XRP

Release 2023.0

WPI

Oct 15, 2025

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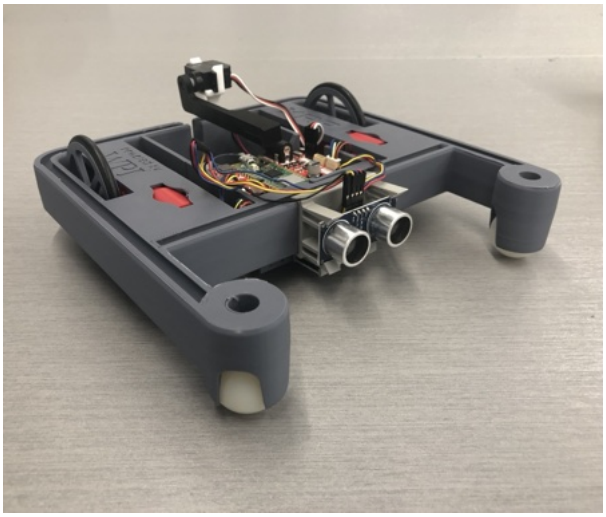


The XRP (Experiential Robotics Platform) [beta], started by WPI and DEKA Research & Development Corp., aims to level the STEM playing field globally and create a future generation of STEM innovators and technology leaders.

The robot kits you received are designed to operate autonomously and perform basic tasks. Its simple, tool-free assembly means robots can be built quickly, and replacement parts can be easily 3-D printed. As part of this platform, WPI will provide virtual support through online courses and will guide students and teachers through the new system, including the ability to scale up using the same hardware with free software updates.

The XRP platform is part of WPI's global STEM education initiative, which will bring inspiration and possibility to STEM education in ways that make it available to all.

CHAPTER

ONE

XRP VERSIONS

There are two versions of the XRP in the field or available for purchase:

1. The Beta version of XRP released July 2023
2. Version 1 of XRP released March 14, 2025

Note abouut XRP versions

Throughout this document you will see cases where there are differences between the two versions and in those cases, information about both versions will be documented. In the next few weeks all the documentation will be updated to more fully reflect the differences between the robot kits.

CHAPTER

TWO

TWO ROBOTS IN ONE

The XRP can be used for two different applications:

- A **STEM learning platform using Python or Blockly** with custom tools designed to learn and experiment with robotics. Included is a curriculum to help learn about robotics and programming. This use of the XRP is described in this document.
- A robot to introduce new **FRC teams and team members to WPILib programming** with the same tools, languages, and libraries used in developing competition robots. To learn about using the XRP for the *FIRST* Robotics Competition, you should refer to the standard WPILib documentation.

CHAPTER

THREE

SOFTWARE TOOLS

There are several software tools available to the programmer for the XRP. Some are available, especially for the XRP and other general-purpose tools that may also work with the XRP.

3.1 Programming Languages

The XRP team supports two programming languages for the XRP:

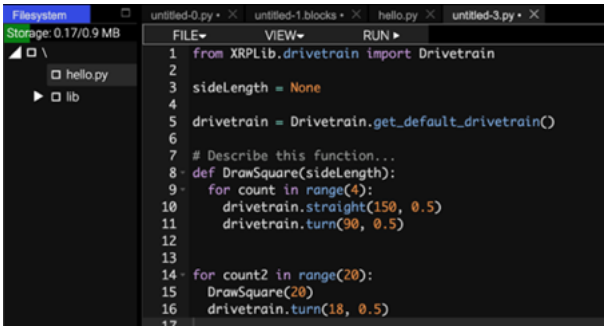
Blockly
: A graphical programming system based on Scratch to make it easier to start codingyour robot without the need to the syntax of Python. Internally, a Blockly program is translated to Python and saved on the robot. Users can even see the generated Python code to help them learn to use the language themselves.

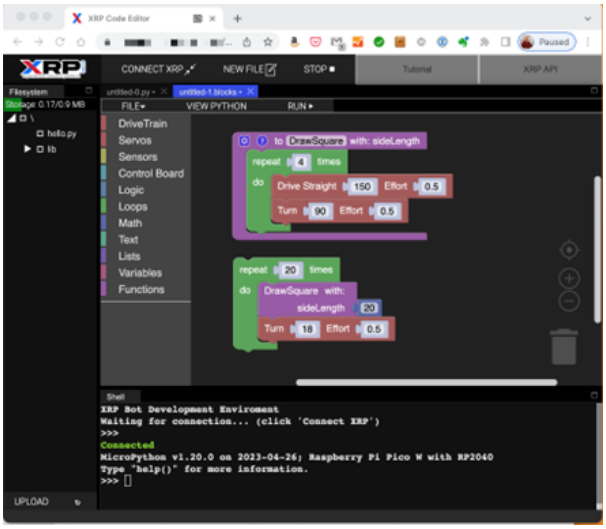
Python
: An object-oriented text-based programming language used throughout industry and taught in many classrooms.

Other languages include C and C++. There may be other languages that can also work with the RP2040 microprocessor in the XRP.

3.2 XRPCode

The recommended programming tool for the XRP is XRPCode. It is a web-based single tool designed specifically for the XRP to support programming in either Python or Blockly. It also can check and update firmware and library versions on the robot as new software releases become available. XRPCode is a web-based programming system that operates inside the Google Chrome or Microsoft Edge browsers, so users will always be running the most recent version of the tool.





3.3 XRPLib

XRPLib is a Python-based programming library that provides classes and functions to make it easy to use all the features of the XRP Robot. XRPLib is completely open source, so users can download the software to see how it works. We also encourage community involvement through pull requests to the library. However, we recommend contacting us before spending too much time to ensure that your ideas are compatible with our plans and development for XRPLib.

Here are some primary features of the XRP:

- The default drive function to control speed, direction, and power applied to the two motors. It can handle driving and turning, with and without sensors such as the IMU, for making accurate point turns.
- The sensors on the robot, such as the motor encoders, rangefinder, reflectance sensor, and IMU (Inertial Measurement Unit), which can get the robot heading and accelerations as it is driving.
- The WiFi connection so that programs can create a web server on the robot that can be used to display a dashboard on a connected phone, tablet, or computer. It is designed for displaying program status, driving controls for teleoperation, and buttons to run user functions when pressed for more control of user robot programs.
- Utility functions for sensing the user buttons, operating the LED, and robot program timing
- Several small sample programs to help illustrate how the various components are used to operate.

3.4 Other tools and languages

In addition to the supplied languages for the robot, users can program the robot using other standard tools such as C, C++ and WPILib using various IDEs like the Arduino IDE and Visual Studio Code. VS Code has several plugins specially designed to support Python programming and the Raspberry Pi Pico, which is the hardware that powers the XRP.

3.5 Where to find the tools

XRPCode IDE: https://xrpcode.wpi.edu/

XRP API Documentation: https://open-stem.github.io/XRP_MicroPython/index.html

XRP Curriculum: https://introtoroboticsv2.readthedocs.io/en/latest/

3.6 Getting help

We have set up a Discourse server where you can get help from our team as well as members of the community using XRP robots.

CHAPTER

FOUR

BUILDING THE XRP ROBOT

Assembling the XRP robot is easy, but be sure to follow the steps here to be sure that the wiring is correct and all the pieces are added correctly to the chassis.

Below is a video provided by SparkFun Electronics showing how to assemble the robot followed by a step by step set of written instructions below.

XRP Beta

XRP Version 1

https://youtu.be/JQyKhzlMSms

https://youtu.be/vpV9_qn0hYs

4.1 The XRP kit (0:37)

The XRP kit contains all the parts you need to assemble and use your robot. You only need to supply 4 AA Batteries (preferably rechargeable) and a micro USB cable to connect your computer to the robot. The contents of the kit are shown to help you identify the parts during assembly.

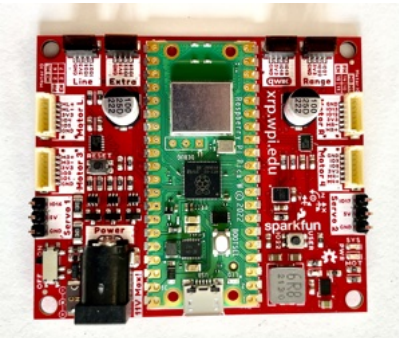
Robot chassis

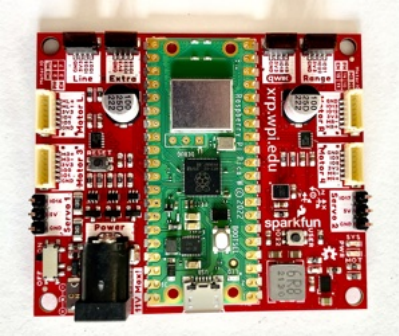
The chassis is a single-piece design that holds all of the robot components. It is designed with a rail system that is designed to make adding additional components easy and without the need for tools. All the robot parts simply snap onto the chassis to make assembly as simple as possible. You can also 3D print your own parts to attach to the chassis.

Robot controller

XRP Beta

XRP Version 1





The robot controller has the RP2350 microprocessor for Version 1 and the RP2040 microprocessor for the Beta version that reads the sensors inputs, runs the Python or Blockly program and drives the actuators (motors). It also has additional components to sense accelerations and headings of the robot, and communicate over WiFi with your laptop or phone.

Electronics parts

The components in the bag of elctronics parts will each be shown individually below.

Motors and cables

The motors are used to drive the robot and are attached to motor controller through the associated cables.

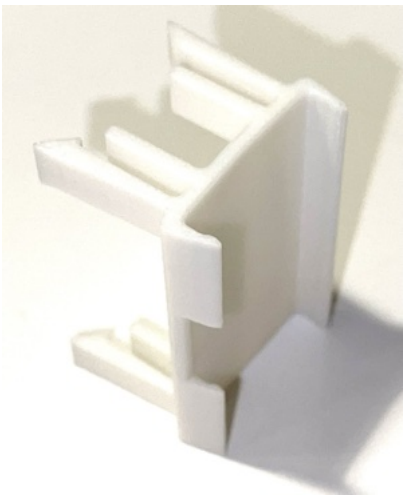
Battery case

The battery case holds 4 AA batteries. You can use any standard alkaline cells but rechargeable cells are prefered so that you don't have to keep replacing them as they run out of energy.

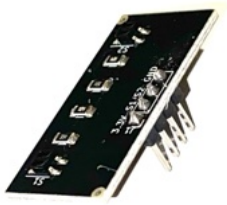
Ultrasonic rangefinder

The ultrasonic wire has two power wires labeled Vcc (red wire) and Gnd (black wire). It also has two additional connections that operate the sensor and get range data. These are trig (blue wire) and echo (yellow wire). A common mistake when wiring this sensor is to get these two wired incorrectly.

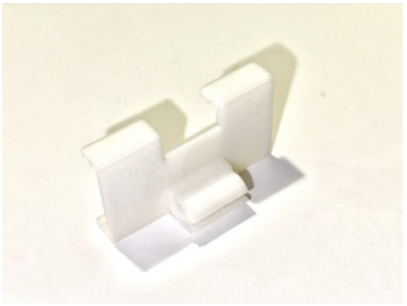
Rangefinder bracket



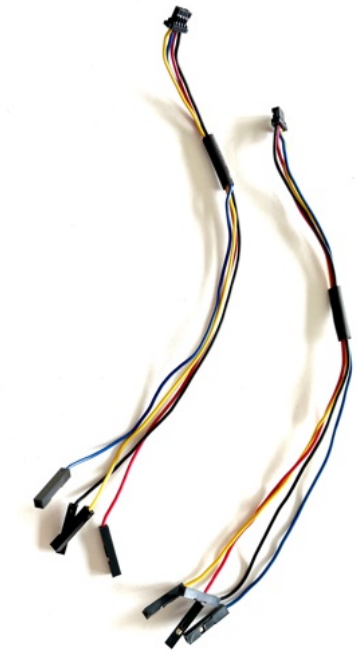
Reflectance sensor



Reflectance sensor bracket



Sensor cables



These cables connect the rangefinder and line following sensors to the robot controller. **When installing these on the sensor end, you must be careful to install the wires correctly, so be sure to carefully read the instructions when attaching them.** Miswiring is the motors is the most common cause of problems when assembling the XRP robot.

Tires (o-rings)

These o-rings are used to form tires to slip over the plastic wheels to give the robot more traction, especially on smooth surfaces.

Servo motor

Servo arm

Servo bracket

The servo is a special type of motor such that when programmed with a position the shaft will automatically move to the specified angle. This is used to power the arm on your robot it can move to predetermined angles all by itself.

Casters

The casters simply provide a low friction contact point for the front of the robot to allow the two rear drive wheels to easily steer the robot forwards, backwards, or any angle.

4.2 Assembling the XRP Robot

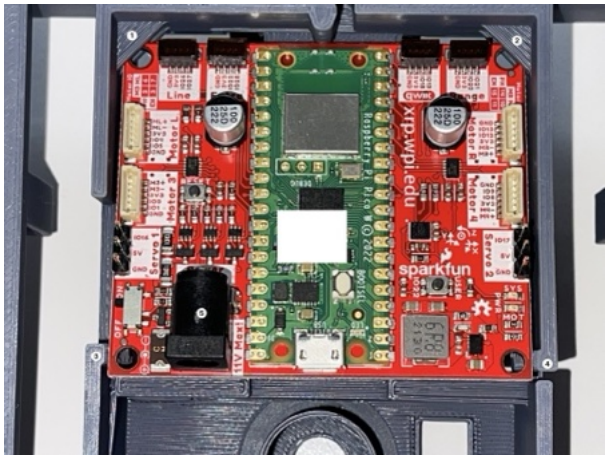
Assembling the XRP robot can be done without the use of tools with the optional exception of screwing the servo arm to the servo. The total process should take about 15 minutes, especially once you understand how it goes together.

Each of the following sections has a time reference for the video at the top of this page so you can see how to assemble that part. We suggest that you view the entire video before starting the assembly so you can get a good overview of how it goes together.

