
Luma.LED*MatrixDocumentation*

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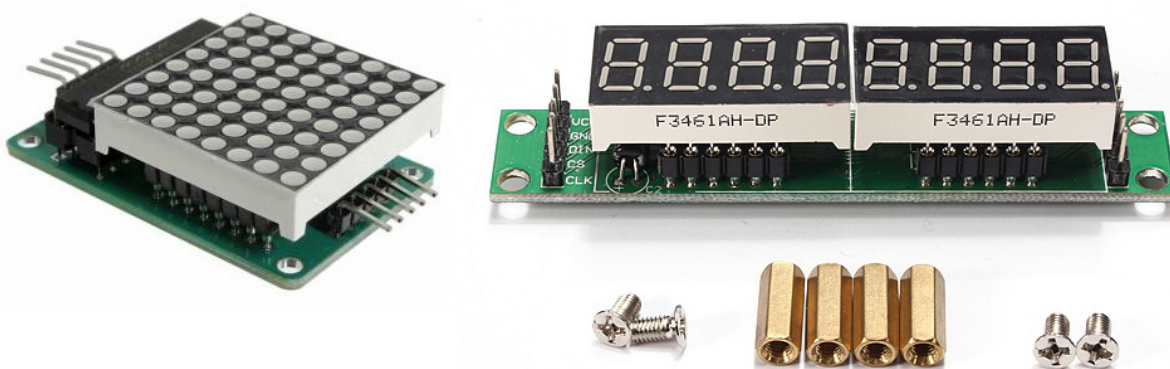
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CHAPTER 1

Introduction

Python library interfacing LED matrix displays with the MAX7219 driver (using SPI) and WS2812 & APA102 NeoPixels (inc Pimoroni Unicorn pHat/Hat and Unicorn Hat HD) on the Raspberry Pi and other Linux-based single board computers - it provides a Pillow-compatible drawing canvas, and other functionality to support:

- multiple cascaded devices
- LED matrix, seven-segment and NeoPixel variants
- scrolling/panning capability,
- terminal-style printing,
- state management,
- dithering to monochrome,
- Python 2.7 and 3.4+ are both supported



A LED matrix can be acquired for a few pounds from outlets like [Banggood](#). Likewise 7-segment displays are available from [Ali-Express](#) or [Ebay](#).

See also:

Further technical information for the specific devices can be found in the datasheets below:

- MAX7219
- WS2812
- WS2812B
- APA102

Note: The library has been tested against Python 2.7 and 3.4+.

For a **Python 3** installation, substitute the following in the instructions below.

- `pip pip3,`
- `python python3,`
- `python-dev python3-dev,`
- `python-pip python3-pip.`

2.1 Pre-requisites

2.1.1 MAX7219 Devices

By default, the SPI kernel driver is **NOT** enabled on a Raspberry Pi Raspbian image. You can confirm whether it is enabled using the shell command below:

```
$ lsmod | grep -i spi
spi_bcm2835          7424  0
```

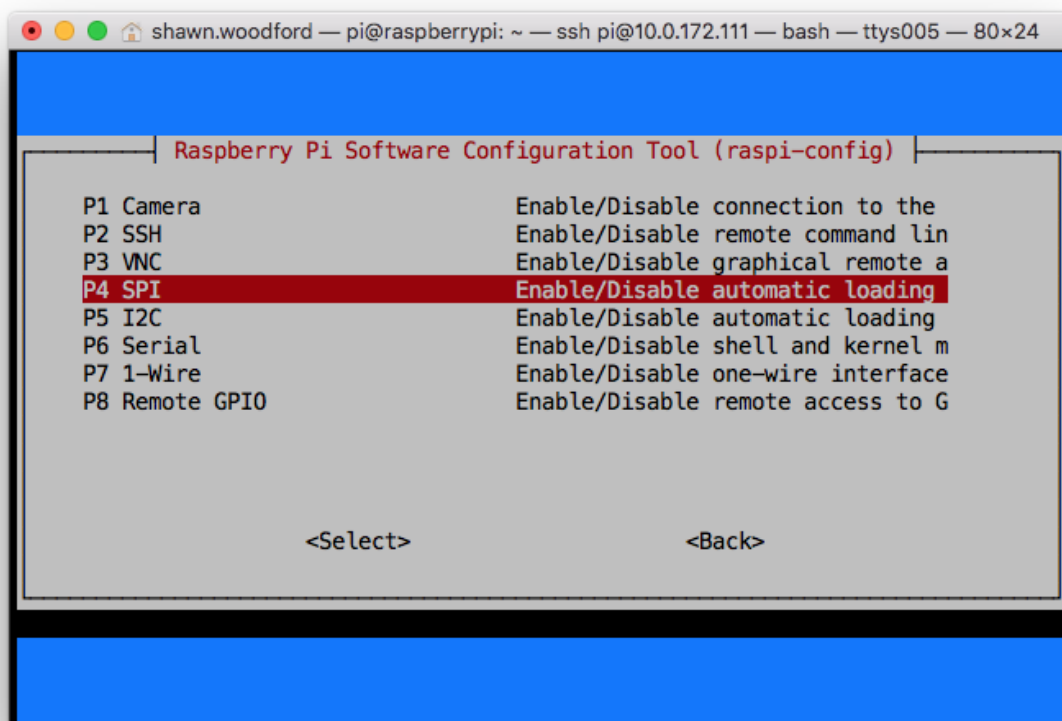
Depending on the hardware/kernel version, this may report **spi_bcm2807** rather than **spi_bcm2835** - either should be adequate.

