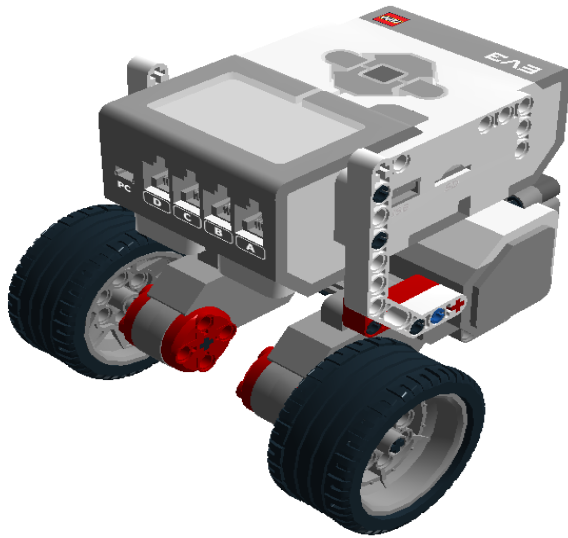


App Inventor + IoT: Lego EV3 robot one touch control

60
mins

(including robot
assembly)

Level: advanced



Introduction

This tutorial demonstrates how to control your Lego EV3 robot with one finger dragging on the screen. From the middle of the screen, you drag the small icon forward and robot will go forward, drag icon backward and robot will go backward, so is left and right, etc. You can learn how to transfer touch point's coordinate into robot's motor speed by trigonometric functions.

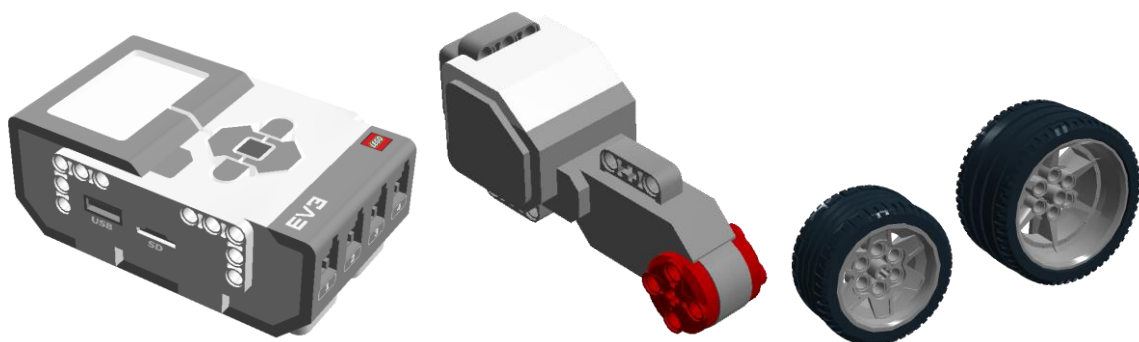
Notice: You don't have to write a program for the EV3, just power it on and pair with your Android phone. App Inventor's EV3 components can talk to Lego EV3 brick with a special protocol called [Lego EV3 Direct Command](#). These commands are actually byte arrays which can be executed directly by Lego EV3 bricks. Lego EV3 components were developed by CAVEDU Education and merged to official AI2 in 2016.

- [Source .aia](#)

Basic dual-wheel robot platform

Core component of this project:

1. Lego EV3 intelligent brick, x1
2. Lego EV3 motor, x2
3. Wire, x2
4. rubber tires, x2
5. Lego parts



Please assemble your robot like Figure 1, if you are not familiar with Lego brick, [please check this assembly tutorial](#) (use lesser parts) or [Lego Official TRACK3R building tutorial](#) (use far more parts). If your robot looks a little different, that's fine. Just make sure the two motors (attach to port B and C) are on the opposite side of robot. This kind of robot base is called a **differential drive platform** because the robot's behavior can be easily adjusted according to the motor speed. For instance,

the robot will go forward with both motors moving at the same speed and will turn right with the left motor moving a little slower than the right motor.