4.2.1 Inserting the robot controller into the chassis (1:18)

Note: If you look at the connectors on the edge of the controller board labeled “Line”, “extra”, “qwiik”, and “range” have very small pieces of tape covering the openings. Remove the tape from all four connectors before inserting the board in the chassis.

Insert the robot controller circuit board into the chassis as shown in the following picture. Observe the orientation of the board where the battery connector (5) istowards the back of the robot as shown. Also the top corners of the board are inserted part way into the corner pockets as shown at (1) and (2). The clips in the chassis (3) and (4) are designed to hold the chassis in place when it is pushed in.

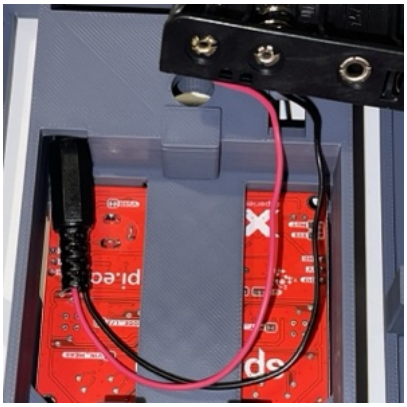


Then push down and foward on the back edges of the board so that the front corners are completely seated in the pocket as shown at (1) and (2) and the board snaps down as shown at (3) and (4) in the following photograph. It might be helpful to view this part of the assembly in the video from the top of this page.

4.2.2 Installing the battery pack (1:39)

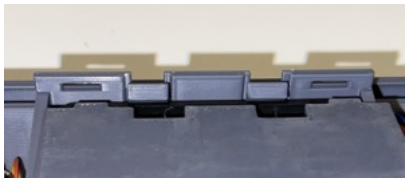
The battery pack is installed by:

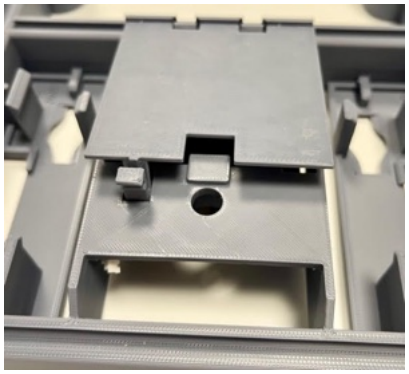
1. Inserting the cable through the cutout in the battery pack area in the chassis.
2. Pushing the edge of the battery pack against the fingers in the chassis which hold it in place.
3. Push the battery pack in place into the robot chassis so that it is full seated.



4.2.3 Adding the battery cover (2:29)

The battery cover is very easy to install, just line up the two tabs on the battery cover with the two slots in the chassis just outside of the battery case. Then the clip snaps into place as you push the battery cover into place.





4.2.4 Inserting the casters into the chassis (3:06)

Install the white front casters (balls) into the chassis by pushing them into place. Once they are installed, the casters should rotate freely.

4.2.5 Adding the motors

The red hobby motors supplied with the kit include encoders (sensors to measure wheel rotation) to make it easy to program the robot to drive for specific distances and speeds. This will give your robots more control and accuracy as your are writing progams to operate it.

4.2.6 Putting the wheels onto the motors (3:22)

The wheels press fit onto the white motor shafts. Notice that the motor shafts have two flat sides that correspond to the flat edges in the center of the wheel. The wheel is pressed over the motor shaft so that the center part of the wheel that sticks out is closest to the motor body and that the wheel is pressed all the way onto the motor shaft.

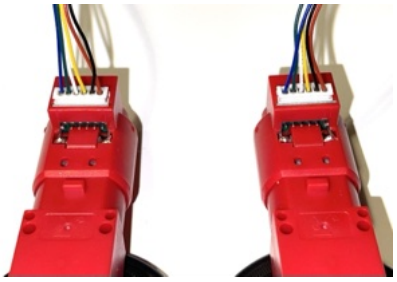
4.2.7 Putting the tires onto the wheels (3:45)

The tires are rubber o-rings that slip into the groove on the outside rim of the wheel. Simply stretch the o-ring to get it to move into place. These will provide friction when the robot is driving, especially on smooth surfaces.

4.2.8 Connecting the motor cables to the motors (3:52)

The motor cables connect the motor to the robot controller so that it can drive the drive the motors and receive data from the motor encoder sensors that provide position and speed information for your robot program. This encoders all the robot to drive at a desired speed and drive for a desired distance.

The wider connector on the cable is inserted into the motor. Notice that pins (wires) on the motor connector are closer to one side than the other. Similarly, the holes on the connector attached to the cable are closer to one side.

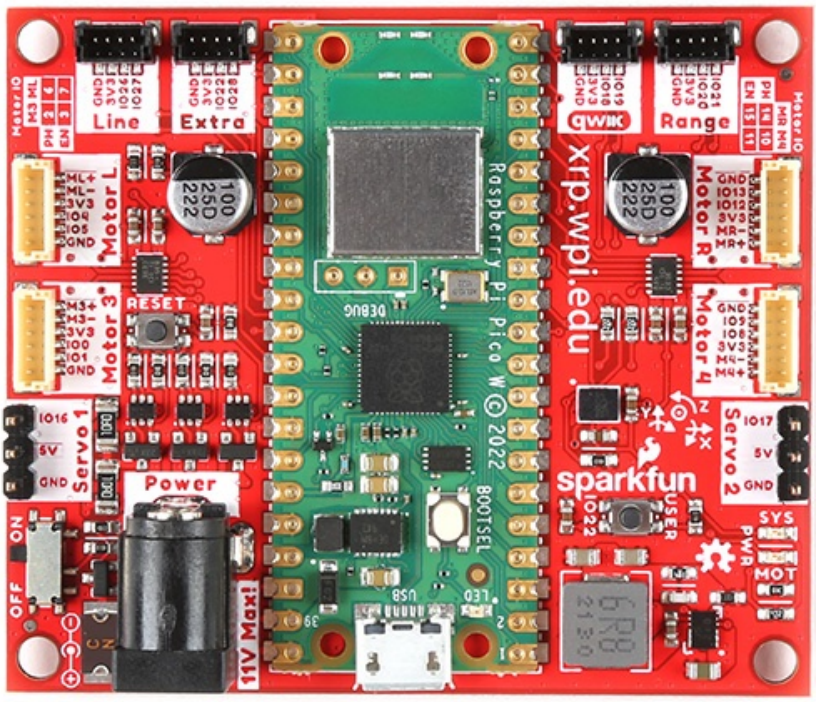


4.2.9 Installing the motors into the chassis (4:09)

The motors snap into the chassis from the bottom once the wheels and cables are installed. The motor is oriented so that the wheel goes through the slot on the chassis as shown in the picture. Ideally you should push the wires from the motor through the opening in the chassis to the top of the chassis so they can be attached to the robot controller. Then seat the end of the motor opposite the cable end, then snap the wheel side of the motor into place. Repeat for both motors.

4.2.10 Photo of the controller board

Many of the following instructions require attaching cables to the connectors on the controller board on the robot. The printing on the board identifying the purposes of each of the connectors and the pins is very small to fit on the small board. To make assembly easier, refer to the following photograph of the board if needed.



4.2.11 Connecting the motor cables to the robot controller (4:43)

The motor cables are connected to the white connectors on the side of the chassis labeled Motor L and Motor R for the left and right motor cables.

4.2.12 Adding the Sensors

The line following sensor can detect lines on the driving surface that have a different reflectivity. These are typically used in robot applications to follow lines or locating interesting places on a board or mat. It has two pairs of LEDs and photo sensors to emit infrared light and measure the reflected brightness.

The ultrasonic rangefinder uses sound to measure the distance to objects in front of the sensor. An ultrasonic (inaudible high frequency) short sound is sent from one of the transducers which is reflected back by nearby objects and received by the second transducer. The time of the sound round-trip is measured to determine distance to nearby objects.

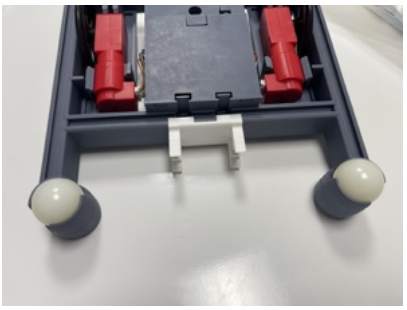
4.2.13 Wiring the sensors (5:11)

The sensor cable is connected to the line following (reflectance) sensor as shown in the picture below. Be sure to observe the order and color of the wires connecting to the sensor. The connectors simply push over the sensor pins. Be sure that they are fully seated as shown in the picture and video to ensure a good connection.

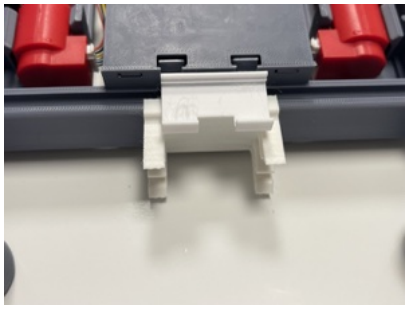
The rangefinder is wired by attaching the four wires from the sensor cable to the pins on the rangefinder as shown in the picture below. Be sure to connect the wires to the pins in the right order.

4.2.14 Attaching the brackets to the chassis (5:44)

The rangefinder bracket is attached to the front of the chassis just above the reflectance sensor as shown in the picture below.

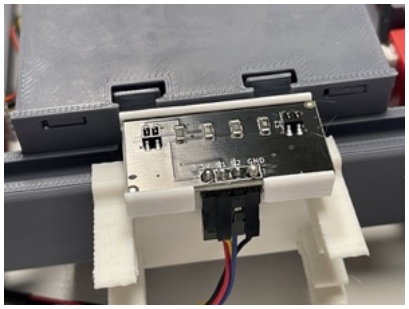


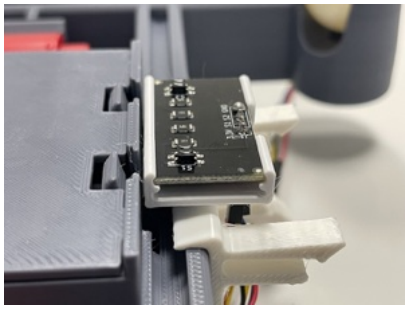
The reflectance sensor bracket is installed on the chassis as shown in the picture below. The ball end of the bracket is inserted into the slot in the front rail.



4.2.15 Inserting the line follower into the bracket (6:19)

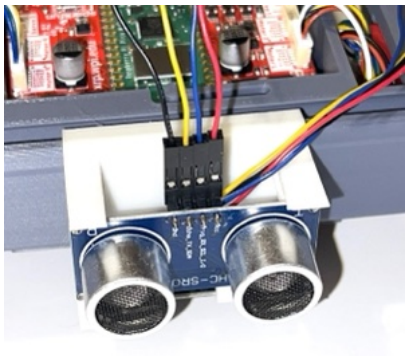
The reflectance sensor is inserted into the bracket as shown in the picture below. Also look at the side view of the assembly to see how the sensor is correctly positioned in the bracket.





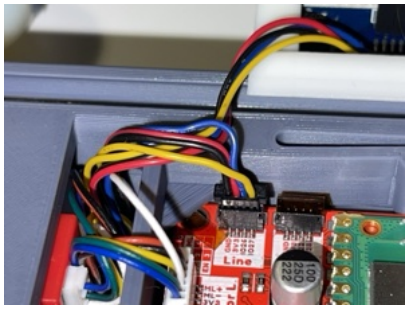
4.2.16 Attaching the rangefinder to the bracket (6:38)

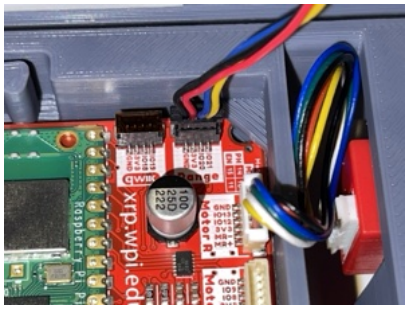
Attach the rangefinder to the bracket as shown in the picture below.



4.2.17 Connecting the cables for the line follower and rangefinder (6:55)

The cables from the reflectance sensor (line follower) and the rangefinder are connected to the connectors on the controller board. Notice that there are labels on the board for each of these cables to help you get them into the right connectors. The line follower cable goes into the connector labeled Line and the rangefinder goes into the connector labeled Range. It is a good idea to put a small loop in the wire that can be tucked into the chassis before connecting it to help keep the wiring neat and less likely to get snagged.





4.2.18 Attaching the servo

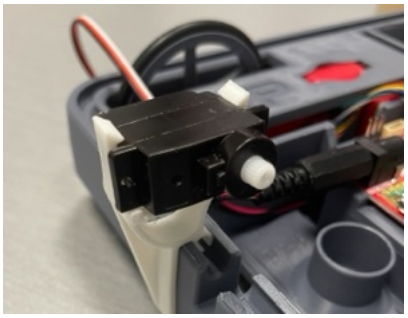
The servo is used to rotate the arm to the desired position. It has the advantage over a normal motor in that it has sensors inside of it to allow it to move to a desired position that you can program.

4.2.19 Attaching the servo bracket to the robot chassis (7:29)

The servo is attached to the robot by first inserting the ball end of the bracket into the upper slot on the back rail, then snapping the bottom part of the bracket over the bottom part of the rail.

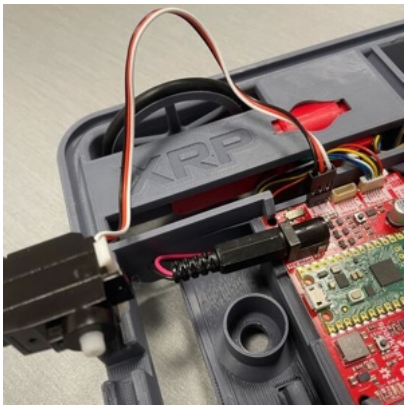
4.2.20 Mounting the servo to the servo bracket (7:54)

The servo snaps into the servo bracket as shown in the photo below.