And to verify that the devices are successfully installed in `/dev`:

```
$ ls -l /dev/spi*
crw----- 1 root root 153, 0 Jan  1  1970 /dev/spidev0.0
crw----- 1 root root 153, 1 Jan  1  1970 /dev/spidev0.1
```

If you have no `/dev/spi` files and nothing is showing using `lsmod` then this implies the kernel SPI driver is not loaded. Enable the SPI as follows (steps taken from <https://learn.sparkfun.com/tutorials/raspberry-pi-spi-and-i2c-tutorial#spi-on-pi>):

1. Run `sudo raspi-config`
2. Use the down arrow to select 5 Interfacing Options
3. Arrow down to P4 SPI
4. Select **yes** when it asks you to enable SPI
5. Also select **yes** when it asks about automatically loading the kernel module
6. Use the right arrow to select the **<Finish>** button
7. Reboot.



After rebooting re-check that the `lsmod | grep -i spi` command shows whether SPI driver is loaded before proceeding. If you are still experiencing problems, refer to the official Raspberry Pi [SPI troubleshooting guide](#) for further details, or ask a [new question](#) - but please remember to add as much detail as possible.

2.2 GPIO pin-outs

2.2.1 MAX7219 Devices (SPI)

The breakout board has two headers to allow daisy-chaining:

Board Pin	Name	Remarks	RPi Pin	RPi Function
1	VCC	+5V Power	2	5V0
2	GND	Ground	6	GND
3	DIN	Data In	19	GPIO 10 (MOSI)
4	CS	Chip Select	24	GPIO 8 (SPI CE0)
5	CLK	Clock	23	GPIO 11 (SPI CLK)

See also:

Also see the section for *cascading/daisy-chaining*, power supply and level-shifting.

2.2.2 WS2812 NeoPixels (DMA)

Typically, WS2812 NeoPixels require VCC, VSS (GND) and DI pins connecting to the Raspberry Pi, where the DI pin is usually connected to a PWM control pin such as GPIO 18.

Board Pin	Name	Remarks	RPi Pin	RPi Function
1	DO	Data Out	•	•
2	DI	Data In	12	GPIO 18 (PWM0)
3	VCC	+5V Power	2	5V0
4	NC	Not connected	•	•
5	VDD	Not connected	•	•
6	VSS	Ground	6	GND

The DO pin should be connected to the DI pin on the next (daisy-chained) neopixel, while the VCC and VSS are supplied in-parallel to all LED's. WS2812b devices now are becoming more prevalent, and only have 4 pins.

2.2.3 NeoSegments

@msurguy's NeoSegments should be connected as follows:

Board Pin	Name	Remarks	RPi Pin	RPi Function
1	GND	Ground	6	GND
2	DI	Data In	12	GPIO 18 (PWM0)
3	VCC	+5V Power	2	5V0

2.3 Installing from PyPi

Install the dependencies for library first with:

```
$ sudo usermod -a -G spi,gpio pi
$ sudo apt install build-essential python-dev python-pip libfreetype6-dev libjpeg-dev
↳ libopenjp2-7 libtiff5
```

Warning: The default `pip` and `setuptools` bundled with `apt` on Raspbian are really old, and can cause components to not be installed properly. Make sure they are up to date by upgrading them first:

```
$ sudo -H pip install --upgrade --ignore-installed pip setuptools
```

Proceed to install latest version of the `luma.led_matrix` library directly from [PyPI](#):

```
$ sudo -H pip install --upgrade luma.led_matrix
```

2.4 Examples

Ensure you have followed the installation instructions above. Clone the [repo](#) from github, and run the example code as follows:

```
$ python examples/matrix_demo.py
```

The matrix demo accepts optional flags to configure the number of cascaded devices and correct the block orientation phase shift when using 4x8x8 matrices:

```
$ python examples/matrix_demo.py -h
usage: matrix_demo.py [-h] [--cascaded CASCADED]
                    [--block-orientation {0,90,-90}] [--rotate {0,1,2,3}]
                    [--reverse-order REVERSE_ORDER]

matrix_demo arguments

optional arguments:
  -h, --help            show this help message and exit
  --cascaded CASCADED, -n CASCADED
                        Number of cascaded MAX7219 LED matrices (default: 1)
  --block-orientation {0,90,-90}
                        Corrects block orientation when wired vertically
                        (default: 0)
  --rotate {0,1,2,3}    Rotate display 0=0_, 1=90_, 2=180_, 3=270_
                        (default: 0)
  --reverse-order REVERSE_ORDER
                        Set to true if blocks are in reverse order (default:
                        False)
```

Similarly, there is a basic demo of the capabilities of the `luma.led_matrix.virtual.sevensegment` wrapper:

```
$ python examples/sevensegment_demo.py
```

and for the `luma.led_matrix.device.neopixel` device:

```
$ sudo python examples/neopixel_demo.py
```

Further examples are available in the [luma.examples](#). git repository. Follow the instructions in the README for more details.

A small example application using [ZeroSeg](#) to display TOTP secrets can be found in <https://github.com/rm-hull/zaup>.