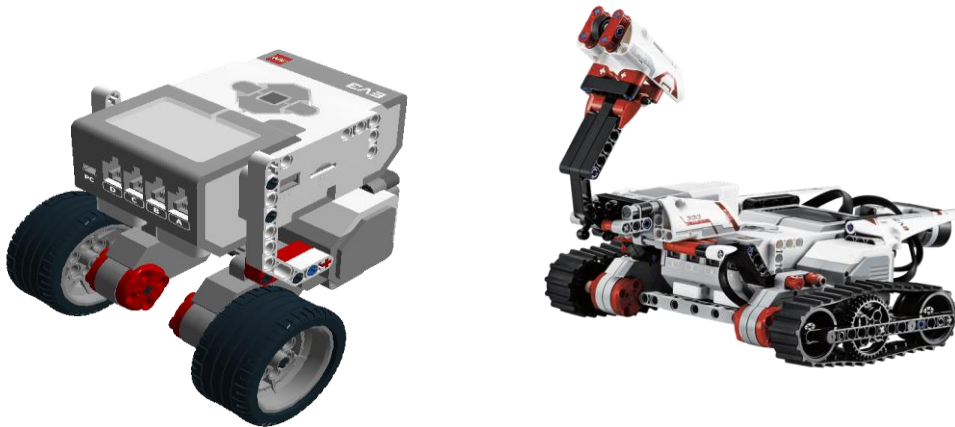


Figure 1a. dual-wheel robot platform

Figure 1b. Use tracks to make your robot cooler (Image source: Lego.com)

Take a look of a real cool Lego robot!

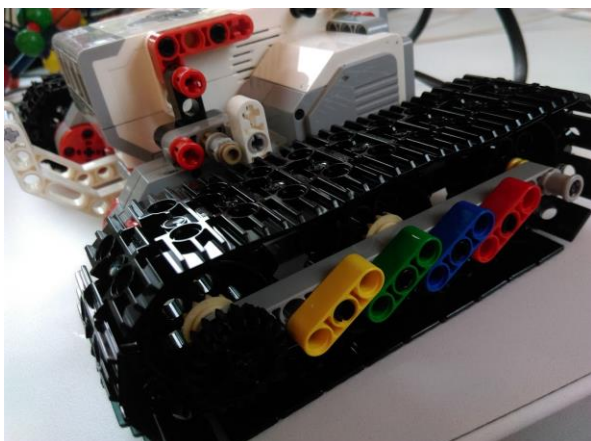
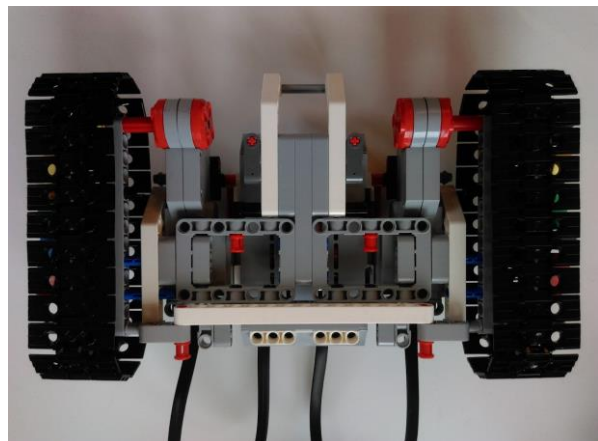
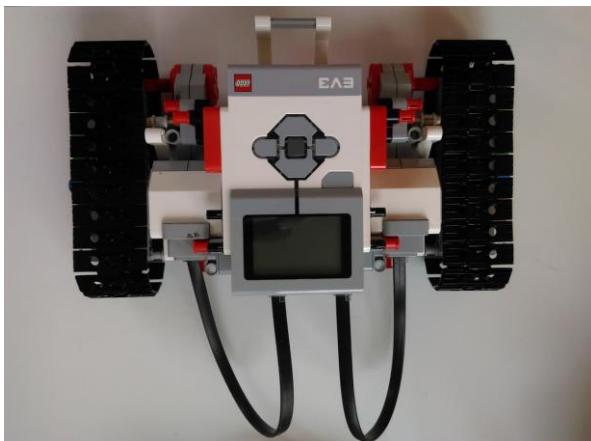


Figure 1c~1e. physical photo of Lego track robot.

Power on your EV3 and pair it with your Android phone (default key: **1234**). You can check whether the robot's EV3 is on with the Bluetooth icon at the upper-left screen corner.