4.2.21 Connecting the servo cable to the robot controller (8:06)

The servo cable is connected to the slot labeled Servo 1 on the robot controller board as shown in the photo below. Be sure to connect it as shown with the black wire connecting to the Gnd terminal on the Robot Controller board.



4.2.22 Inserting the servo horn into the robot arm (8:27)

The servo horn is the small white plastic arm that attaches to the servo by pressing onto the servo shaft. There are several servo horns that come with the servo accessories. The one that you should use has a hole for attaching to the servo shaft at one end, and a small arm at the other end. It gets installed into the slot at the end of the larger black servo arm as shown in the picture below and the video. **Be sure to install the servo arm so that it is oriented as shown in the photo, in particular make sure that the mounting flange is facing the correct direction**.

4.2.23 Mounting the arm to the servo (8:45)

The servo arm simply presses onto the white shaft on the servo. The servo shaft only has about 180 degrees of rotation so it's important to install the arm so that it can move through its full range of motion while mounted on the robot. Holding the servo so that it's flat with the wires coming out to the left, the arm should be mounted so that it has 180 degrees of motion from front to back. That is the arm will never travel below the level of the servo body. You can see how this is done by looking at the video at the indicated time stamp. This image shows the servo at the end of its travel inside the robot chassis. The other end of the travel will be slightly below horizontal behind the robot.

4.3 Initializing and testing your XRP (10:21)

Refer to SparkFun's video at the top of this page to set up your XRP and ensure that it's working correctly!

Once your XRP is connected, skip to (12:44) in the video and follow along with the built-in test to ensure that the sensors and motors are working properly.

4.4 Troubleshooting the robot build

Generally the build of the robot is very strightforward, but from feedback we have compiled this section that describes some of the common issues we have seen as people are building the XRP.

4.4.1 Rangefinder or the line following sensors don't work in the Installation Verification Test

It is very easy to accidentally attach the rangefinder and line following sensor cables to the wrong connectors on the controller board. Be sure to verify that the rangefinder is in the connector marked "Range" and the line following sensor is in the connector marked "Line".

If the connectors are reversed and you have to remove them, **be sure to only remove the connector by pulling on the plastic shell**. Do not pull on the wires as you might accidently pull them out of the connector.

CHAPTER

FIVE

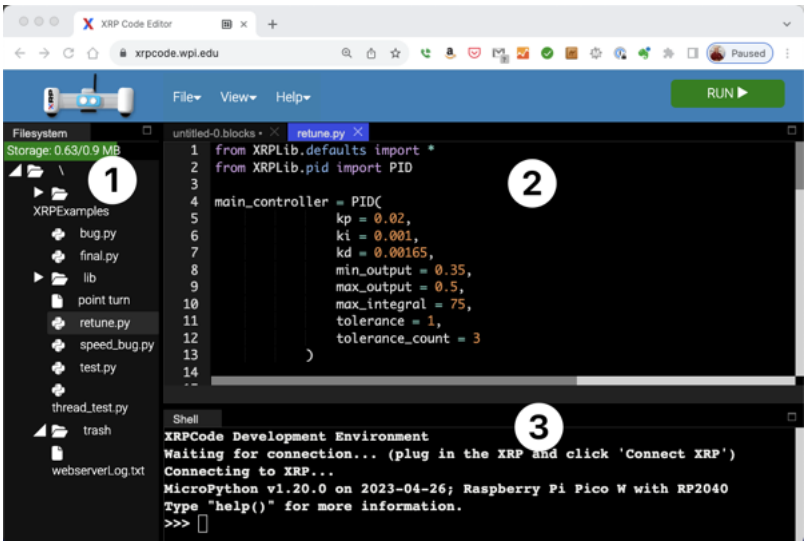
XRPCODE INTEGRATED DEVELOPMENT ENVIRONMENT

XRPCode is a web-based development tool that is run in either the Google Chrome or Microsoft Edge browsers. XRPCode can be used to create either Python or Blockly language programs that run natively on the XRP control board. Blockly programs are first translated to Python and then run. In fact, you can view or even translate the Blockly program into a Python program.

Run XRPCode by navigating to XRPCode web site.

If this is your first time accessing XRPCode or if there has been an update, a changelog will be displayed. Read through the changelog to learn what is new in the current release of XRPLib or the editor.

5.1 Exploring the XRPCode user interface



There are 3 major window areas for XRPCode.

On the left (1) is the Filesystem window. This will show the files on your XRP whenever an XRP is connected.

In the middle (2) is the editor. This is where you will be working on your programs.

At the bottom (3) is the shell window. This is where print statement output will be displayed. You can also use the shell as a command line to write Python code as an interactive way to quickly test ideas.

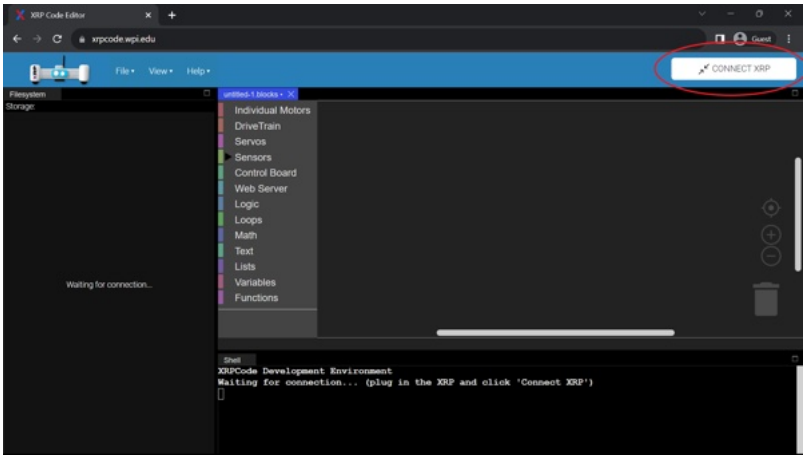
5.2 Connecting your XRP to XRPCode

The XRP robot has a micro USB connector on the controller board that is connected to your computers USB port with a cable.

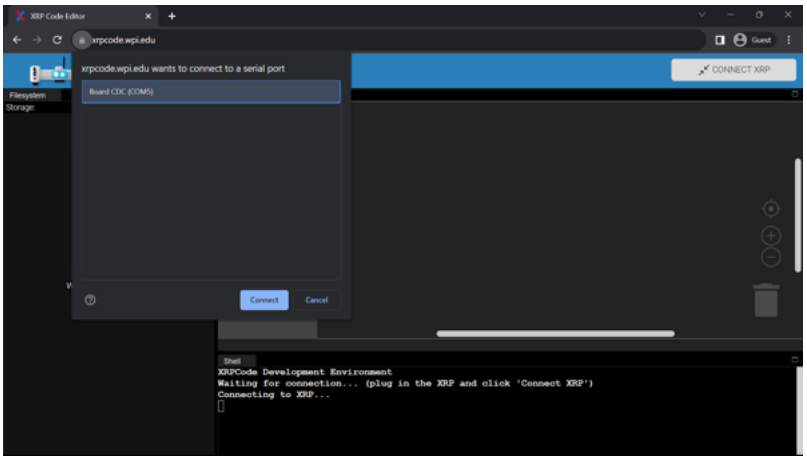
> **Warning:** Many USB cables are for power only and do not transmit data. You will need a USB cable that can transfer data and power.

5.3 Connecting to the XRP

To establish the connection between the XRP robot and the computer, press the 'CONNECT XRP' button. Often the connection will happen automatically when the XRP is plugged in and XRPCode is started.



This will bring up a dialog that lets you select the computer's serial port that XRPCode will connect to. In most cases, there will be just one serial device, but if there are more, select the one that is for your XRP robot. Click on the CONNECT button after selecting the desired serial port.

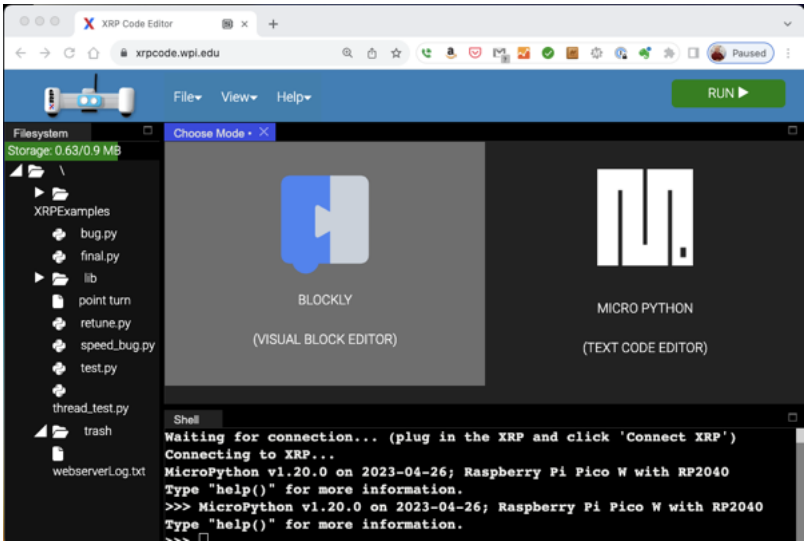


When the connection is made, the 'CONNECT XRP' button will change to a green 'RUN' button indicating that the connection has been made and a program can be run. The Filesystem window will show the files on the connected XRP.

If XRPCode cannot find your serial connection, or there are other connection issues please refer to the troubleshooting section at the bottom of this page.

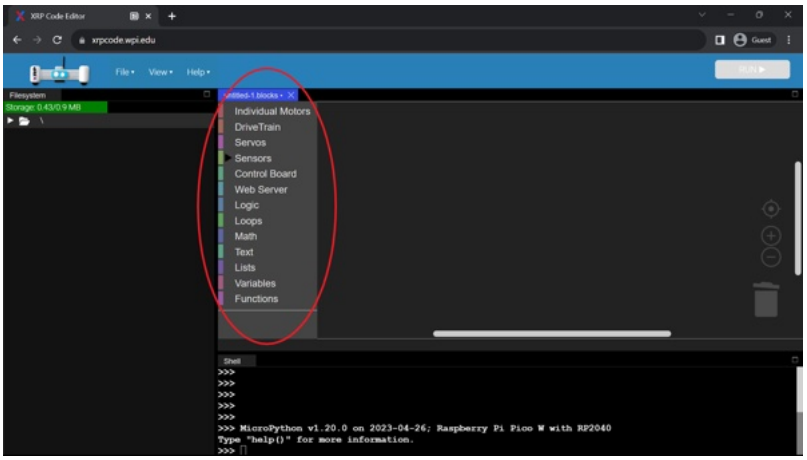
5.4 Using XRPCode

Now that the robot is connected, this is a good time to write a short program to learn about the editor.



In the editor area, there should be a window asking what type of editor to use, either BLOCKLY or MICROPYTHON. (If this is not showing, click on 'New File' under the 'File' Menu) and select BLOCKLY.

On the left of the editor is a palette of all the available blocks.



Notice that they are grouped by functionality. We recommend you click through each section to get a sense of where blocks are.

In this example, we'll create a program that will turn a controller board LED on and print a message in the XRPCode shell window a the bottom of the screen.

Click on the "Control Board" tab and then click on the 

block. This will place this block onto your working canvas. You can move the block around and place it where you like. Now click on the "Text" tab. Then select the first block 

. This block is now also on your canvas. You can move this block around and place it right

under the 

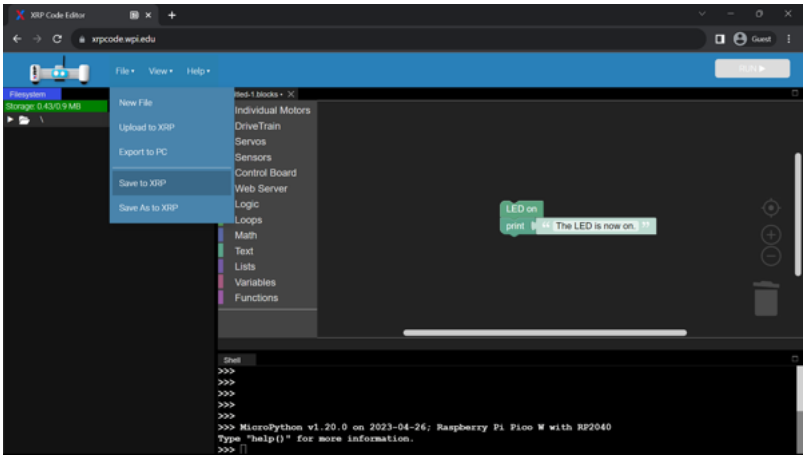
block. You will notice that as you get close to the bottom of the 

block it will show a yellow line indicating that the two fit together. When you let go of the 

block it should click together with the 

block. Feel free to change the "abc" to say what you want to print; ideally something useful to the program. For example, you might print something like "The LED is now on".

Save this new program to the XRP. Under the 'File' menu select 'Save to XRP'.



A dialog will be displayed for you to give this program a name. Change the *untitled* text to a name for your program such as 'first program' and click 'OK'. The program has now been saved to the XRP. You will see the name of your program in the Filesystem window on the left.

You can now press on the green "RUN" button, to run this program. Flip the power switch on your XRP to 'on' and then click 'OK'. If your XRP is not turned on, a warning will pop up telling you to turn on the power switch.