3.1 8x8 LED Matrices

For the matrix device, initialize the `luma.led_matrix.device.max7219` class, as follows:

```
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.led_matrix.device import max7219

serial = spi(port=0, device=0, gpio=noop())
device = max7219(serial)
```

The display device should now be configured for use. The specific `max7219` class exposes a `display()` method which takes an image with attributes consistent with the capabilities of the configured device's capabilities. However, for most cases, for drawing text and graphics primitives, the canvas class should be used as follows:

```
from PIL import ImageFont

font = ImageFont.truetype("examples/pixelmix.ttf", 8)

with canvas(device) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="black")
```

The `luma.core.render.canvas` class automatically creates an `PIL.ImageDraw` object of the correct dimensions and bit depth suitable for the device, so you may then call the usual Pillow methods to draw onto the canvas.

As soon as the with scope is ended, the resultant image is automatically flushed to the device's display memory and the `PIL.ImageDraw` object is garbage collected.

Note: The default Pillow font is too big for 8px high devices like the LED matrices here, so the `luma.examples` repo includes a small TTF pixel font called `pixelmix.ttf` (attribution: <http://www.dafont.com/>) which just fits.

Alternatively, a set of “legacy” fixed-width bitmap fonts are included in the `luma.core` codebase and may be used as follows:

```
from luma.core.legacy import text
from luma.core.legacy.font import proportional, CP437_FONT, LCD_FONT

with canvas(device) as draw:
    text(draw, (0, 0), "A", fill="white", font=proportional(CP437_FONT))
```

The fixed-width fonts can be “converted” on-the-fly to proportionally spaced by wrapping them with the `luma.core.legacy.font.proportional` class.

3.1.1 Scrolling / Virtual viewports

A single 8x8 LED matrix clearly hasn’t got a lot of area for displaying useful information. Obviously they can be daisy-chained together to provide a longer line of text, but as this library extends `luma.core`, then we can use the `luma.core.virtual.viewport` class to allow scrolling support:

```
import time

from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.core.virtual import viewport
from luma.led_matrix.device import max7219

serial = spi(port=0, device=0, gpio=noop())
device = max7219(serial)

virtual = viewport(device, width=200, height=100)

with canvas(virtual) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="black")
    draw.text((3, 3), "Hello world", fill="white")

for offset in range(8):
    virtual.set_position((offset, offset))
    time.sleep(0.1)
```

Calling `set_position()` on a virtual viewport, causes the device to render what is visible at that specific position; altering the position in a loop refreshes every time it is called, and gives an animated scrolling effect.

By altering both the X and Y co-ordinates allows scrolling in any direction, not just horizontally.

3.1.2 Color Model

Any of the standard `PIL.ImageColor` color formats may be used, but since the 8x8 LED Matrices are monochrome, only the HTML color names "black" and "white" values should really be used; in fact, by default, any value *other* than black is treated as white. The `luma.core.render.canvas` constructor does have a `dither` flag which if set to `True`, will convert color drawings to a dithered monochrome effect.

```
with canvas(device, dither=True) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="red")
```

3.1.3 Landscape / Portrait Orientation

By default, cascaded matrices will be oriented in landscape mode. Should you have an application that requires the display to be mounted in a portrait aspect, then add a `rotate=N` parameter when creating the device:

```
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.led_matrix.device import max7219

serial = spi(port=0, device=0, gpio=noop())
device = max7219(serial, rotate=1)

# Box and text rendered in portrait mode
with canvas(device) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="black")
```

N should be a value of 0, 1, 2 or 3 only, where 0 is no rotation, 1 is rotate 90° clockwise, 2 is 180° rotation and 3 represents 270° rotation.

The `device.size`, `device.width` and `device.height` properties reflect the rotated dimensions rather than the physical dimensions.

3.1.4 Daisy-chaining

The MAX7219 chipset supports a serial 16-bit register/data buffer which is clocked in on pin DIN every time the clock edge falls, and clocked out on DOUT 16.5 clock cycles later. This allows multiple devices to be chained together.

If you have more than one device and they are daisy-chained together, you can initialize the library in one of two ways, either using `cascaded=N` to indicate the number of daisy-chained devices:

```
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.led_matrix.device import max7219

serial = spi(port=0, device=0, gpio=noop())
device = max7219(serial, cascaded=3)

with canvas(device) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="black")
```

Using `cascaded=N` implies there are *N* devices arranged linearly and horizontally, running left to right.

Alternatively, the device configuration may be configured with `width=W` and `height=H`. These dimensions denote the number of LEDs in all the daisy-chained devices. The width and height *must* both be multiples of 8: this has scope for arranging in blocks in, say 3x3 or 5x2 matrices (24x24 or 40x16 pixels, respectively).

