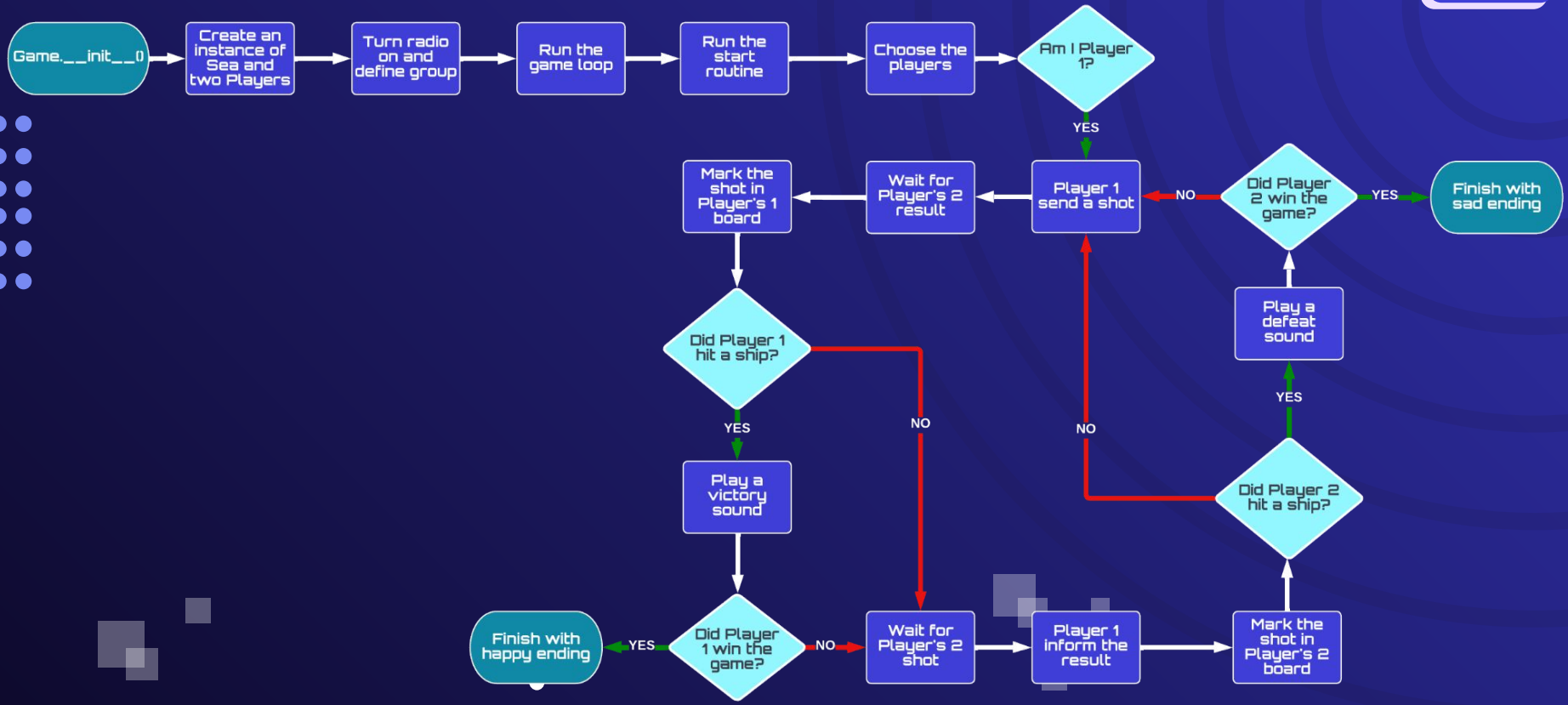
Game

Control the logic of the game

Analyzing the code

Open file **battleship-multiplayer/template_1.py** in the repository

Game Breakdown



Game - Init Sea and Players

```
class Game:
    """
    Holds the state of the game.
    """
    def __init__(self):
        """
        Initialize the game.

        Create the game board and the player boards.
        Each player will have a board to place the ships and a board to make the shots.
        """
        self.sea = Sea()
        self.me = Player()
        self.opponent = Player()

        self.winner = ""

        radio.on()
        radio.config(group=GROUP)
```

same Player class for both players

define the group with a partner and set the constant

Game - Start

same as the single player version

```
def start(self):
    """
    Routine to start the game.
    """
    display.show(Image.TARGET)
    music.play(music.ENTERTAINER)
    while not (button_a.is_pressed() and button_b.is_pressed()):
        display.clear()
        sleep(350)
        display.show(Image.TARGET)
        sleep(350)

    for number in "321":
        display.show(number)
        music.play(music.BA_DING)
        sleep(1000)
    music.play(music.JUMP_UP)
    display.clear()
```