You will notice a few things:

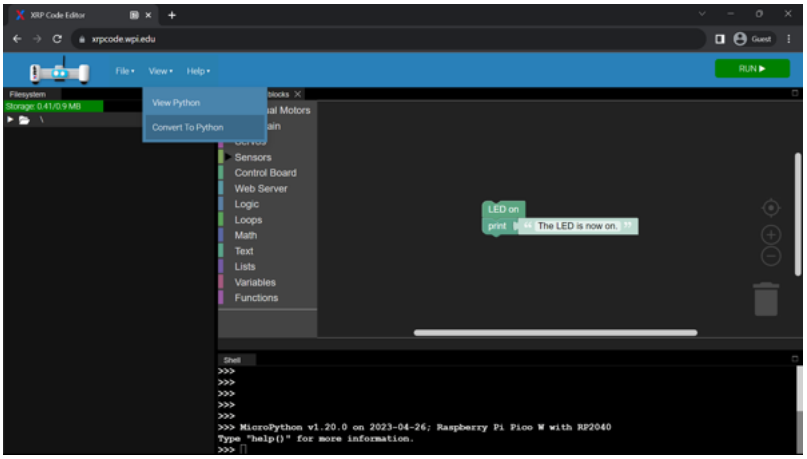
- The green LED next to where the USB cable connects to on the XRP will go on for a little while and then turn back off.
- The shell window at the bottom of XRPCode will print out your message from the print statement.

You may have also noticed that the green 'RUN' button changed to a red 'STOP' button while your program was running and then turn back after.

Clicking on the 'STOP' button will interrupt the program.

You might have noticed that the robot turns off when the program finishes or is interrupted. This is so that at the end of each run, the XRP is reset to a known state in preparation for the next time a program is started.

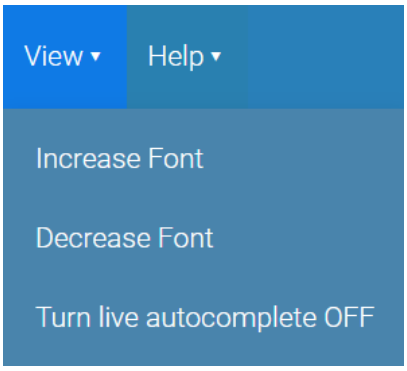
The 'View' menu contents change depending on the language you are using. For Blockly it will show View options for a Blockly program. Click on 'View' and then on 'View Python'. This will bring up a view of the Python code that is generated from your Blockly file. Let's actually convert this Blockly program program into a Python program. Click on 'View' and then on "Convert to Python".



XRPCode will first give you a warning to make sure you want to convert the program as this cannot be undone. Click "OK". It will do the operation and you should notice two things have happened:

1. There is a new 'trash' directory on your XRP.
2. Your program name now ends in .py instead of .blocks.

If you now go to the 'View' menu you will notice that the menu items have changed to be specific to Python.



Close the 'View' menu and find the print statement in the program; it should be the last line. Change the message that is between the quotes. If you look at the file name tab at the top of the editor you will notice a white dot at the end of the name. That means that this file has been modified and has not yet been saved. Now if you click on the 'RUN' button it will save your program and run it again. The message in the shell window should be your new message.

You can close a file by clicking on the X next to the file name at the top of the editor. If you want to open the program again you can double click on the file name in the Filesystem window.

Congratulations, you have now learned how to create and run programs in XRPCode!

5.5 Troubleshooting XRPCode connection issues

Cannot see the serial port when connecting

- Be sure that the USB cable is a data cable and not just a power cable.
- Unplug the XRP from the computer and check the connection of the cable on the XRP side.
- Toggle the power switch on the XRP off. Confirm that the sys LED is on. This means it is properly receiving power from the USB cable. If the LED is not on, try a different cable.

- Make sure you are running either Google Chrome or Microsoft Edge browsers. At the time of writing, only those browsers support serial communication required for programming the XRP.

XRP was previously used for WPILib or some other purpose

- In this case, XRPCode will try to load the current MicroPython firmware onto it; just follow the instructions.

CHAPTER

SIX

DRIVING

6.1 Robot driving

The XRP is a mobile robot platform where driving from one place to another is central to the design of any program. The differential_drive class makes driving easy and has functions to:

- **Set the motor efforts**, which is the power or average voltage applied to the motors. The range of values can be set from -1 for full effort in reverse, to 0 for no voltage or stopped, to +1 for full effort in the forward direction.
- **Specify a speed to drive** in centimeters per second for each wheel. The robot will try to maintain the specified speed as best it can using the drive motor encoders.
- **Drive for a specified distance** using the drive motor encoders to sense how far the robot has traveled.
- **Make point turns** for a desired number of degrees, either clockwise or counterclockwise.

6.2 Effort vs. Speed

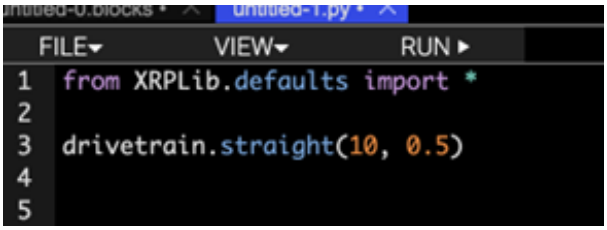
Throughout this document, we refer to the effort and speed of the drivetrain. Although they seem similar, they are distinguished as follows:

Effort
: The effort reflects the amount of power (or average voltage) supplied to the motors. For a given effort, the speed will vary depending on things like the driving surface, the battery voltage, and the slope (either flat, uphill or downhill).

Speed
: The speed is the actual number of centimeters per second that the robot will travel. When set in a program, the software will automatically adjust the motor effort within its capability to keep the robot moving at the desired speed.

6.3 Driving for a distance

The following program fragments show how to program the robot to drive forward for 10 centimeters with an effort of 0.5 or 50 percent power. This function uses the encoders to determine when the robot has traveled the requested 10cm. In addition, this function will ensure that the robot drives in a straight line by varying the speed of the left or right motors if one is slightly faster.



Note: when requesting a distance to drive, the encoders are used to sense the number of degrees of wheel rotation to complete the operation. If the wheels slip while driving, the distance measurement will be incorrect.

6.4 Driving with an effort

This program will set the effort on the left and right drive motors to 50 percent, wait for 3 seconds, and stop the motors. The set_effort() function has parameters for the left and right drive motors to allow them to be set independently. No motor speed control is provided, so different driving surfaces, slopes, or battery voltage will affect the driving speed of the robot. The value of effort ranges from -1 for 100 percent backward to 0 for no effort or stopped to +1 for 100 percent effort forwards.

```
1  from XRPLib.differential_drive import DifferentialDrive
2  import time
3
4  differentialDrive = DifferentialDrive.get_default_differential_drive()
5
6
7  differentialDrive.set_effort(0.5, 0.5)
8  time.sleep(3)
9  differentialDrive.stop()
10
```

6.5 Driving at a speed

Set_speed() attempts to maintain some linear speed in centimeters per second. The maximum speed is measured to be approximately 60cm/s tested on a flat surface.

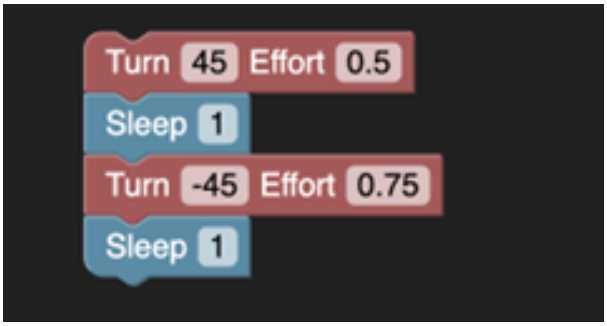
This program will set the robot speed to 5 cm per second, in centimeters per second, of the left and right wheels separately. If both motors are set to the same speed, the robot will drive straight. If they are different, the robot will turn in a direction away from the faster wheel.

```
1  from XRPLib.defaults import *
2
3  drivetrain.set_speed(5, 5)
4  sleep(3)
5  drivetrain.stop()
6
```

6.6 Point turns

The robot can turn in place around a point directly centered between the two drive wheels. This is done by driving the left and right drive motors in opposite directions at the same speed. If the left wheel is spinning in the forward direction, the robot will rotate clockwise or to the right. If the right wheel is spinning in the forward direction, the robot will rotate counterclockwise or to the left.

The turn function specifies the number of degrees to turn, with a positive number indicating a counterclockwise turn, and a negative number indicating a clockwise turn. The second parameter specifies effort from -1 to 1.



```
from XRPLib.defaults import *

def test_turns():
    drivetrain.turn(45, 0.5)
    time.sleep(1)
    drivetrain.turn(-45, 0.75)
    time.sleep(1)
```

When you use the turn function, the IMU (Inertial Measurement Unit) gyro sensor on the robot will determine when the robot has completed the requested turn. This means the turn will continue until complete and is not affected by wheel slip.

Note: If you were to pick up the robot while it is doing a turn, the wheels will continue turning until the gyro senses that the robot has turned the desired number of degrees.

6.7 Swing turns

This type of turn is where one wheel moves forward, and the other is stationary. The robot will pivot on the stationary wheel, making it the center of rotation. The circle's diameter traveled by the moving wheel will be twice the wheel track (the distance between the two wheels).

6.8 Smooth turns

Smooth turns are where the two wheels move in the same direction so that the robot drives in an arc, eventually completing a full circle. The circle's radius depends on the speed difference between the two wheels. The larger the difference, the smaller the circle diameter.

CHAPTER

SEVEN

MOTORS

7.1 Motor classes

The XRP has two drive motors connected to the ports Motor L and Motor R on the robot controller board. The board also supports two additional motors labeled Motor 3 and Motor 4. These motors can be used to create additional mechanisms for the XRP.

There are four classes related to motors:

Motor
: The motor class handles a single motor with a single method for setting the effort between -1 and 1.

Encoder
: The encoder class is responsible for measuring the current position of a motor. This is useful to derive the speed of the motor, or the distance traveled by the motor.

EncodedMotor
: Encoded motors contain a motor and an encoder, and has higher level logic for functionality that incoporate both objects. This class supports features like resetting and getting the motor position, setting the effort and speed of the motor, and configuring what controller is used for closed-loop speed control.

MotorGroup
: It is often desirable to treat several motors as if they were one. For example, in a four wheel drive robot, the left side motors usually get the same settings when driving the robot. A motor_group is created with multiple motors, and functionality like setting effort can be applied to all the motors in the motor group.

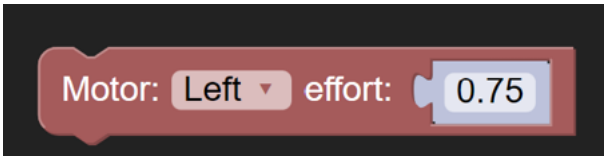
Since the XRP bot is built with an encoder on each motor, it usually is not necessary to directly deal with Motor or Encoder objects. Instead, use EncodedMotor or MotorGroup for higher level functionality.

7.2 Using EncodedMotor

Interacting with EncodedMotor objects is often the most convenient way to control motors on the XRP. The XRPLib.defaults module provides two ready-made EncodedMotor objects, left_motor and right_motor, which allow for fully independent control over the drive motors of the robot.

There are four motor controllers total on the XRP, numbered 1-4. 1 and 2 are the left and right motors, and 3 and 4 are labeled on the robot controller board. left_motor and right_motor objects are provided by default in the XRPLib.defaults module. Let's take a look at how we can use the left_motor object to set the left motor to an effort of 0.75.

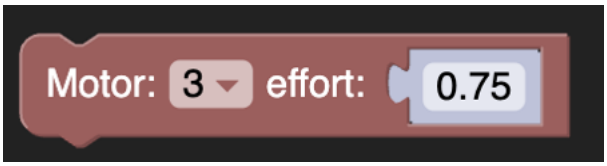
```
from XRPLib.defaults import *

left_motor.set_effort(0.75)
```



Alternatively, you may also construct your own EncodedMotor objects, which is needed to control motors 3 and 4. The following code sets Motor 3 to an effort of 0.75.

```
from XRPLib.encoded_motor import EncodedMotor
motor3 = EncodedMotor.get_default_encoded_motor(3)
motor3.set_effort(0.75)
```

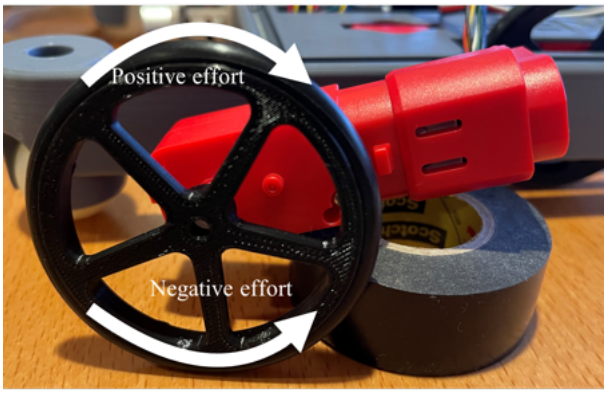
In Blockly, constructing motor objects is not necessary. Under the "Individual Motors" category, each block takes in a parameter to specify which motor to use. This is all that is needed to set Motor 3 to an effort of 0.75 in Blockly:



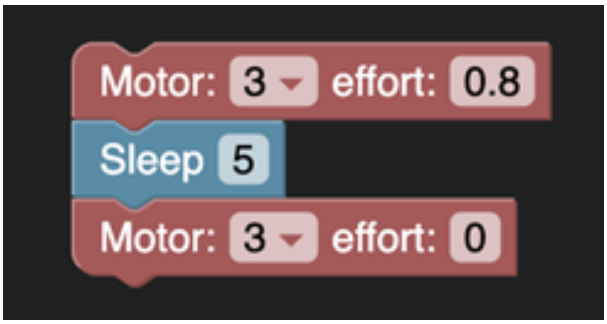
7.3 Methods for EncodedMotor objects

set_effort(effort_value)

As seen earlier, this method spins the motor at some raw effort. The effort value ranges from -1 to +1, where negative efforts spin the motor in reverse, and positive efforts spin the motor forwards. An effort of 0 stops the motor.



The programs shown below set Motor 3 to 80 percent effort for 5 seconds, then afterwards, back to 0 percent effort to stop the motor. This example uses motor 3, but any motor can be used in its place.