Given 12 daisy-chained MAX7219's arranged in a 4x3 layout, the simple example below,

```
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.core.legacy import text
from luma.core.legacy.font import proportional, LCD_FONT
from luma.led_matrix.device import max7219

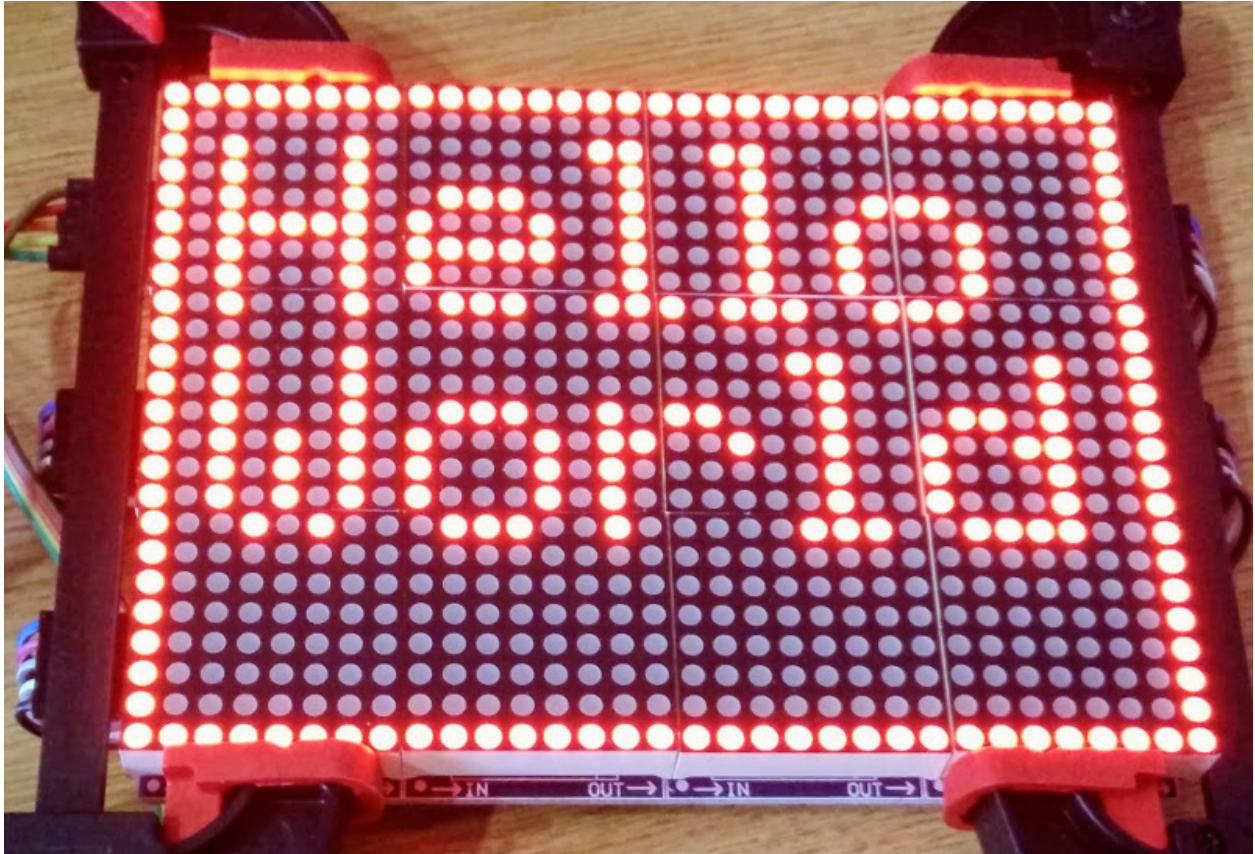
serial = spi(port=0, device=0, gpio=noop(), block_orientation=-90)
device = max7219(serial, width=32, height=24)
```

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```
with canvas(device) as draw:
    draw.rectangle(device.bounding_box, outline="white")
    text(draw, (2, 2), "Hello", fill="white", font=proportional(LCD_FONT))
    text(draw, (2, 10), "World", fill="white", font=proportional(LCD_FONT))
```

displays as:



3.1.5 Trouble-shooting / common problems

Some online retailers are selling pre-assembled ‘4-in-1’ LED matrix displays, but they appear to be wired 90° out-of-phase such that horizontal scrolling appears as below:

This can be rectified by initializing the `max7219` device with a parameter of `block_orientation=-90` (or `+90`, if your device is aligned the other way):

```
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.led_matrix.device import max7219

serial = spi(port=0, device=0, gpio=noop())
device = max7219(serial, cascaded=4, block_orientation=-90)
```

Every time a display render is subsequently requested, the underlying image representation is corrected to reverse the 90° phase shift.

Similarly, in other pre-assembled configurations, the 4-in-1 blocks arrange the 8x8 blocks in reverse order. In that case, you need to pass a True value to parameter `blocks_arranged_in_reverse_order`, requesting an additional pre-processing step that fixes this:

```
...
device = max7219(serial, cascaded=4, block_orientation=-90,
                 blocks_arranged_in_reverse_order=True)
```

3.2 7-Segment LED Displays

For the 7-segment device, initialize the `luma.core.virtual.sevensegment` class, and wrap it around a previously created `max7219` device:

```
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas
from luma.core.virtual import sevensegment
from luma.led_matrix.device import max7219

serial = spi(port=0, device=0, gpio=noop())
device = max7219(serial, cascaded=2)
seg = sevensegment(device)
```

The `seg` instance now has a `text` property which may be assigned, and when it does will update all digits according to the limited alphabet the 7-segment displays support. For example, assuming there are 2 cascaded modules, we have 16 character available, and so can write:

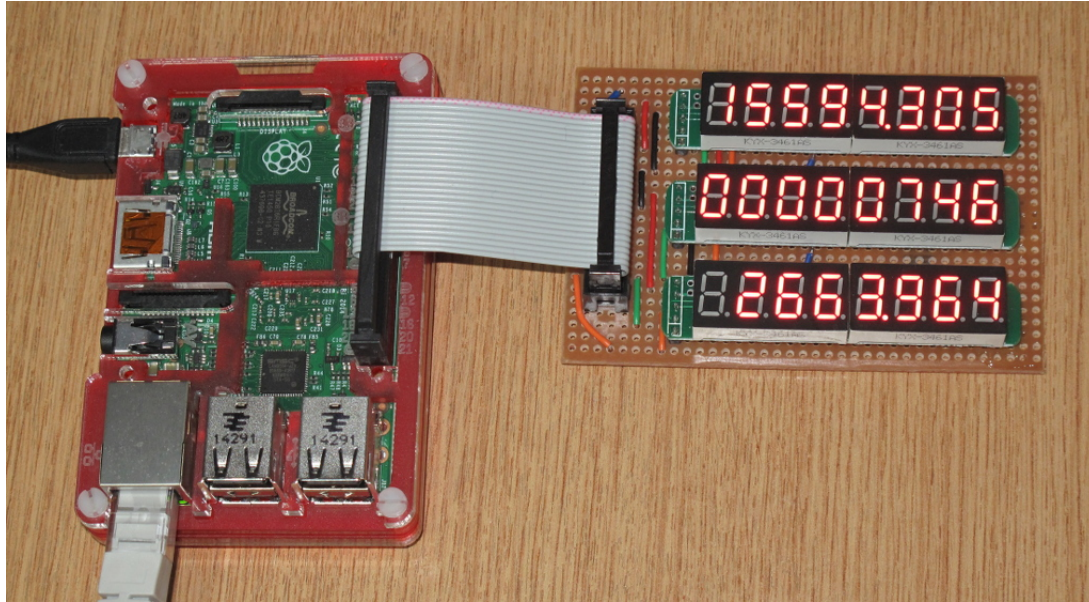
```
seg.text = "Hello world"
```

Rather than updating the whole display buffer, it is possible to update ‘slices’, as per the below example:

```
seg.text[0:5] = "Goodbye"
```

This replaces Hello in the previous example, replacing it with Goobyee. The usual python idioms for slicing (inserting / replacing / deleting) can be used here, but note if inserted text exceeds the underlying buffer size, a `ValueError` is raised.

Floating point numbers (or text with ‘.’) are handled slightly differently - the decimal-place is fused in place on the character immediately preceding it. This means that it is technically possible to get more characters displayed than the buffer allows, but only because dots are folded into their host character



3.3 WS2812 NeoPixels

For a strip of neopixels, initialize the `luma.led_matrix.device.ws2812` class (also aliased to `luma.led_matrix.device.neopixel`), supplying a parameter `cascaded=N` where N is the number of daisy-chained LEDs.

This script creates a drawing surface 100 pixels long, and lights up three specific pixels, and a contiguous block:

```
from luma.core.render import canvas
from luma.led_matrix.device import ws2812

device = ws2812(cascaded=100)

with canvas(device) as draw:
    draw.point((0,0), fill="white")
    draw.point((4,0), fill="blue")
    draw.point((11,0), fill="orange")
    draw.rectangle((20, 0, 40, 0), fill="red")
```

If you have a device like Pimoroni's `Unicorn pHat`, initialize the device with `width=N` and `height=N` attributes instead:

```
from luma.core.render import canvas
from luma.led_matrix.device import ws2812

# Pimoroni's Unicorn pHat is 8x4 neopixels
device = ws2812(width=8, height=4)

with canvas(device) as draw:
    draw.line((0, 0, 0, device.height), fill="red")
    draw.line((1, 0, 1, device.height), fill="orange")
    draw.line((2, 0, 2, device.height), fill="yellow")
    draw.line((3, 0, 3, device.height), fill="green")
    draw.line((4, 0, 4, device.height), fill="blue")
```

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```
draw.line((5, 0, 5, device.height), fill="indigo")
draw.line((6, 0, 6, device.height), fill="violet")
draw.line((7, 0, 7, device.height), fill="white")
```

Note: The ws2812 driver uses the [ws2812](#) PyPi package to interface to the daisy chained LEDs. It uses DMA (direct memory access) via `/dev/mem` which means that it has to run in privileged mode (via `sudo` root access).

The same viewport, scroll support, portrait/landscape orientation and color model idioms provided in `luma.core` are equally applicable to the ws2812 implementation.

3.3.1 Pimoroni Unicorn HAT

Pimoroni sells the [Unicorn HAT](#), comprising 64 WS2812b NeoPixels in an 8x8 arrangement. The pixels are cascaded, but arranged in a ‘snake’ layout, rather than a ‘scan’ layout. In order to accomodate this, a translation mapping is required, as follows:

```
import time

from luma.led_matrix.device import ws2812, UNICORN_HAT
from luma.core.render import canvas

device = ws2812(width=8, height=8, mapping=UNICORN_HAT)

for y in range(device.height):
    for x in range(device.width):
        with canvas(device) as draw:
            draw.point((x, y), fill="green")
        time.sleep(0.5)
```

This should animate a green dot moving left-to-right down each line.