Game - Lost

```
def lost(self):
    """
    Check if the player has lost the game.

    The player loses the game if the opponent hits all the ships.
    """
    for i in range(5):
        for j in range(5):
            if self.sea.board[i][j] == SHIP and self.opponent.shots[i][j] != SHIP:
                return False
    return True
```

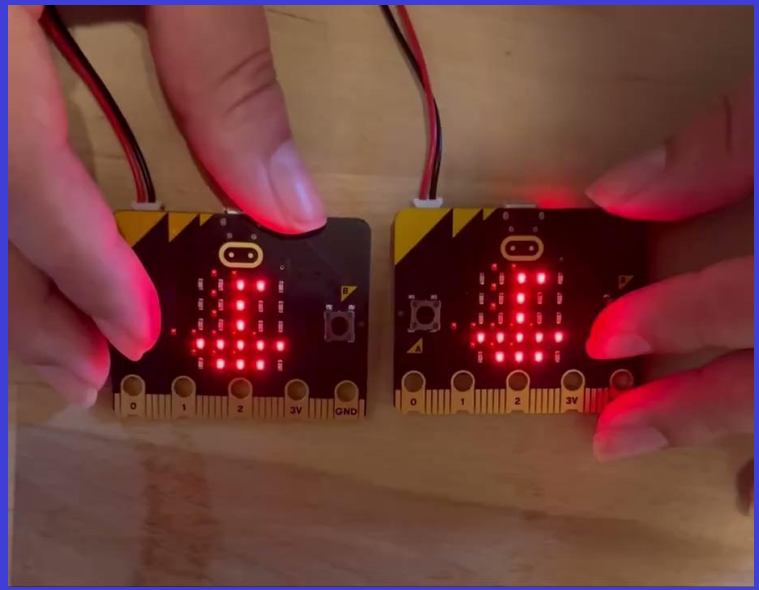
only the player receiving the shot can check if they've lost the game

Game - End

different endings depending on which player won the game

```
def end(self, win):
    """
    Routine to end the game.

    If the player wins, show a happy face.
    If the player loses, show a sad face.
    """
    if win:
        display.show(Image.HAPPY)
        music.play(music.CHASE)
    else:
        display.show(Image.SAD)
        music.play(music.WAWAWAWAA)
```

Choosing Players



Game - Choose Players

1

Display boat image

Show an image while waiting for the input from the players

2

Loop until press

Wait for both players to be ready to start the game

3

Player 1 - Button A

Send a message after Player 1 pressed Button A, wait for response from Player 2

4

PLayer 2 - Button B

After Player 2 pressed Button B, wait for message from Player 1 and reply with acknowledgment message

5

Assign the players

Store the player number to define who starts the turn

Writing the Choose Players method

Edit file **battleship-multiplayer/template_1.py** in the repository

Game - Choose Players

```
def choose_players(self):
    display.show(Image("00990:00900:00900:99999:09990"))

    while True:
        if button_a.is_pressed():
            display.show(Image.ARROW_W)
            radio.send("PLAYER_1 READY")
            while True:
                message = radio.receive()
                sleep(100)
                if message and message == "PLAYER_2 READY":
                    self.me.player_number = "PLAYER_1"
                    self.opponent.player_number = "PLAYER_2"
                    display.show("1")
                    break
            break
    if button_b.is_pressed():
        display.show(Image.ARROW_E)
        while True:
            message = radio.receive()
            sleep(100)
            if message and message == "PLAYER_1 READY":
                radio.send("PLAYER_2 READY")
                self.me.player_number = "PLAYER_2"
                self.opponent.player_number = "PLAYER_1"
                display.show("2")
                break
        break

sleep(1000)
```

define the group with a partner and set the constant

Game - Send Shot

1

Run Shoot method

Update the coordinates of the current player

2

Send message

Send to the opponent the coordinates of the shot

3

Wait for response

Wait for the opponent to reply with the result of the shot

4

Mark result

Mark in the current player's board the result of the shot

5

Check hit

Celebrate if the current player's shot hit a ship

6

Return value

Returns True if the current player won

Writing the Send Shot method

Continue editing the file **battleship-multiplayer/template_1.py** in the repository

Game - Send Shot

```
def send_shot(self):
    self.me.shoot()

    message = str(self.me.row) + " " + str(self.me.col)
    radio.send(message)
    sleep(100)

    response = None
    while not response:
        response = radio.receive()
        sleep(100)

    hit, won = response.split(" ")
    hit = hit == "True"
    won = won == "True"
```

```
self.me.mark(self.me.row, self.me.col, hit)

if hit:
    display.show(Image.TARGET)
    music.play(music.POWER_UP)
else:
    display.show(Image.NO)
    music.play(music.POWER_DOWN)

sleep(100)
return won
```