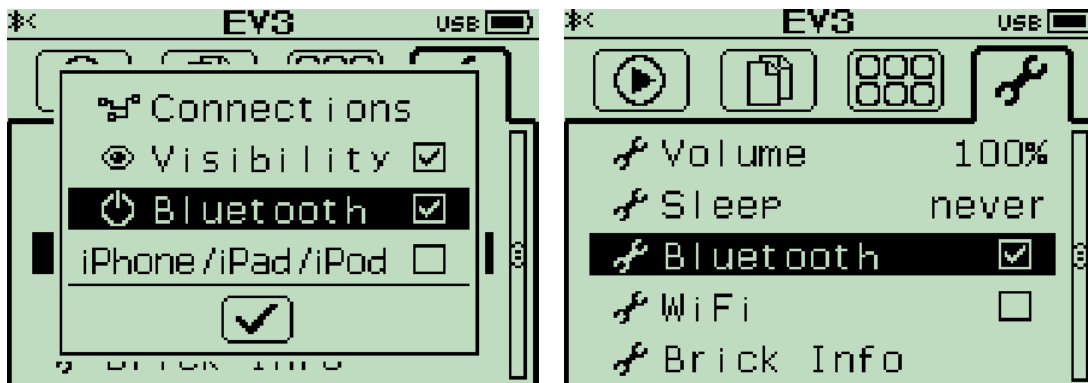


Figure 1c, 1d. Check EV3 Bluetooth is turned on.

App Inventor

Now log into [MIT App Inventor site](#) and create a new project.

Designer

In the Designer page of App Inventor platform, please add these components and place them as shown in Figure 2. For details, please refer to Table 1.

For connection, the ListPicker selects a paired Bluetooth device, your Lego EV3 in this case. A Disconnect button closes the Bluetooth connection with Lego EV3.

There is a canvas with a ball component in the middle of our screen, user can drag this ball to drive the robot moving around.

Note: Ball1 is within Canvas1, since we set its **Visible** property to false, then you cannot see it on Designer.

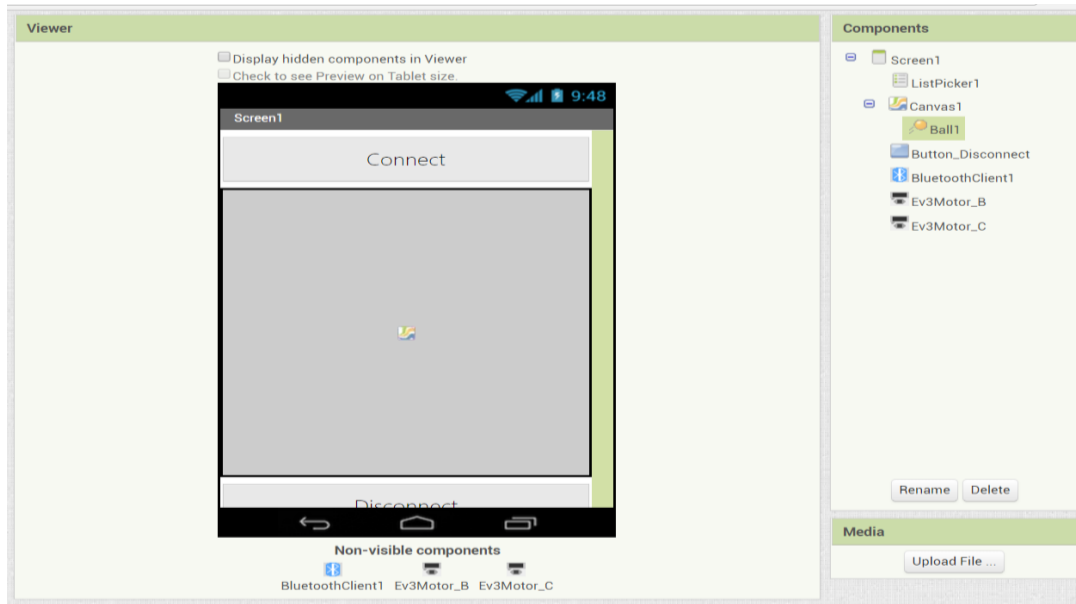


Figure 2. Designer

Table 1. Required components of this project

Name	Palette	Settings	Description
ListPicker1	User Interface	set Text to " Connect "	Choose paired Bluetooth device - > our robot
Canvas1	Drawing and animation	set height and width to 320 pixels	area to control the robot
Ball1	Drawing and animation	set X and Y to 160 (center of Canvas1) set Visible to false	indicator of user finger (touch point)
Button_Disconnect	User Interface	set Text to " Disconnect "	Click to disconnect from EV3 brick.
Ev3Motor_B	LEGO® MINDSTORMS®	set BluetoothClient to BluetoothClient1 set MotorPorts to B	Control and get status of Ev3 Motor.
Ev3Motor_C	LEGO® MINDSTORMS®	set BluetoothClient to BluetoothClient1 set MotorPorts to C	Control and get status of Ev3 Motor.