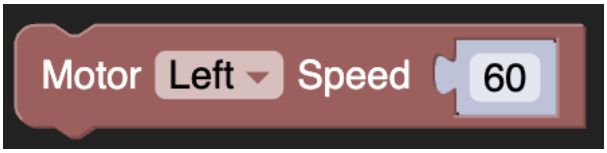

```
from XRPLib.encoded_motor import EncodedMotor
import time

motor3 = EncodedMotor.get_default_encoded_motor(3)


motor3.set_effort(0.8)
time.sleep(5)
motor3.set_effort(0)
```

set_speed(speed_rpm)

Unlike the Drivetrain object which uses cm/second, the motor objects handle speed in rotations per minute. They reads from the encoder to determine the current speed, and adjust based on a closed-loop controller, which by default is a PID controller. Similarly to set_effort(), the sign of the speed determines the direction of the motor.

The example programs below set a speed of 60 rpm for the left motor:

```
from XRPLib.encoded_motor import EncodedMotor
motor1 = EncodedMotor.get_default_encoded_motor(1)
motor1.set_speed(60)
```

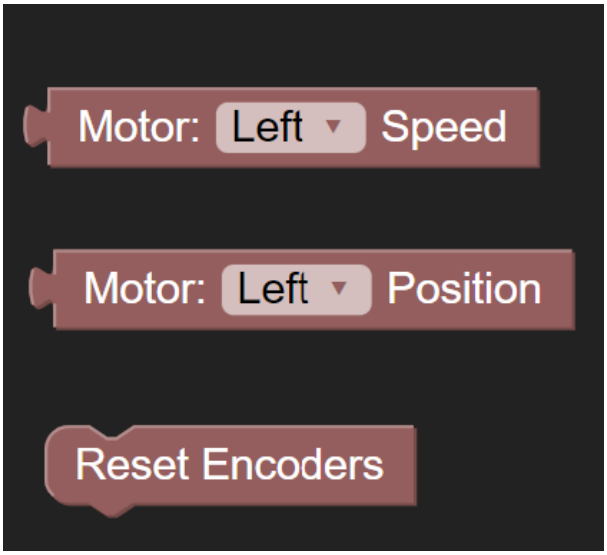


set_speed_controller(controller)

The set_speed() function relies on a controller to determine how to vary the effort of the motor to maintain the specified speed. By default, the controller is a PID controller, but it can be changed to any object that implements the Controller abstract class.

The example below sets the speed controller with custom PID tunings. For more information on controllers, refer to the page under Miscellaneous Topics. Currently, there is no support for custom controllers in Blockly.

```
from XRPLib.encoded_motor import EncodedMotor
from XRPLib.pid import PID
motor1 = EncodedMotor.get_default_encoded_motor(1)
motor1.set_speed_controller(PID(kp=2, ki=0, kd=0.1))
motor1.set_speed(60)
```



get_speed() -> float

Returns the current speed of the motor in rotations per minute, as measured by the encoder.

get_position() -> float

Returns the current position of the motor in rotations, as measured by the encoder.

get_count() -> integer

Returns the current position of the motor in encoder counts, as measured by the encoder.

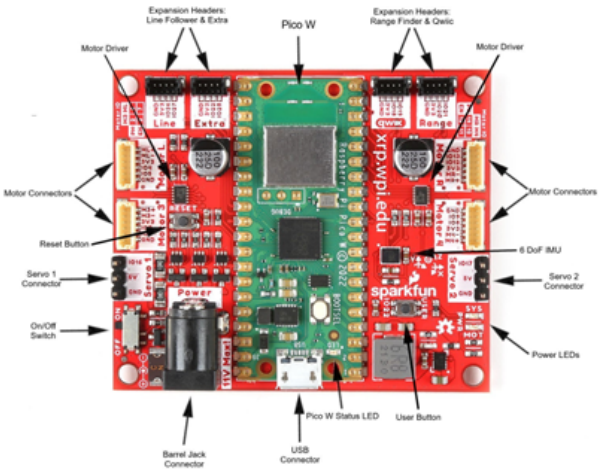
reset_encoder_position()

Resets the encoder counts to 0. get_position() and get_count return the difference in distance since the last reset.

CHAPTER

EIGHT

SENSING THE ENVIRONMENT



8.1 Measuring the distance to an object

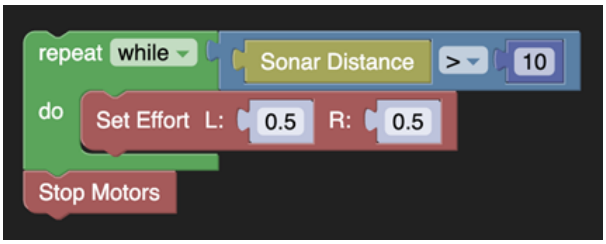
The XRP includes an ultrasonic rangefinder that can measure the distance to objects in front of it. The sensor has two transducers; one acts as a speaker, and the other acts as a microphone. It does it by sending a burst of ultrasonic sound out of the speaker that hits an object in front of the robot. The sound reflects off the object back to the sensor and is captured by the microphone. The time for that round trip determines the distance to the object. Understanding how well the sound reflects off various objects of different sizes, profiles, and materials is important for using the sensor. A good exercise is to test the sensor by printing returned values at various distances from any object you want the robot to detect.

Note: It is important to wire the sensor correctly, as described in the assembly instructions, to ensure it works properly. Interchanging the trigger and echo wires is a common error using that part.

XRPLib has a rangefinder class that takes care of the sending and receiving signals to the sensor. All the program has to do is request the distance, and the library returns it. There is a single method called distance() that returns the distance to the nearest object in centimeters. The range of operation is from 2cm to 4m.

8.2 Example use of the rangefinder

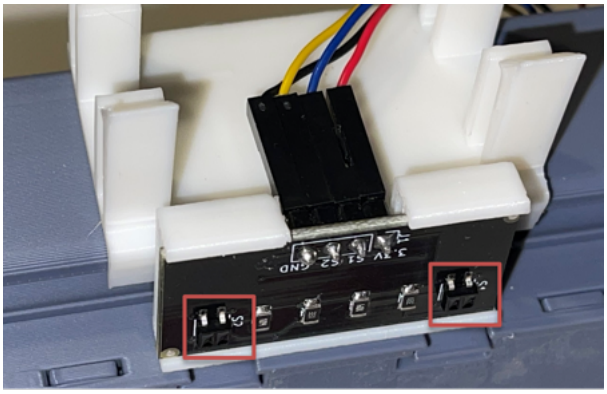
The following program drives the XRP forwards until the code detects an object within 10cm of the ultrasonic rangefinder. Then it stops.



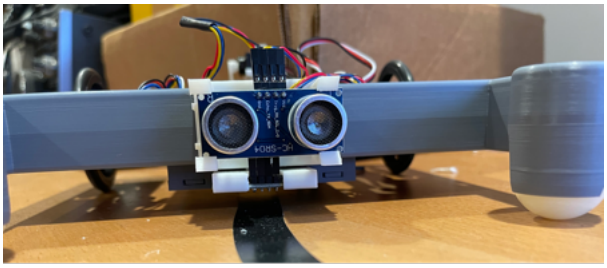

```
from XRPLib.rangefinder import Rangefinder
from XRPLib.differential_drive import DifferentialDrive

rangefinder = Rangefinder.get_default_rangefinder()
differentialDrive = DifferentialDrive.get_default_differential_drive()

while (rangefinder.distance()) > 10:
  differentialDrive.set_effort(0.5, 0.5)
differentialDrive.stop()

```

This program stops the motors when the object is detected. A better way of solving the same problem might be to use proportional or PID control to gradually bring the robot to a stop to avoid overshoot, where inertia might carry the robot beyond the 10cm set point before it comes to rest.

8.3 Following lines



A photo showing the two LEDs and photo sensor pairs



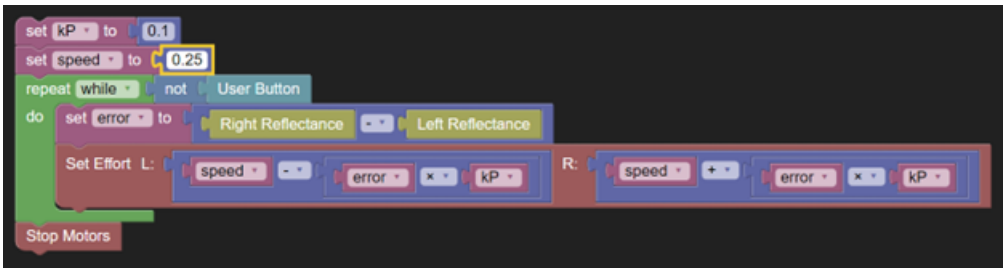
Robot following a line taped on a table

A reflectance sensor that can be used for line following is included with the XRP. It has two pairs of LEDs and light sensors. The LEDs emit infrared light that reflects off the driving surface. The light sensor measure the reflected light intensity, which depends on the surface below the sensor. Electrical tape is typically used to make a line that the robot can follow and has a different reflectivity than the surface, usually a whiteboard or tabletop. With a pair of sensors, the robot can read the reflectance value and tell where it is relative to the taped line.

The class reflectance has methods get_right() to retrieve the right reflectance value and get_left() to retrieve the left reflectance value. The reflectance ranges from 0 (white) to 1 (black).

8.4 Line following example program

The following program uses proportional control with the line sensors to follow a line across the driving surface for the robot. The Kp variable sets the gain for the controller.



```
from XRPLib.board import Board
from XRPLib.reflectance import Reflectance
from XRPLib.differential_drive import DifferentialDrive

board = Board.get_default_board()
reflectance = Reflectance.get_default_reflectance()
differentialDrive = DifferentialDrive.get_default_differential_drive()

kP = 0.1
speed = 0.25
while not board.is_button_pressed():
  error = reflectance.get_right()) - (reflectance.get_left()
  differentialDrive.set_effort(speed - error * kP, speed + error * kP)

differentialDrive.stop()
```

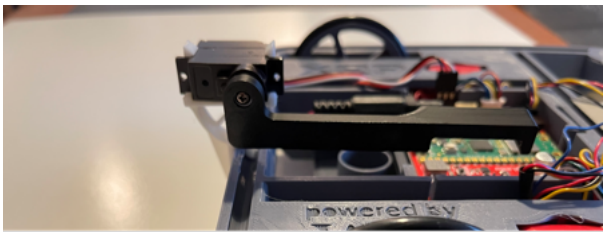
CHAPTER

NINE

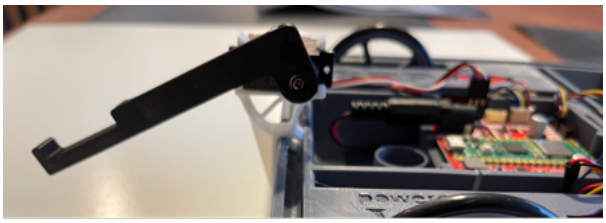
USING THE ARM

9.1 Setting up the arm on the servo

The servo motor used to attach the arm on the XRP has about 200 degrees of rotation and can move to a desired position using internal sensors. When attaching the arm to the servo, it is important that one end of its range is with the arm relatively horizontal inside the robot chassis and the other end of the rotation outside the back of the robot for picking up objects. The full range of arm rotation is shown in the two images below.



Arm at one end of servo rotation inside the chassis for storage



Arm at the other end of rotation positioned behind chassis to pick up objects

To position the arm correctly, install it in any position and use it to rotate the servo to the full clockwise direction, as seen in the top photo. Then reinstall the arm so that it is in the shown position. Then the software will be able to move it to any position in between the two photos above.

9.2 Moving the arm under program control

Use the servo class to move the servo motor to the desired position. The method set_angle() sets the servo position to the desired angle. Below is an example program that moves the servo position from one end of its motion to the other.


```
1  from XRPLib.servo import Servo
2  import time
3
4  servo1 = Servo.get_default_servo()
5
6
7  for count in range(10):
8    servo1.set_angle(0)
9    time.sleep(3)
10   servo1.set_angle(135)
11   time.sleep(3)
```

When the servo is controlled from the program, it is held in the position it was last set to. To free it, that is to allow it to be moved by hand, the free() function may be called, and the program will stop sending the position signal to the servo.

CHAPTER

TEN

CREATING A DASHBOARD

A program can display a web page that can act as a dashboard or control panel for your robot. The web page can be used for:

1. Program debugging by wirelessly displaying values such as errors, messages about what the program is doing, sensor readings, and other status as the robot is driving. This allows the XRP to output important values without needing to be plugged in
2. Binding functions to web page buttons so that when pressed, the functions are executed by the web server. Using this technique, your device can act as a remote controller for your XRP. This is also a great technique to test functions as you write them by executing them from the web server.
3. To create more graphically pleasing buttons for controlling your robot, there are predefined buttons for forward, backward, left, right and stop operation. These will display on the web page like a game controller dashboard.

Before starting the web server, you should define all the displayed values, user buttons, and the driver panel.

First, one (but not both) of the following two methods must be called to initialize the network:

```
start_network(robot_id: int)
```

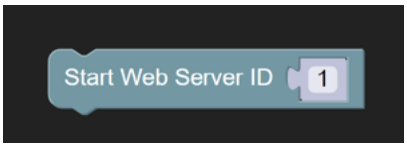
This opens an access point from the XRP board to be used as a captive host. The network password is "remote.xrp"

```
connect_to_network(ssid: str, password: str, timeout=10)
```

This will connect to a wifi network with the given ssid and password. If the connection fails, the board will disconnect from the network and return.

Then, XRPLib will create and start a web server using the robot built-in WiFi connectivity when the Webserver class method is called:

```
webserver.start_server(id)
```



Note that this will only suceed if one (not both) of the above two methods is called first. This function call will:

1. Bring up the WiFi interface on the robot using a robot number parameter to create a unique SSID. When a device (computer, phone, or tablet) connects to that SSID from the network settings, it will then be on the robot's local network and no longer on the internet.
2. Start listening on port 80 (HTTP) for a connection from a browser.