3.3.2 Pimoroni Unicorn HAT HD

Pimoroni sells the [Unicorn HAT HD](#), comprising 256 high-intensity RGB LEDs in a 16x16 arrangement. The pixels are driven by an ARM STM32F making the display appear as an SPI device:

```
import time

from luma.led_matrix.device import unicornhathd
from luma.core.interface.serial import spi, noop
from luma.core.render import canvas

serial = spi(port=0, device=0, gpio=noop())
device = unicornhathd(serial)

for y in range(device.height):
    for x in range(device.width):
        with canvas(device) as draw:
            draw.point((x, y), fill="green")
        time.sleep(0.5)
```

This should animate a green dot moving left-to-right down each line.

3.3.3 NeoSegments (WS2812)

@msurguy has crowdsourced some WS2812 neopixels into a modular 3D-printed seven-segment unit. To program these devices:

```
import time

from luma.led_matrix_device import neosegment

neoseg = neosegment(width=6)

# Defaults to "white" color initially
neoseg.text = "NEOSEG"
time.sleep(1)

# Set the first char ('N') to red
neoseg.color[0] = "red"
time.sleep(1)

# Set fourth and fifth chars ('S','E') accordingly
neoseg.color[3:5] = ["cyan", "blue"]
time.sleep(1)

# Set the entire string to green
neoseg.color = "green"
```

The `neosegment` class extends `sevensegment`, so the same text assignment (Python slicing paradigms) can be used here as well - see the earlier section for further details.

The underlying device is exposed as attribute `device`, so methods such as `show`, `hide` and `contrast` are available.

3.4 Next-generation APA102 NeoPixels

APA102 RGB neopixels are easier to control than WS2812 devices - they are driven using SPI rather than precise timings that the WS2812 devices need. Initialize the `luma.led_matrix_device.apa102` class, supplying a parameter `cascaded=N` where *N* is the number of daisy-chained LEDs.

The following script creates a drawing surface 8 pixels long, and lights up three specific pixels:

```
from luma.core.render import canvas
from luma.led_matrix_device import apa102

device = apa102(cascaded=8)

with canvas(device) as draw:
    draw.point((0,0), fill="white")
    draw.point((0,1), fill="blue")
    draw.point((0,2), fill=(0xFF, 0x00, 0x00, 0x80)) # RGBA tuple, alpha controls_
↪brightness
```

APA102 RGB pixels can have their brightness individually controlled: by setting the alpha channel to a translucent value (as per the above example) will set the brightness accordingly.

3.5 Emulators

There are various [display emulators](#) available for running code against, for debugging and screen capture functionality:

- The `luma.emulator.device.capture` device will persist a numbered PNG file to disk every time its `display()` method is called.
- The `luma.emulator.device.gifanim` device will record every image when its `display()` method is called, and on program exit (or Ctrl-C), will assemble the images into an animated GIF.
- The `luma.emulator.device.pygame` device uses the `pygame` library to render the displayed image to a `pygame` display surface.

Invoke the demos with:

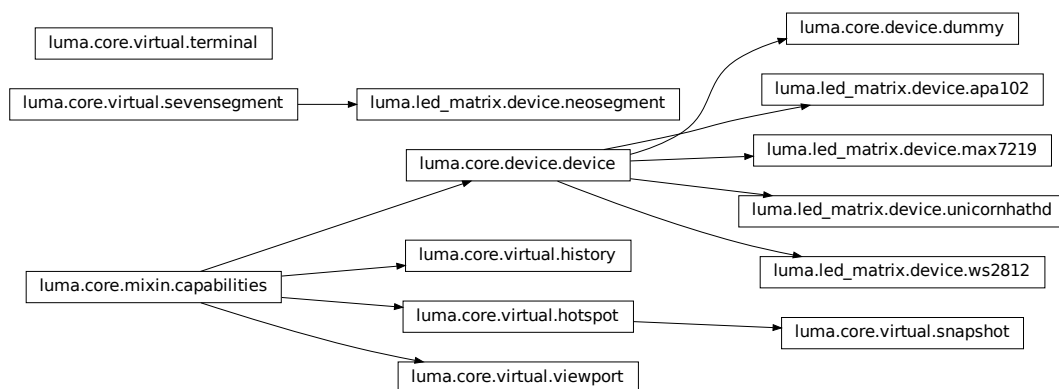
```
$ python examples/clock.py -d capture --transform=led_matrix
```

or:

```
$ python examples/clock.py -d pygame --transform=led_matrix
```

Note: *Pygame* is required to use any of the emulated devices, but it is **NOT** installed as a dependency by default, and so must be manually installed before using any of these emulation devices (e.g. `pip install pygame`). See the install instructions in [luma.emulator](#) for further details.

Display drivers for LED Matrices & 7-segment displays (MAX7219) and RGB NeoPixels (WS2812 / APA102).



4.1 Upgrading

Warning: Version 0.3.0 was released on 19 January 2017: this came with a rename of the project in github from **max7219** to **luma.led_matrix** to reflect the changing nature of the codebase. It introduces a complete rewrite of the codebase to bring it in line with other ‘luma’ implementations.

There is no direct migration path, but the old [documentation](#) and [PyPi packages](#) will remain available indefinitely, but that deprecated codebase will no longer receive updates or fixes.

This breaking change was necessary to be able to add different classes of devices, so that they could reuse core components.