BluetoothClient1	Connectivity	No need to change	Communication between AI2 and Lego EV3 brick
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Blocks

STEP1 Initialize variable for motor power:

This project used several variables:

- **_X**: new X coordinate with origin at the canvas center.
- **_Y**: new Y coordinate with origin at the canvas center.
- **theta**: angle between touch point and the X-axis, derived from **_X** and **_Y**.
- **r**: distance between touch point and the new origin, derived from **_X** and **_Y**.
- **speedL**: the final computed result for left motor (connect to Ev3's C port) speed, derived from theta and r.
- **speedR**: the final computed result for right motor (connect to Ev3's B port) speed, derived from theta and r.

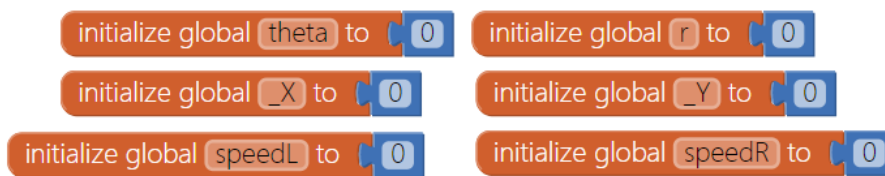


Figure 3.

STEP2 ListPicker for connecting Lego EV3

We use a ListPicker to show paired devices with your Android device and connect to it by selecting in the Listpicker. This is a better approach and less chance of type error for user to connect to EV3 compared with typing EV3's Bluetooth address in a TextBox.

Before we click the Listpicker, we must set its elements first(**ListPicker1.BeforePicking** event). Here we have to set its element to paired devices (**BluetoothClient1.AddressAndNames**).

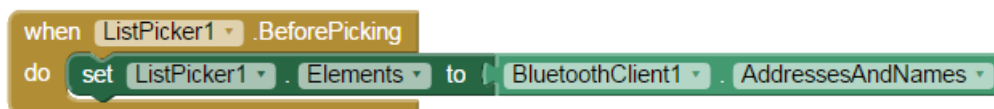




Figure 4a. Initialize and what's inside the ListPicker

Click to open the ListPicker, we are going to connect (**BluetoothClient1.Connect**) our paired EV3 by selecting it (**ListPicker1.AfterPicking**). If connect successfully, **Listpicker** will be disabled, and Ball1 will show up at the center of Canvas, means user can touch the canvas to drive the robot.

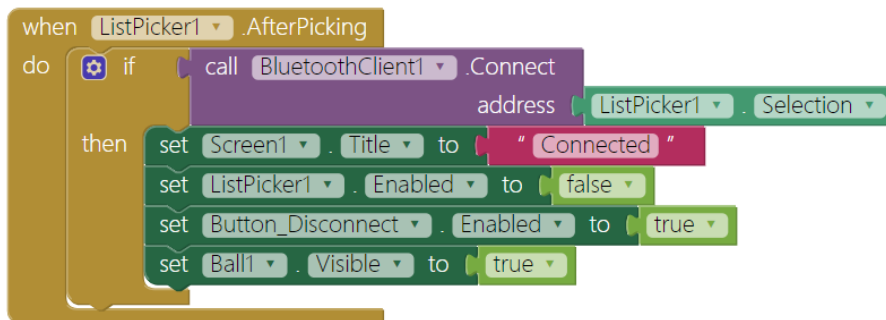


Figure 4b. Select an item to connect to Lego EV3

STEP3 Drag finger to move the robot:

This is the largest code of this project, including three parts:

1. move origin point of canvas to the center and calculate theta and r
2. move the ball component and calculate speedL/speedR
3. drive motor

Let's discuss them in detail:

1. move origin point of canvas to the center and calculate theta and r

First take a look of the relationship of these variables. We would like to transfer the current touch point coordinate to motors' speed. According the figure below:

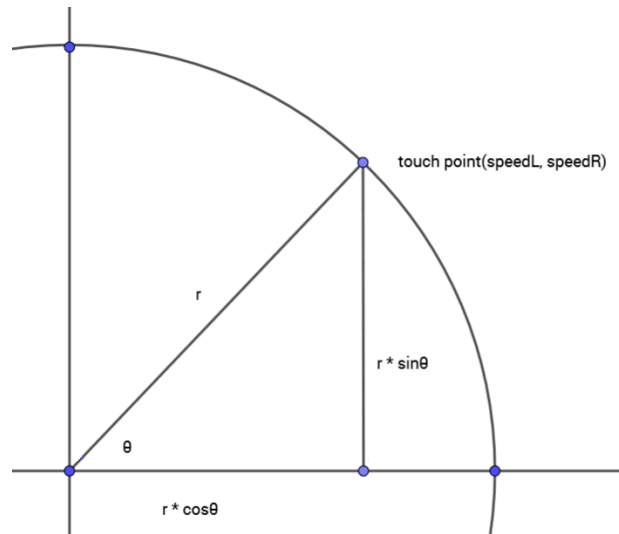


Figure 5a.

The origin of canvas is at the top-left corner not the center, so we have to shift the origin: representing by $_X$ and $_Y$:

- $_X = (\text{currentX} - 160) / 1.6$
- $_Y = (160 - \text{currentY}) / 1.6$

For **theta**, we will use trigonometric function to calculate the angle theta with atan2 function. It takes $_X$ and $_Y$ as input coordinates and returns the angle between the x axis.

r is the distance from your finger's coordinates the origin, which means the larger **r** will make your robot move faster. This will make your robot more controllable and fun.

- **theta**: $\text{atan} ((_Y/_X)) - 45$
- **r**: square root of $(_X)^2 + (_Y)^2$

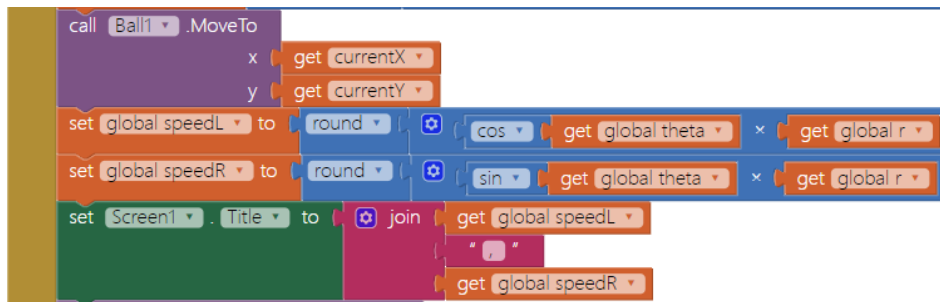
```
when Canvas1 .Dragged
  startX  startY  prevX  prevY  currentX  currentY  draggedAnySprite
do
  set global _X to (get currentX - 160) / 1.6
  set global _Y to (160 - get currentY) / 1.6
  set global theta to atan2 (get global _Y, get global _X) - 45
  set global r to square root of (get global _X ^ 2 + get global _Y ^ 2)
```


Figure 5b.

2. move the ball component and calculate speedL/speedR

We want the ball component to follow our finger movement, so use **Ball.MoveTo** command with x as **currentX** and y as **currentY**. And calculate **speedL** and **speedR** by the follow equation and show these two values on Screen title.

- **speedL**: $\cos(\text{theta} * r)$
- **speedR**: $\sin(\text{theta} * r)$

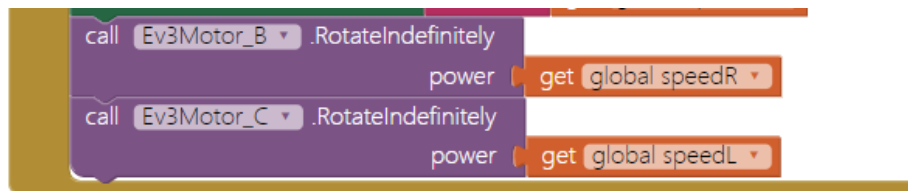


```
call Ball1.MoveTo
  x: get currentX
  y: get currentY
set global speedL to round(cos(get global theta) * get global r)
set global speedR to round(sin(get global theta) * get global r)
set Screen1.Title to join(get global speedL, ", ", get global speedR)
```

Figure 5c.

3. drive motor

Use **Ev3Motor.RotateIndefinitely** command to control right motor (connect to EV3's **B** port) and left motor (**C** port).



```
call Ev3Motor_B.RotateIndefinitely
  power: get global speedR
call Ev3Motor_C.RotateIndefinitely
  power: get global speedL
```

Figure 5d.