3. Dynamically create a web page based on user programming that can have driving controls, buttons corresponding to user functions, and display of program data for debugging or robot monitoring.

The user can then connect to the robot web server using a phone, tablet, or computer to see the web page the robot program creates.

Note: If you connect to the robot to the computer you are using to programming it, you might lose connectivity with the internet, so that XRPCode stops working.

The user should enter the URL: ROBOT_URL.

10.1 Using the web server

The start_server() function will never return. Once your program calls start_server(), the only way of executing code will be through the generated program. The program will then be event-driven, that is, only responding to pushbutton events from the web server.

10.2 Display running program data

A program can log any expression to the web server as a value by supplying a text label for the value and the value itself.

Some examples are:

```
webserver.log_data("test", "test")
webserver.log_data("List", [1,2,3])
webserver.log_data("Dict", {"a":1,"b":2,"c":3})
webserver.log_data("Tuple", (1,2,3))
```

10.3 Teleop driving from the dashboard

To drive the robot, a program can create a driving interface by binding functions to left, right, forward, backward arrow buttons and a stop button. If bound, these buttons will apear in a diamond pattern in the browser and will call the bound functions when pressed.

Here is an example of how to do set up those bindings using lambdas (single line functions) that will operate a robot.

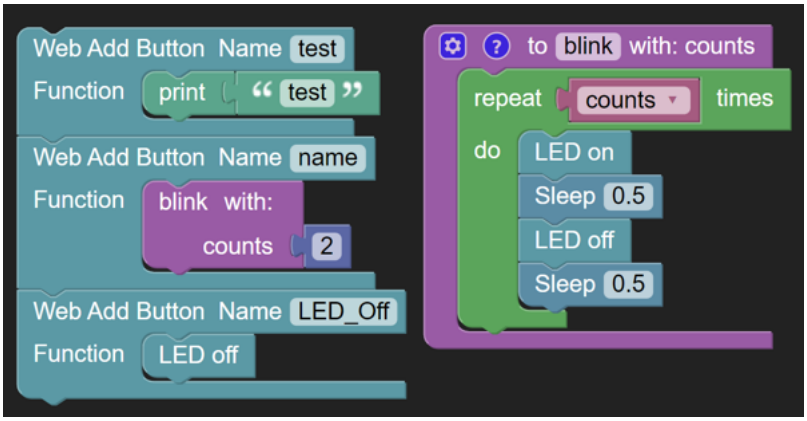
```
webserver.registerForwardButton(lambda: drivetrain.set_effort(0.5, 0.5))
webserver.registerLeftButton(lambda: drivetrain.set_effort(-0.5, 0.5))
webserver.registerRightButton(lambda: drivetrain.set_effort(0.5, -0.5))
webserver.registerBackwardButton(lambda: drivetrain.set_effort(-0.5, -0.5))
webserver.registerStopButton(lambda: drivetrain.set_effort(0, 0))
```

By using the set_effort function, the robot will continue to drive after a single button press until told to do something else.

10.4 Calling arbitrary functions from the dashboard

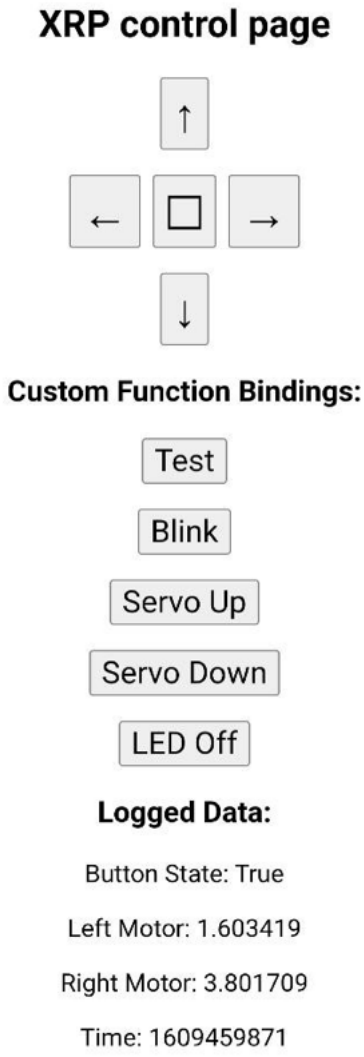
A program can create a button, that when pressed, will call a user function to do any operation that is required.

```
webserver.add_button("test", lambda: print("test"))
webserver.add_button("blink", lambda: print(led.blink(2)))
webserver.add_button("LED_Off", lambda: led.off())
```



10.5 Sample dashboard output

Below is an example of a dashboard that contains data logging, function buttons, and driving controls. This is a screen capture from a cell phone web browser where one can push buttons to run functions or use arrow keys as well as viewing values from the program.


XRP control page
↑
←
□
→
↓
Custom Function Bindings:
Test
Blink
Servo Up
Servo Down
LED Off
Logged Data:
Button State: True
Left Motor: 1.603419
Right Motor: 3.801709
Time: 1609459871

CHAPTER

ELEVEN

USING A GAME PAD

The Gamepad support in the XRP library works swith a single USB gamepad connected to the computer that is controlling the XRP. The computer recognizes that gamepad model and sends the control signals to the robot. With a gamepad you can write programs where an operator can control various aspects of the robot.

While this lets a person drive the robot, for the most *robotic* operations, we recommend using the buttons on the gamepad to control programed seequences, therefor making the XRP more accurate and fastest operating for the driver.

11.1 Supported Game Pads

There are many supported gamepads. We have tested with the Logitech and XBox USB gamepads with good results. To test if your Gamepad will work with XRPCode, go to web page https://hardwaretester.com/gamepad. If the buttons and joysticks work on the web site then you should expect that they will work with your XRP.

Use of gamepads requires a Bluetooth connection to the XRP

Gamepad support currently requires that the robot be connected to the laptop via a Bluetooth connection. If the robot is connected with a USB cable, you cannot also use a gamepad to control the robot. This will be fixed in an upcoming release of XRP code.

11.2 How to use the game pad in XRP programs

The program flow for a typical *user control* program is a loop that reads input values from the gamepad controller which is then interpreted by the program to either drive the robot or operate attached mechanisms.

The game pad can be accessed programatilcally in either of two ways:

1. Reading the values from the joysticks that range from -1 to 1 for full up to full down. These values might be applied to motor efforts (left stick to left motor and right stick to right motor) to drive the robot in *tank* mode.

2. Testing if a particular button is pressed could trigger any number of functions from moving the servo arm to a preset position, operating some user created mechanism connected to the robot, or run a sequence of code as a way of automating the roobt operation. When the button is pressed a value of 1 is and a value of 0 when not pressed.

Python

Blockly

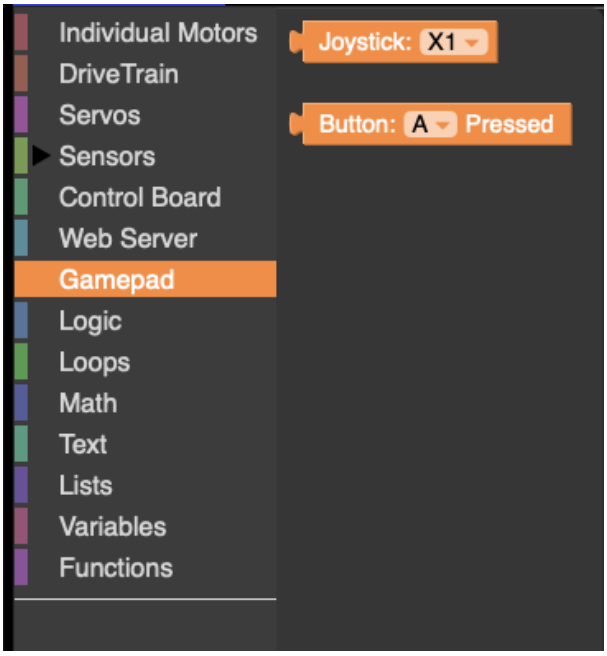
The Gamepad class has two methods that are used to read the state of the gamepad. They are: Gamepad.X1, Gamepad.X2, Gamepad.Y1, and Gamepad.Y2. X1 and Y1 are for the left joystick and X2 and Y2 are for the right stick.:

```
get_value(axis)
```

where the axis is one of the constants described above.

This sample program below will drive the robot by setting the left and right efforts from the gamepad joysticks Y-axis (tank drive), and will set the servo position to either 90 or 135 degrees depending on whether the A or B buttons are pressed:

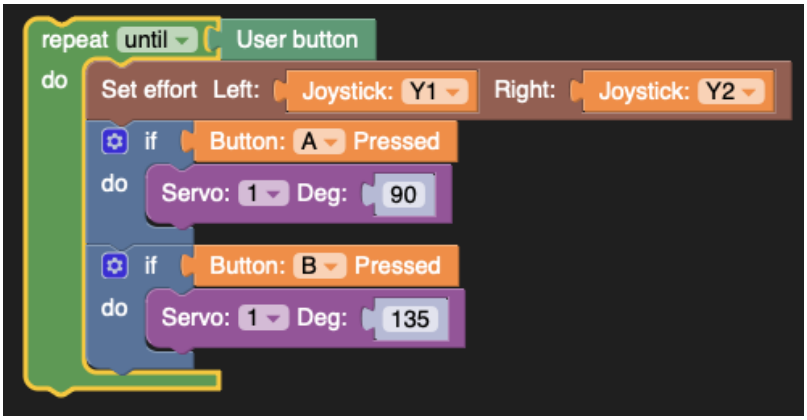
```
from XRPLib.board import Board
from XRPLib.differential_drive import DifferentialDrive
from XRPLib.gamepad import *
from XRPLib.servo import Servo

board = Board.get_default_board()

differentialDrive = DifferentialDrive.get_default_differential_drive()

gp = Gamepad.get_default_gamepad()

servo1 = Servo.get_default_servo(1)

while not (board.is_button_pressed()):
    differentialDrive.set_effort((gp.get_value(gp.Y1)), (gp.get_value(gp.Y2)))
    if gp.is_button_pressed(gp.BUTTON_A):
        servo1.set_angle(90)
    if gp.is_button_pressed(gp.BUTTON_B):
        servo1.set_angle(135)
```



The **Joystick** block returns a -1 to 1 value based on the position of the selected Joystick axis. This is typically used for directly controlling the speed of motors, either the robot drive motors or mechanisms like arms.

The **Button** block returns a 0 (released) or 1 (pressed) for the selected gamepad button. This is typially used to trigger code or move a mechanism to a preset location.

This sample program below will drive the robot by setting the left and right efforts from the gamepad joysticks Y-axis (tank drive), and will set the servo position to either 90 or 135 degrees depending on whether the A or B buttons are pressed.



CHAPTER

TWELVE

MISCELLANEOUS TOPICS

12.1 Operating the LED

```
def test_led():
    led.blink(5)
    time.sleep(3)
    led.off()
```

12.2 Waiting for a button press

There are 3 buttons on the XRP control circuit board that are:

Reset
: Resets the robot controller causing the main program to start up after initialiization

Boot Sel
: Puts the contoller into boot loader mode when pressed while power is being applied. The controller will appear as a connected drive that can accept new firmware that is dragged to it

User
: A selectable button that can be read by the robot program using functions in the XRP software library.

To have the robot program wait for the user to press the "User" button, use the "Wait for button press" block if you are writing a Blockly program or with the "board.wait_for_button()" button in Python.

12.3 Feedback-based control

12.4 Custom controllers

The set_speed() method of EncodedMotor uses a pretuned PID controller to maintain the speed through adjusting the the raw effort. However, through:

```
encodedMotor.set_speed_controller(controller)
```

a custom controller can be specified. The method expects a Controller object. The Controller abstract class is defined with the following three methods:

update(error) -> float

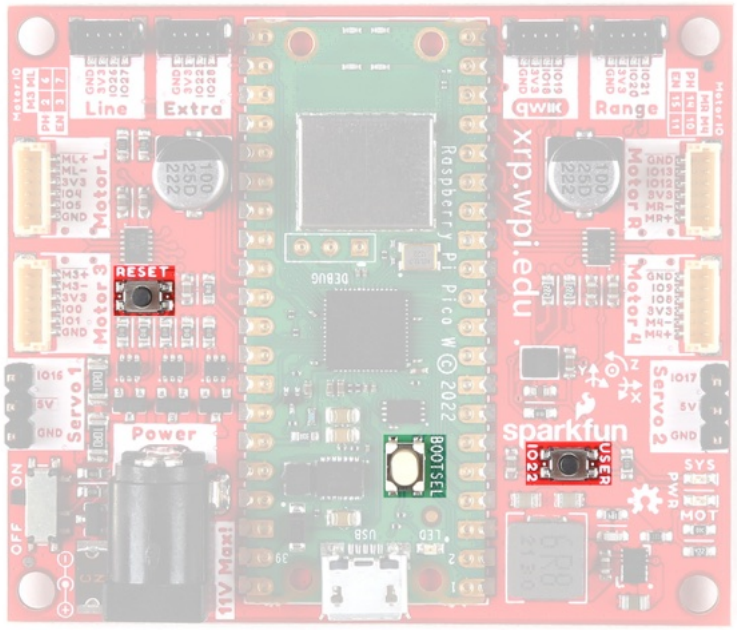


Fig. 1: Pushbuttons on the XRP controller circuit board

This method is called at every tick, and returns an output value given an input error value. This would be where PID logic would take place, for example.

is_done() -> bool

This is a getter method that returns True if the controller has reached the target value, and False otherwise.

clear_history()

The intent of this method is to reset any internal state of the controller, i.e. integral sum. This is called on the speed controller when set_speed() is called on the encoded motor.

By subclassing the Controller class and implementing these three methods, a custom controller can be used to control the speed of each motor.