Game - Receive Shot

1

Show the board

Display the sea board to the current user

2

Wait for message

Wait for the opponent to make the shot

3

Blink the coordinate

Display in the board the coordinate that the opponent shot

4

Check hit and mark

Check if the opponent hit a ship in the sea board and mark the shot in the opponent's board

5

Check lose

Check if the opponent hit the last ship in the current player's board

6

Send response

Send message with result of the shot and if the opponent won the game

7

Show shot result

Display the result of the shot to the current player

8

Return value

Returns True if the current player lost

Writing the Receive Shot method

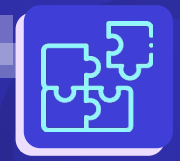
Continue editing the file **battleship-multiplayer/template_1.py** in the repository

Game - Receive Shot

```
def receive_shot(self):
    self.sea.show()

    response = None
    while not response:
        response = radio.receive()
        sleep(100)

    row, col = response.split(" ")
    row = int(row)
    col = int(col)

    self.sea.blink(row, col)
    hit = self.sea.hit(row, col)
    self.opponent.mark(row, col, hit)
```

```
    lost = self.lost()

    message = str(hit) + " " + str(lost)
    radio.send(message)
    sleep(100)

    if hit:
        display.show(Image.TARGET)
        music.play(music.POWER_DOWN)
    else:
        display.show(Image.NO)
        music.play(music.POWER_UP)

    sleep(100)
    return lost
```

Game - Run



1

Start the game

Run the start routine

2

Choose players

Decide who's starting the game

3

Player 1

Shoots first then receives a shot

4

Player 2

Receives the first shot and then shoots

5

Current player win?

The current player wins when send_shot returns True

6

Opponent win?

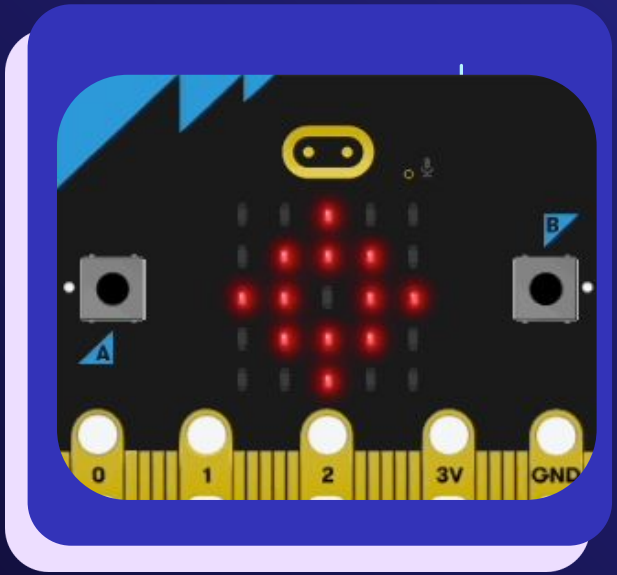
The current player loses when receive_shot returns True

Writing the Run method

Continue editing the file **battleship-multiplayer/template_1.py** in the repository

Game - Run

```
def run(self):
    self.start()
    self.choose_players()

    while True:
        if self.me.player_number == "PLAYER_1":
            if self.send_shot():
                self.winner = self.me.player_number
                break
            if self.receive_shot():
                self.winner = self.opponent.player_number
                break
        elif self.me.player_number == "PLAYER_2":
            if self.receive_shot():
                self.winner = self.opponent.player_number
                break
            if self.send_shot():
                self.winner = self.me.player_number
                break

    self.end(self.winner == self.me.player_number)
```



Try it in the micro:bit

Find a partner, decide the group number and upload **battleship-multiplayer/template_1.py** with your implementation to the micro:bit

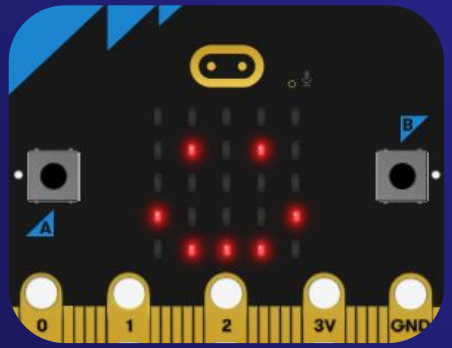
https://python.microbit.org

Improvements

- Track the score
- Let the player place the ships manually
- Mark in the player board the sunk ships

What improvements would you make?

Thank you for attending!



I hope you enjoyed it :)

For more games, watch my talk at PyCon US 2023

https://www.youtube.com/watch?v=teALLngESw0

Reach out via social media

@julianaklulo

Reach out via social media

I'll post more details about the MicroPython open space