Raspberry Pi Build HAT
Python library
Easily access LEGO® Technic™ motors and sensors in Python
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Introduction

The Build HAT library has been created to support the Raspberry Pi Build HAT, an add-on board for the Raspberry Pi computer which allows control of up to 4 LEGO® Technic™ motors and sensors included in the SPIKE™ Portfolio.

Other LEGO® devices may be supported if they use the LPF2 connector:

In order to drive motors, your Raspberry Pi and Build HAT will need an external 8V power supply. For best results, use the official Raspberry Pi Build HAT power supply.

⚠️ WARNING

The API for the Build HAT is undergoing active development and is subject to change. An online version of this documentation can be found at https://buildhat.readthedocs.io/.
Installation

The Python library can be installed using pip,

```bash
$ pip3 install buildhat-*.whl
```

Alternatively it can be cloned from its Github repository,

```bash
$ git clone https://github.com/RaspberryPiFoundation/python-build-hat.git
$ cd python-build-hat
```

and installed. If using asdf first by,

```bash
$ asdf install
```

and then,

```bash
$ pip3 install . --user
```

Building the library,

```bash
$ ./build.sh
```
Usage

See the Library section for detailed documentation for the available Python objects.

```python
import time
from signal import pause
from buildhat import Motor

motor = Motor('A')
motor.set_default_speed(30)

print("Position", motor.get_a_position())

def handle_motor(speed, pos, apos):
    print("Motor", speed, pos, apos)

motor.when_rotated = handle_motor

print("Run for degrees")
motor.run_for_degrees(360)

print("Run for seconds")
motor.run_for_seconds(5)

print("Run for rotations")
motor.run_for_rotations(2)

print("Start motor")
motor.start()
time.sleep(3)
print("Stop motor")
motor.stop()
pause()
```
### Programming Bootloader

You can use `openocd` to program the bootloader. This can be installed by,

```bash
$ sudo apt install automake autoconf build-essential texinfo libtool libftdi-dev libusb-1.0-0-dev
$ git clone https://github.com/raspberrypi/openocd.git --recursive --branch rp2040 --depth=1
$ cd openocd
$ ./bootstrap
$ ./configure --enable-ftdi --enable-sysfsgpio --enable-bcm2835gpio
$ make -j4
$ sudo make install
```

Then use the following command to program the bootloader

```bash
$ openocd -s /usr/local/share/openocd/scripts -f interface/raspberrypi-swd.cfg -f target/rp2040.cfg -c "program bootloader.elf verify reset exit"
```
Library

ColorSensor

The LEGO® Education SPIKE™ Colour Sensor (LEGO® Colour Sensor 45605) can sort between 8 different colours and can measure reflected and ambient or natural light.

```python
from buildhat import ColorSensor

color = ColorSensor('C')

print("HSV", color.get_color_hsv())
print("RGBI", color.get_color_rgb())
print("Ambient", color.get_ambient_light())
print("Reflected", color.get_reflected_light())
print("Color", color.get_color())

print("Waiting for color black")
color.wait_until_color("black")
print("Found color black")

print("Waiting for color white")
color.wait_until_color("white")
print("Found color white")

while True:
    c = color.wait_for_new_color()
    print("Found new color", c)
```

ColorDistanceSensor

The LEGO® Color and Distance Sensor 88007 can sort between six different colors and objects within 5 to 10 cm range.

⚠️ WARNING

Support for this device is experimental and not all features are available yet.

```python
from buildhat import ColorDistanceSensor

color = ColorDistanceSensor('C')

print("RGBI", color.get_color_rgb())
print("Ambient", color.get_ambient_light())
print("Reflected", color.get_reflected_light())
print("Color", color.get_color())

print("Waiting for color black")
```
DistanceSensor

The LEGO® Education SPIKE™ Distance Sensor (LEGO® Distance Sensor 45604) behaves like a conventional ultrasonic range finder but also has 4 LEDs that can be used to create the "eyes" of a robot. Each LED can be controlled individually.

```python
from signal import pause
from buildhat import Motor, DistanceSensor

motor = Motor('A')
dist = DistanceSensor('D', threshold_distance=100)

print("Wait for in range")
dist.wait_for_in_range(50)
motor.run_for_rotations(1)

print("Wait for out of range")
dist.wait_for_out_of_range(100)
motor.run_for_rotations(2)

def handle_in(distance):
    print("in range", distance)

def handle_out(distance):
    print("out of range", distance)

dist.when_in_range = handle_in
dist.when_out_of_range = handle_out

pause()
```