Finally, our **Canvas.Dragged** event is finished:

```

when Canvas1.Dragged
  startX startY prevX prevY currentX currentY draggedAnySprite
do
  set global _X to (get currentX - 160) / 1.6
  set global _Y to (160 - get currentY) / 1.6
  set global theta to atan2
    y (get global _Y)
    x (get global _X)
  set global r to square root
    (get global _X)^2 + (get global _Y)^2
  call Ball1.MoveTo
    x (get currentX)
    y (get currentY)
  set global speedL to round
    (cos (get global theta) * get global r)
  set global speedR to round
    (sin (get global theta) * get global r)
  set Screen1.Title to join
    (get global speedL)
    (",")
    (get global speedR)
  call Ev3Motor_B.RotateIndefinitely
    power (get global speedR)
  call Ev3Motor_C.RotateIndefinitely
    power (get global speedL)

```

Figure 5e.

STEP4 Finger up to stop the robot

In this project, we wish the robot will stop when our finger is no longer touch the screen. Therefore, in **Canvas.TouchUp** event, we use two **Ev3Motor.Stop**(set **useBrake** to **true**) command to stop two motors and let the ball component return to the canvas center.

```

when Canvas1.TouchUp
  x y
do
  call Ev3Motor_B.Stop
    useBrake true
  call Ev3Motor_C.Stop
    useBrake true
  call Ball1.MoveTo
    x 160
    y 160

```

Figure 6. Set power variable to slider's thumb position.

STEP5 Disconnect:

When **Button_Disconnect** is pressed (**Button_Disconnect.Click** event), we tell **BluetoothClient** to disconnect from EV3 brick and set listpicker and ball to original status, ready for the next connection. Like Figure 8.

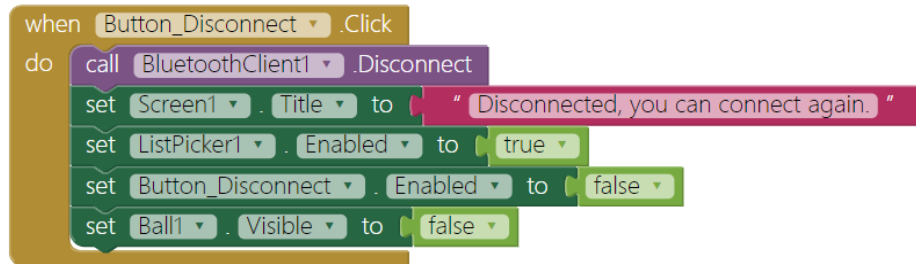


Figure 7. Disconnect from Bluetooth device

Tips

Once you have paired your device with EV3 robot, then press its power button and check that the EV3's BT is switched on. Press the [**Choose your EV3**] listpicker and choose the name of the paired EV3 to connect, you will see the ball appeared when connected successfully. Please click each button to see how robot moves and also drag the slider to adjust motor power.

App starts up like Figure 9, please click **Connect** ListPicker and select your EV3. Click and connect successfully, you can click the five buttons in the middle of the app to control your robot. Enjoy!

Click Disconnect button to close the Bluetooth connection with EV3,

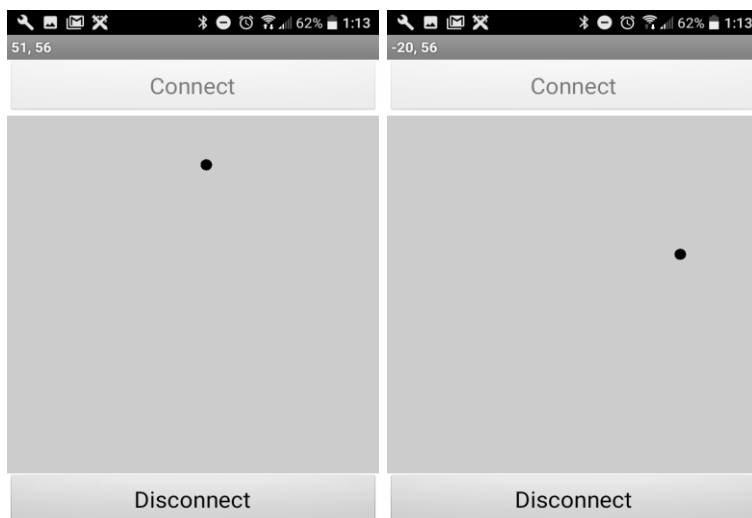


Figure 9a. robot goes forward with left/right motor speed (51, 56)

Figure 9b. robot turns right with left/right motor speed (-20, 56)

Brainstorming

1. Build a maze, see if you can drive your robot to conquer the maze.