4.2 luma.led_matrix.device

Collection of serial interfaces to LED matrix devices.

```
class luma.led_matrix.device.max7219(serial_interface=None, width=8, height=8, cascaded=None, rotate=0, block_orientation=0, blocks_arranged_in_reverse_order=False, contrast=112, **kwargs)
```

Bases: `luma.core.device.device`

Serial interface to a series of 8x8 LED matrixes daisy chained together with MAX7219 chips.

On creation, an initialization sequence is pumped to the display to properly configure it. Further control commands can then be called to affect the brightness and other settings.

capabilities (*width, height, rotate, mode='I'*)

Assigns attributes such as width, height, size and bounding_box correctly oriented from the supplied parameters.

Parameters

- **width** (*int*) – The device width.
- **height** (*int*) – The device height.
- **rotate** (*int*) – An integer value of 0 (default), 1, 2 or 3 only, where 0 is no rotation, 1 is rotate 90° clockwise, 2 is 180° rotation and 3 represents 270° rotation.
- **mode** (*str*) – The supported color model, one of "1", "RGB" or "RGBA" only.

cleanup ()

Attempt to switch the device off or put into low power mode (this helps prolong the life of the device), clear the screen and close resources associated with the underlying serial interface.

If `persist` is `True`, the device will not be switched off.

This is a managed function, which is called when the python process is being shutdown, so shouldn't usually need be called directly in application code.

clear ()

Initializes the device memory with an empty (blank) image.

command (**cmd*)

Sends a command or sequence of commands through to the delegated serial interface.

contrast (*value*)

Sets the LED intensity to the desired level, in the range 0-255.

Parameters **level** (*int*) – Desired contrast level in the range of 0-255.

data (*data*)

Sends a data byte or sequence of data bytes through to the delegated serial interface.

display (*image*)

Takes a 1-bit `PIL.Image` and dumps it to the LED matrix display via the MAX7219 serializers.

hide ()

Switches the display mode OFF, putting the device in low-power sleep mode.

preprocess (*image*)

Performs the inherited behaviour (if any), and if the LED matrix orientation is declared to need correction, each 8x8 block of pixels is rotated 90° clockwise or counter-clockwise.

show ()

Sets the display mode ON, waking the device out of a prior low-power sleep mode.

class `luma.led_matrix.device.ws2812` (*dma_interface=None*, *width=8*, *height=4*, *cascaded=None*, *rotate=0*, *mapping=None*, ***kwargs*)

Bases: `luma.core.device.device`

Serial interface to a series of RGB neopixels daisy-chained together with WS281x chips.

On creation, the array is initialized with the correct number of cascaded devices. Further control commands can then be called to affect the brightness and other settings.

Parameters

- **dma_interface** – The WS2812 interface to write to (usually omit this parameter and it will default to the correct value - it is only needed for testing whereby a mock implementation is supplied).
- **width** (*int*) – The number of pixels laid out horizontally.
- **height** – The number of pixels laid out vertically.
- **cascaded** (*int*) – The number of pixels in a single strip - if supplied, this will override width and height.
- **rotate** (*int*) – Whether the device dimensions should be rotated in-situ: A value of: 0=0°, 1=90°, 2=180°, 3=270°. If not supplied, zero is assumed.
- **mapping** (*int*[]) – An (optional) array of integer values that translate the pixel to physical offsets. If supplied, should be the same size as `width * height`.

New in version 0.4.0.

capabilities (*width*, *height*, *rotate*, *mode='1'*)

Assigns attributes such as `width`, `height`, `size` and `bounding_box` correctly oriented from the supplied parameters.

Parameters

- **width** (*int*) – The device width.
- **height** (*int*) – The device height.
- **rotate** (*int*) – An integer value of 0 (default), 1, 2 or 3 only, where 0 is no rotation, 1 is rotate 90° clockwise, 2 is 180° rotation and 3 represents 270° rotation.
- **mode** (*str*) – The supported color model, one of "1", "RGB" or "RGBA" only.

cleanup ()

Attempt to reset the device & switching it off prior to exiting the python process.

clear ()

Initializes the device memory with an empty (blank) image.

command (**cmd*)

Sends a command or sequence of commands through to the delegated serial interface.

contrast (*value*)

Sets the LED intensity to the desired level, in the range 0-255.

Parameters **level** (*int*) – Desired contrast level in the range of 0-255.

data (*data*)

Sends a data byte or sequence of data bytes through to the delegated serial interface.

display (*image*)

Takes a 24-bit RGB `PIL.Image` and dumps it to the daisy-chained WS2812 neopixels.

hide ()

Simulates switching the display mode OFF; this is achieved by setting the contrast level to zero.

preprocess (*image*)

Provides a preprocessing facility (which may be overridden) whereby the supplied image is rotated according to the device's rotate capability. If this method is overridden, it is important to call the `super` method.

Parameters **image** (`PIL.Image.Image`) – An image to pre-process.

Returns A new processed image.

Return type `PIL.Image.Image`

show ()

Simulates switching the display mode ON; this is achieved by restoring the contrast to the level prior to the last time `hide()` was called.