ForceSensor

The LEGO® Education SPIKE™ Prime Force Sensor (LEGO® Force Sensor Set 45606e) can measure pressure of up to 10 Newtons, but it can also be used as a touch sensor or a simple button.
NOTE

The Prime Force Sensor is also known as the LEGO® Technic Force Sensor.

```python
from signal import pause
from buildhat import Motor, ForceSensor

motor = Motor('A')
button = ForceSensor('D', threshold_force=1)

print("Waiting for button to be pressed fully and released")

button.wait_until_pressed(100)
button.wait_until_released(0)
motor.run_for_rotations(1)

print("Wait for button to be pressed")

button.wait_until_pressed()
motor.run_for_rotations(2)

def handle_pressed(force):
    print("pressed", force)

def handle_released(force):
    print("released", force)

button.when_pressed = handle_pressed
button.when_released = handle_released
pause()
```

Matrix

The Spike 3x3 LED matrix has individual elements that can be set individually or as a whole.

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<th>Name</th>
</tr>
</thead>
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<tr>
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</tr>
<tr>
<td>2</td>
<td>lilac</td>
</tr>
<tr>
<td>3</td>
<td>blue</td>
</tr>
<tr>
<td>4</td>
<td>cyan</td>
</tr>
<tr>
<td>5</td>
<td>turquoise</td>
</tr>
<tr>
<td>6</td>
<td>green</td>
</tr>
<tr>
<td>7</td>
<td>yellow</td>
</tr>
<tr>
<td>8</td>
<td>orange</td>
</tr>
</tbody>
</table>
NOTE

Colours may be passed as string or integer parameters.

```python
from buildhat import Matrix
import time
import random

matrix = Matrix('C')
matrix.clear(('red', 10))
time.sleep(1)

matrix.clear()
time.sleep(1)

matrix.set_pixel((0, 0), ('blue', 10))
matrix.set_pixel((2, 2), ('red', 10))
time.sleep(1)

while True:
    out = [[(int(random.uniform(0, 9)), 10) for x in range(3)] for y in range(3)]
    matrix.set_pixels(out)
time.sleep(0.1)
```

Motor

Motors from the LEGO® Education SPIKE™ portfolio (LEGO® Large angular motor 45602 and LEGO® Medium angular motor 45603) have an integrated rotation sensor (encoder) and can be positioned 1-degree accuracy. The encoders which can be queried to find the current position of the motor with respect to a ‘zero’ mark shown on the motor itself.

Other motors — such as the LEGO® Medium Linear motor 88008, Technic™ Large Motor 88013, and Technic™ XL Motor 88014 — without encodes will report a 0 value if queried.

```python
from signal import pause
from buildhat import Motor
import time

motor = Motor('A')
motorb = Motor('B')

def handle_motor(speed, pos, apos):
    print("Motor", speed, pos, apos)

motor.when_rotated = handle_motor
motor.set_default_speed(50)
```
print("Run for degrees 360")
motor.run_for_degrees(360)
time.sleep(3)

print("Run for degrees -360")
motor.run_for_degrees(-360)
time.sleep(3)

print("Start motor")
motor.start()
time.sleep(3)

print("Stop motor")
motor.stop()
time.sleep(1)

print("Run for degrees - 180")
motor.run_for_degrees(180)
time.sleep(3)

print("Run for degrees - 90")
motor.run_for_degrees(90)
time.sleep(3)

print("Run for rotations - 2")
motor.run_for_rotations(2)
time.sleep(3)

print("Run for seconds - 5")
motor.run_for_seconds(5)
time.sleep(3)

print("Run both")
motor.run_for_seconds(5, blocking=False)
motorb.run_for_seconds(5, blocking=False)
time.sleep(10)

print("Run to position -90")
motor.run_to_position(-90)
time.sleep(3)

print("Run to position 90")
motor.run_to_position(90)
time.sleep(3)

print("Run to position 180")
motor.run_to_position(180)
time.sleep(3)
from buildhat import MotorPair

pair = MotorPair('C', 'D')

pair.set_default_speed(20)

pair.run_for_rotations(2)

pair.run_for_rotations(1, speedl=100, speedr=20)

pair.run_to_position(20, 100, speed=20)