12.5 Inbuilt PID controller

The PID class is a library-provided subclass of the Controller class, and provides a full PID implementation. The PID constructor takes in the following parameters, each with default values:

kp = 1.0
: Proportional gain constant

ki = 0.0
: Integral gain constant

kd = 0.0
: Derivative gain constant

minOutput = 0.0
: Constrain output to this minimum value

maxOutput = 1.0
: Constrain output to this maximum value

maxDerivative = None
: Constrain derivative term to this maximum magnitude

tolerance = 0.1
: Error tolerance for is_done()

toleranceCount = 1
: Number of consecutive ticks within tolerance to return True for is_done()

The default set_speed() controller uses a PID controller with the default parameters. However, it may be useful to pass in a PID object to set_speed_controller() with customized parameters to fine-tune the controller.

CHAPTER

THIRTEEN

FREQUENTLY ASKED QUESTIONS

13.1 Bluetooth connections

13.1.1 Robot often disconnects from XRPCode

The most frequent cause of Bluetooth disconnects is low batteries. This can cause the Bluetooth connection to be unreliable or completely unavailable. Make sure that your batteries are fully charged, ideally having 2 sets of rechargable batteries so that one can always be recharging.

13.1.2 Windows development computers

The Windows operating system, in particular, often has a 10 to 15 second reconnection time. This happens while waiting for an initial connection, or reconnecting after pressing the STOP button. This delay can often be avoided by letting the program exit, that is run to the end of the file. If, instead, a running program is interripted using the Stop button in XRPCode, then the connection has to be reestablished and it might take up to 15 seconds.

13.1.3 Infinite loops

A common way to write user control (or teleoperated) programs is to have an infinite loop where the game controller buttons and joystick values are read and the motors are set accordingly. The problem with this style of program is that the only way to stop this program is with the Stop button or resetting the robot, and in either case, restarting will have the long delay. You can eliminate that long delay by making sure that you program exits when it's finished.

This can easily be done by changing the unconditional loop to one that can be stopped so that the program exits and the connection is maintained. This can be done by using a button to trigger program termination. A convenient button to use is the User button on the XRP control board, although one coule also use a gamepad button as a trigger to stop the program.

Below are examples of having an infinite loop, and a loop that terminates with the User button.

Python

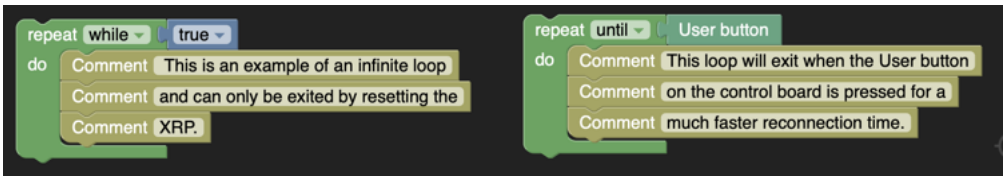
Blockly

The following program uses a differential_drive (differential_drive) object and a Gamepad object (gp) and shows how an infinite loop might be used for a teleoperated driving program. Notice that the program doesn't ever exit from the loop and so the only way to end the program is to use the stop button or reset the robot:

```
while True:
    differential_drive.set_effort(gp.get_value(Y1), gp.get_value(Y2))
```

The next program uses a loop that can be ended by using the user button on the XRP control board. Upon pressing the button the loop ends, and the the program stops without requiring a lengthly reset:

```
while not (board.is_button_pressed()):
    differential_drive.set_effort(gp.get_value(Y1), gp.get_value(Y2))
```



13.1.4 XRP not appearing in the Bluetooth pairing window

If the name is not showing up in the Bluetooth pairing dialog box, then the XRP may need to be reset. You can press the reset on the XRP, or turn the switch off and back on. When using the switch, make sure the XRP is not connected via a USB cable, as that cable provides power and the XRP will not turn off fully by the switch. If this does not start the XRP showing its pairing address, then see the Wrong Firmware section.

13.1.5 Refresh page

There are times when the browser gets confused about the bluetooth connection. XRPCode will now pop up a dialog to letting you know to refresh the page when it sees these conditions. But, if you get to the point of the XRP spinner is going for more than 20 seconds then refreshing the page and resetting the XRP is a good course of action.

13.1.6 Can't connect

If the XRP bluetooth address is showing up, but it never finishes pairing after hitting the Pair button, then try refreshing the web page and resetting the XRP.

13.1.7 Multiple XPRCode pages open

XRPCode is designed to only have one window open at a time. If you have more than one XRPCode open, close all them and then re-open one and try again.

13.1.8 Wrong firmware or libraries

For bluetooth to work it must have both the correct version of MicroPython and the correct version of the XRPLib libraries. Always let XRPCode update your MicroPython and XRPLib to the latest.

13.1.9 XRPCode won't connect even with a cable

Assuming you have checked that you are using a USB data cable and not just a USB power cable. Then check to see if a disk drive shows up when you connect the XRP to the computer with the USB cable. The drive name may be something like:

- PICODISK
- RPI-RP2
- RP2350

If you see one of those drives when plugging in the XRP you need to manually put MicroPython back onto your XRP. Follow this link on how to do that:

- XRP Beta Board
- XRP Board

CHAPTER

FOURTEEN

BLOCKLY DICTIONARY

Individual Motors

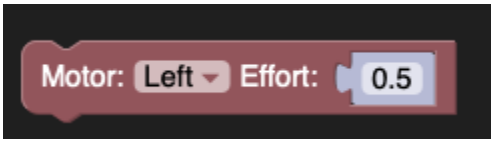


Fig. 1: Set the motor effort from -1.0 to 1.0 and start the motor. Negative values turn in the opposite direction. Motor efforts are based on the applied voltage, but are not the same as rotation, since changes in web_log_data will change the rate of rotation.

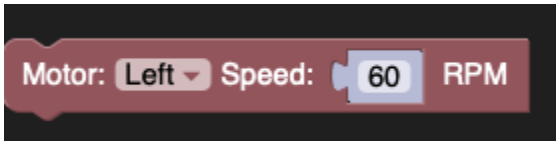


Fig. 2: Set the motor rotational velocity expressed in RPMs (revolutions per minute). Setting speeds greater than the motor can spin will just run at maximum speed. Negative values spin the motor in the opposite direction. This uses a PID controller to try to constantly control the effort to keep the rate of rotation at the specified value.

Fig. 3: Get the motor speed in RPMs (revolutions per minute).

Drivetrain

Servo

Sensors

Control board

Web Server

Assign a function to the forward button.

Assign a function to the backward button.

Assign a function to the left button.

Assign a function to the right button.

Fig. 4: The position of the encoded motor, in encoder counts, relative to the last time reset was called.

Fig. 5: Gets the position of the encoded motor, in encoder counts, relative to the last time reset was called.

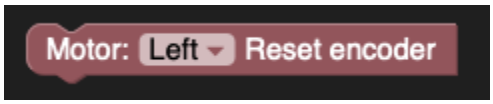


Fig. 6: Resets the encoder position to zero.

Fig. 7: Go forward the specified distance in centimeters, and exit function when distance has been reached. Max_effort is bounded from -1 (reverse at full speed) to 1 (forward at full speed)

Fig. 8: Turn the robot some relative heading given in degrees, and continue Until the robot has reached that heading. effort is bounded from -1 (turn counterclockwise the relative heading at full speed) to 1 (turn clockwise the relative heading at full speed) This block uses the IMU to determine the heading of the robot and P control for the motor controller.

Fig. 9: Set the effort of the left and right motors using the supplied values ranging from -1.0 to 1.0.

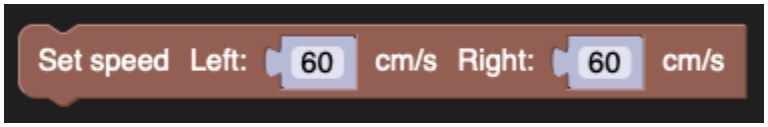


Fig. 10: Varies the effort on each wheel motor to keep the robot driving at the requested speed. As the load changes, the effort will change by a value to keep the speed constant.

Fig. 11: The robot will drive at the specified speed and at the same time, turn by an amount based on the second parameter ranging from -1.0 to 1.0. This is especially useful for steering the robot using proportional control where the 2nd parameter is the gain.

Fig. 12: This block will stop both drivetrain motors. It does not effect the other motors that might be in use on the robot.

Fig. 13: The left and right motor encoders are reset to 0.

Fig. 14: This block is the value of the left encoder.

Fig. 15: This block is the value of the right encoder.

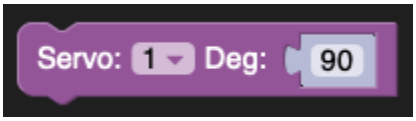


Fig. 16: This block sets the servo angle between 0 and 200 degrees.

Fig. 17: The sonar sensor measures the distance to objects in front of the rangefnder. It does this by using ultrasonic sound that is emitted from one of the transducers on the sensor and measuring how long it takes for the echo to return to the other transducer. Knowing the speed of sound, then sensor then calculates the distance to the object. The distances are returned in centimeters.

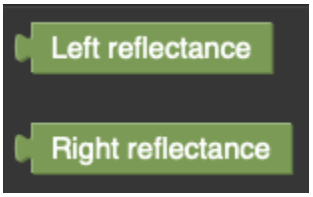


Fig. 18: The reflectance sensor, actually left and right reflectance sensors, each with an LED and a photocell. The LED shines light onto the surface below the sensor and the photocell measures the intensity of reflected light. The range of values returned vary from 0.0 to 1.0 delending on the amount of reflected light.

Fig. 19: The gyro sensor measures the rate of rotation in the X, Y, and Z axis. The rates are integrated (summed over time) giving the rotation angle. For example, if the rate was 10 degrees per second and it is summed for 2 seconds, it would indicate 20 degrees of rotation.

Fig. 20: The accelerometer measures the acceration of the robot in the X, Y, and Z axis. One common use of is to measure the acceration due to gravity that the robot is always experiencing. If the robot is level on a surface, then the Z accelerations will be 1G but as the robot tilts, for example going up or down a slope, the force due to gravity is reduced in the Z axis based on the angle of tilt. This allows the robot to know if it is going up a ramp or other slope.

Fig. 21: Turns the LED on the circuit board on.

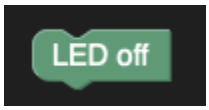


Fig. 22: Turns the LED on the circuit board off.

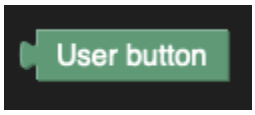


Fig. 23: This block represents the state of the user button, 1 for pressed and 0 for released.

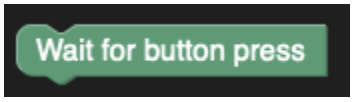
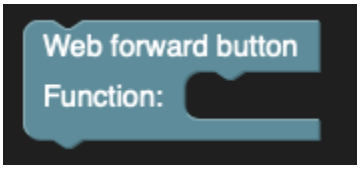
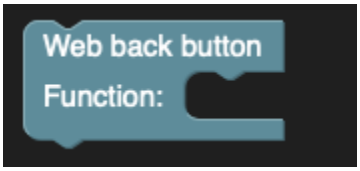


Fig. 24: This block will wait until the user button is pressed. The is particularly useful to make sure that your program doesn't start running until the robot is in position after turning it on.



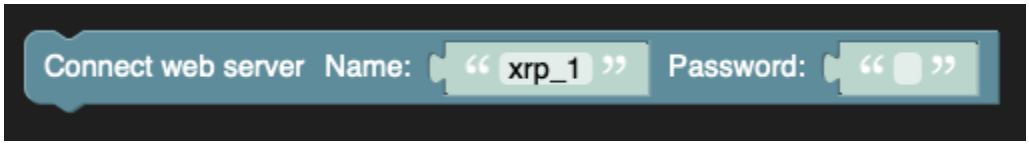


Assign a function to the stop button.

Registers a custom button to be displayed on the webserver.

Display the specified value on the web server along with the label.

Begin the webserver in either access point or bridge mode. The IP is printed to the console.



Connect to a wifi network with the given ssid and password. If the connection fails, the board will disconnect from the network and return.

Gamepad

Return 1 if a button is being pressed or zero if not. The choices for the buttons are in the dropdown.

Get the value for a joystick. The values are from -1 to 1 for full forwards to full backwards. The particular joystick and axis is selected in the dropdown for the block.

Logic

Loops

Math

Text

Lists

Variables

Functions

Fig. 73: The *create variable* button is not a block, but when pressed promts for the name of a variable to create. The variable gets added to the list of variables in this section and can then be used throughout the program.

Fig. 75: The change variable block can change the value of a variable by a specified amount, either positive or negative. It is shorthand for using a set block with an add or subtract block.

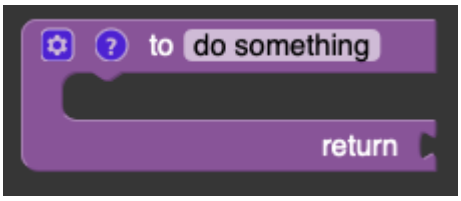


Fig. 77: The function block with a return value is identical to the function block (previous block) except that it returns a value and can be used wherever a value can be used in the program. The returned value is attached to the function block in the *return* connector.

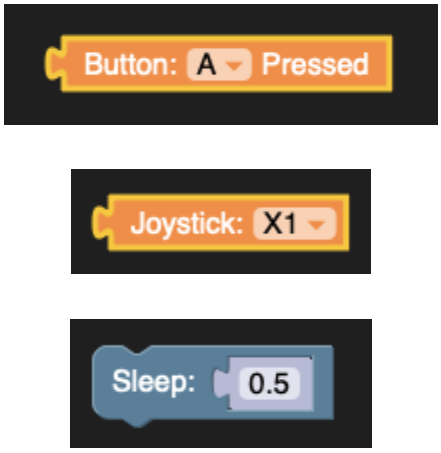


Fig. 25: Pause the program for the specified number of seconds at this block. You may specify a fractional value for seconds to get smaller or more precise values.

Fig. 26: This block will conditionally execute the blocks contained within the if-do block. If the specified logical expression (one which is either true or false) is true, the enclosed blocks are executed, otherwise they are skipped. Additionally, you can add alternate blocks if the expression is false by clicking on the gear icon and adding "else" blocks.

Fig. 27: Relational operators express the relation between values as true or false. There are 6 choices of relational operators, equals, not equals, greater than, less than, greater than or equals and less than or equals.

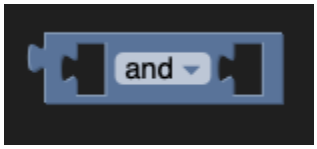


Fig. 28: Logical operators combined with relational operators let you create more complex boolean (true or false) expressions. The logical operators are OR (either of 2 operands are true) and AND (both operands are true). The result is true depending on the operands and the operator used.

Fig. 29: the NOT operator returns true if the pararmeter is false and returns false if the' parameter is true. It literally returns the opposite value specified as the argument.

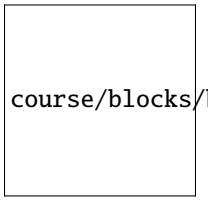


Fig. 30: This block is a boolean (either true or false) value that can be used in conditional expressions or in other places where a boolean value is needed. For example, if the argument of a repeat-while loop is true, it will repeat indefinely making what is referred to as an infinite loop.

Fig. 31: The null value represents a non-existant value that can be tested for in programs. For example, in functions that returns a value unless there is some special case, and then can return null. Null can be tested for by the calling function.

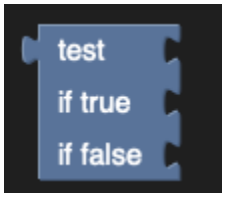


Fig. 32: The test block returns one of two values depending on whether the argument is true or false.

Fig. 33: This block runs the code contained in the block body (do statements) the specified number of times. After it is finished, the block following the repeat is executed.

Fig. 34: This block runs the code contained in the block body (do statements) repeatedly **while** the specified condition is true. The condition is tested before the code is executed the first time, so if the condition is false on executing this block, the block body code is not executed. Optionally the **while** condition can be changed to **until** by selecting until from the pull-down, and then the code will be executed repeatedly until the condition is true.

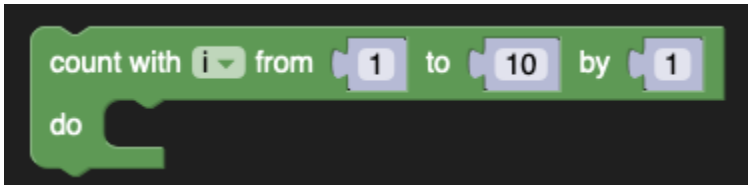


Fig. 35: The count block advances a variable from the first value to the second by the increment amount and running the *do* block once for each value. The block will count up with a positive increment and can count down with a negative increment. Typically 1 is used for the increment, but it can be any value, such as 2 to count even or odd numbers.

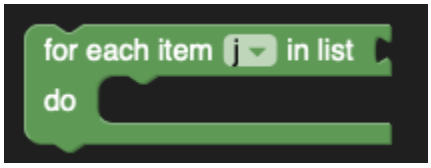


Fig. 36: A **for each** block assigns the loop variable to each value in a list one at a time. With each assignment, the *do* statements are executed. When all the elements of the list have been assigned, the loop ends.

Fig. 37: A break block exits from the loop it is contained in. This is typically used with a conditional to exit a loop early in an exception case or when the loop task is completed. You can Optionally change *break* to *continue*, in which case, the loop will continue on the next iteration or loop, skipping the rest of the blocks in **do** section.

Fig. 38: A numeric constant block that makes it possible to introduce a numereic constant value into an expression. For example, to compare a distance with 10, a comparison block, such as greater than can be used with a sonar sensor value as one operand and a constant block with a 10 as the other.

Fig. 39: This block takes a value and applies a numeric fuction to it, producing a result. The types of numeric functions inclide square root, absolute value, negate, natural log (ln), log base 10, e raised to the power, and 10 raised to the power.

Fig. 40: This block takes a value and peforms a trig funcgtion on it. The types of functions are sin, cos, tan, arcsin, arc cosine, and arc tangent.

Fig. 41: This block provides a constant value for commonly used values. The types are pi, e, square root of 2, square root of 1/2, and infinity.

Fig. 42: This block tests a value to determine if it is a particular type. The choices are even, odd, prime, whole, positive, negative, and divisible by a value.

Fig. 43: This block rounds its numeric parameter either up (to the next integer), down (to the lower integer), or rounds it to the nearest integer, either up or down.

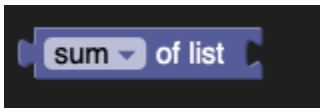


Fig. 44: This block is given a list of values as a parameter and can return a value based on the list values. It can find the sum, the minimum value, the maximum value, the average value, the median value, the modes, the standard deviation, or choose a random item from the list.

Fig. 45: The remainder block computes the remainder (modulus) of the divison of the two numeric parameters.

Fig. 46: The constrain block returns a value that is constrained by two values. In other words, if the parameter (1st number) is between the low and the high value, then the number is returned. If the value is less than low value, then the low value is returned. If it is higher than the high value, then the high value is returned. This is especially useful in robotic applications where you want to make sure that, for example, the effort values you are supplying for a motor are always within the allowable (-1 to 1) range.

Fig. 47: The random integer block returns a pseudo-random integer value in the range of the two parameters.

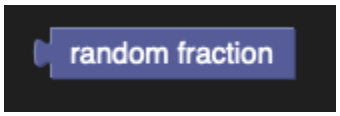


Fig. 48: The random fraction returns a floating point (fractional) value between 0 up to (and not including) 1.

Fig. 49: The comment block can be used to add information about your program to tell you or someone else what the program does. The blocks are ignored when the program is running, it is only for clarity of the program for a reader.

Fig. 50: The parameter of the print block is displayed in the shell output windows in the XRPCode application.

Fig. 51: The string constant block takes a string literal (any visible characters) and can use then in expressions requiring strings. For example, checking if a string variable is equal to the value “ON” can be done with a comparison block and a string constant.

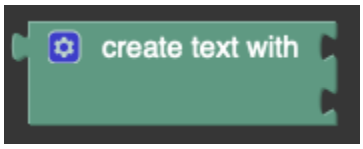


Fig. 52: The create text block takes a number of text values and concatenates (merges) them together to form a larger string. if more than 2 input values are required, more inputs can be added by clicking on the gear icon and dragging more inputs to the block.

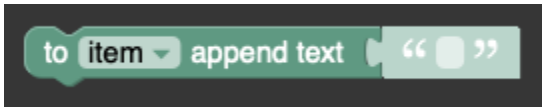


Fig. 53: The append text block appends a string value to the end of the input string and returns the new string as the operators value.

Fig. 54: The string length block returns an integer number of characters in the string argument.

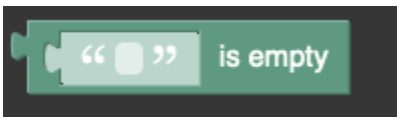


Fig. 55: The is empty block returns true if the string parameter has no characters and false otherwise.

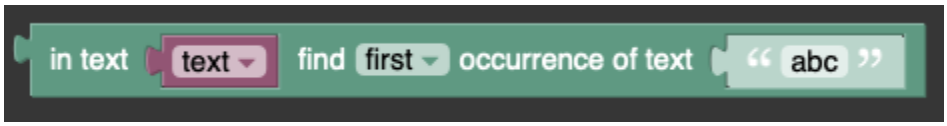


Fig. 56: The find string checks to see if *find* string (2nd value) is contained within the first string. It returns either the character position of the search string or zero if it is not found. It can either search for the *first* occurance or the *last* occurance of the search string.

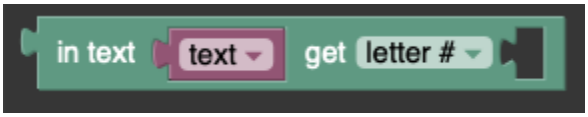


Fig. 57: The get letter block is very flexible and returns particular characters from a text string. It can either return the first character, the last character, the character that is at a position relative to the start of the string, the character that is at a position relative to the end of the string, or a random letter from the string.

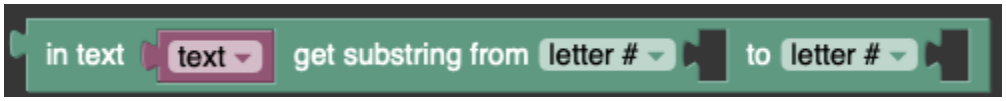


Fig. 58: The find substring block returns a part of the parameter string. The returned value is the substring (or enclosed string) from the starting *letter #* to the *ending letter #*.

Fig. 59: The change case block returns the parameter string with all the letters converted to the specified case. The choices are upper case (all capital letters), lower case, or title case where the first letter of each word is capatalized.

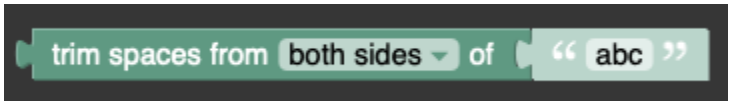


Fig. 60: Trim removes spaces from an input string. The options are leading spaces (start of the input string), trailing spaces (end of the input string), or both sides of the input string.

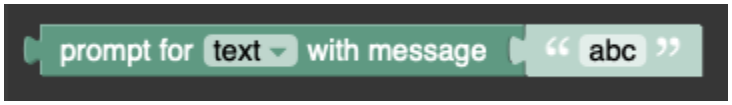


Fig. 61: The read text block reads input from the keyboard of the device running the Blockly program.

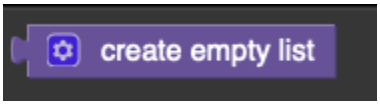


Fig. 62: The empty list block creates a list with no elements. Input values can be added to the block by clicking on the gear icon, mnaking the functionality the same as the create list block. This and the next block create identical results if the number of input values are configure to be the same.

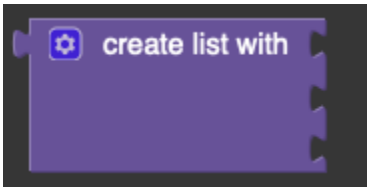


Fig. 63: The create list block can create a list with an arbitrary number of elements in it. The number of elements can be customized by clicking on the gear icon and adding or removinig elements. This and the previous block create identical results if the number of input values are configure to be the same.

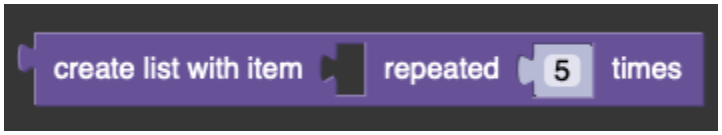


Fig. 64: This list creates an arbitrary sized list filled with the specified value.

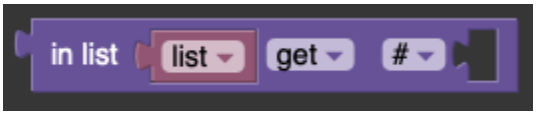


Fig. 65: The get list element block can perform several functions. It can get the list element at a specified position in the list. It can also get the specified element and delete it from the list. And it can also just remove the item from the list. In the first 2 cases the block returns a value. When only removing an item, it does not return a value and can be inserted into a group of statements.

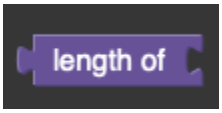


Fig. 66: The list length block returns the number of elements in the list.

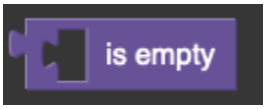


Fig. 67: The is empty block returns true or false depending on whether the list supplied as a parameter has any elements.

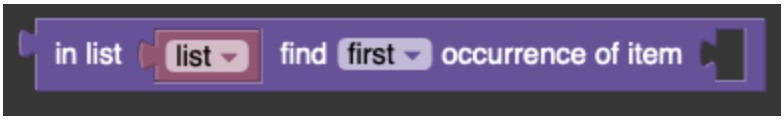


Fig. 68: Find the first or last occurance of an element in a list and returns the items position in the source list.

Fig. 69: This edit list block is very flexible and can perform many function on lists. Depending on the setting of the *set* parameter, it will either set or insert a list element at the specified position. The position of the insert or replace operation can be at a particular index from the beginning or the end of the list, the first element of the list, the last element of the list, or a random element of the list.

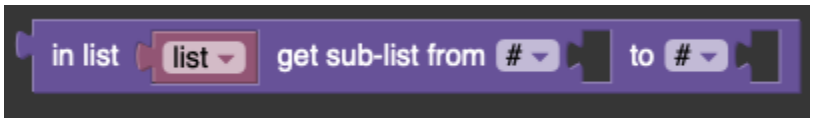


Fig. 70: The sublist block can return a portion of the list argument. The starting position of the sublist can either be an index from the start of the list, the end of the list, or the first element of the list. The ending position can either be an index from the beginning of the list, from the end of the list, or the last element of the list.

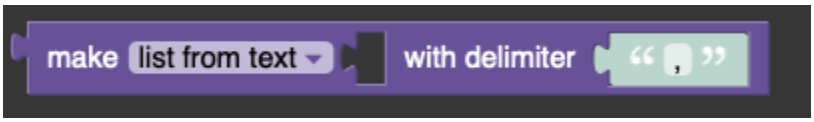


Fig. 71: This make text to list block can take a string and make a list with one element per substring each delimiited with a specified string. For example, a phone number might have 3 sets of numbers each delimited by hyphens (-), and this block can create a list with 3 elements, each a string that was between the hyphens. The block will do the opposite, that is make a list into a text string by concatenating all the elements of the list with the delimeter inbetween each element.

CHAPTER

FIFTEEN

INDICES AND TABLES

- genindex
- modindex
- search