`luma.led_matrix.device.neopixel`

alias of `luma.led_matrix.device.ws2812`

class `luma.led_matrix.device.neosegment` (*width*, *undefined*='_', ***kwargs*)

Bases: `luma.core.virtual.sevensegment`

Extends the `sevensegment` class specifically for @msurguy's modular NeoSegments. It uses the same underlying render techniques as the base class, but provides additional functionality to be able to address individual characters colors.

Parameters

- **width** (*int*) – The number of 7-segment elements that are cascaded.
- **undefined** (*char*) – The default character to substitute when an unrenderable character is supplied to the text property.

New in version 0.11.0.

color

segment_mapper (*text*, *notfound*='_')

text

Returns the current state of the text buffer. This may not reflect accurately what is displayed on the seven-segment device, as certain alpha-numerics and most punctuation cannot be rendered on the limited display.

class `luma.led_matrix.device.apa102` (*serial_interface*=None, *width*=8, *height*=1, *cascaded*=None, *rotate*=0, *mapping*=None, ***kwargs*)

Bases: `luma.core.device.device`

Serial interface to a series of 'next-gen' RGB neopixels daisy-chained together with APA102 chips.

On creation, the array is initialized with the correct number of cascaded devices. Further control commands can then be called to affect the brightness and other settings.

Note that the brightness of individual pixels can be set by altering the alpha channel of the RGBA image that is being displayed.

Parameters

- **serial_interface** – The serial interface to write to (usually omit this parameter and it will default to the correct value - it is only needed for testing whereby a mock implementation is supplied).
- **width** (*int*) – The number of pixels laid out horizontally.
- **height** – The number of pixels laid out vertically.
- **cascaded** (*int*) – The number of pixels in a single strip - if supplied, this will override width and height.
- **rotate** (*int*) – Whether the device dimensions should be rotated in-situ: A value of: 0=0°, 1=90°, 2=180°, 3=270°. If not supplied, zero is assumed.
- **mapping** (*int*[]) – An (optional) array of integer values that translate the pixel to physical offsets. If supplied, should be the same size as width * height.

New in version 0.9.0.

capabilities (*width, height, rotate, mode='I'*)

Assigns attributes such as width, height, size and bounding_box correctly oriented from the supplied parameters.

Parameters

- **width** (*int*) – The device width.
- **height** (*int*) – The device height.
- **rotate** (*int*) – An integer value of 0 (default), 1, 2 or 3 only, where 0 is no rotation, 1 is rotate 90° clockwise, 2 is 180° rotation and 3 represents 270° rotation.
- **mode** (*str*) – The supported color model, one of "1", "RGB" or "RGBA" only.

cleanup ()

Attempt to switch the device off or put into low power mode (this helps prolong the life of the device), clear the screen and close resources associated with the underlying serial interface.

If *persist* is *True*, the device will not be switched off.

This is a managed function, which is called when the python process is being shutdown, so shouldn't usually need be called directly in application code.

clear ()

Initializes the device memory with an empty (blank) image.

command (**cmd*)

Sends a command or sequence of commands through to the delegated serial interface.

contrast (*value*)

Sets the LED intensity to the desired level, in the range 0-255.

Parameters **level** (*int*) – Desired contrast level in the range of 0-255.

data (*data*)

Sends a data byte or sequence of data bytes through to the delegated serial interface.

display (*image*)

Takes a 32-bit RGBA `PIL.Image` and dumps it to the daisy-chained APA102 neopixels. If a pixel is not fully opaque, the alpha channel value is used to set the brightness of the respective RGB LED.

hide ()

Not supported

preprocess (*image*)

Provides a preprocessing facility (which may be overridden) whereby the supplied image is rotated according to the device's rotate capability. If this method is overridden, it is important to call the `super` method.

Parameters *image* (*PIL.Image.Image*) – An image to pre-process.

Returns A new processed image.

Return type *PIL.Image.Image*

show ()

Not supported

class `luma.led_matrix.device.unicornhatd` (*serial_interface=None, rotate=0, **kwargs*)

Bases: `luma.core.device.device`

Display adapter for Pimoroni's Unicorn Hat HD - a dense 16x16 array of high intensity RGB LEDs. Since the board contains a small ARM chip to manage the LEDs, interfacing is very straightforward using SPI. This has the side-effect that the board appears not to be daisy-chainable though. However there a number of undocumented contact pads on the underside of the board which `_may_` allow this behaviour.

Note that the brightness of individual pixels can be set by altering the alpha channel of the RGBA image that is being displayed.

Parameters

- **serial_interface** – The serial interface to write to.
- **rotate** (*int*) – Whether the device dimensions should be rotated in-situ: A value of: 0=0°, 1=90°, 2=180°, 3=270°. If not supplied, zero is assumed.

New in version 1.3.0.

capabilities (*width, height, rotate, mode='I'*)

Assigns attributes such as `width`, `height`, `size` and `bounding_box` correctly oriented from the supplied parameters.

Parameters

- **width** (*int*) – The device width.
- **height** (*int*) – The device height.
- **rotate** (*int*) – An integer value of 0 (default), 1, 2 or 3 only, where 0 is no rotation, 1 is rotate 90° clockwise, 2 is 180° rotation and 3 represents 270° rotation.
- **mode** (*str*) – The supported color model, one of "1", "RGB" or "RGBA" only.

cleanup ()

Attempt to switch the device off or put into low power mode (this helps prolong the life of the device), clear the screen and close resources associated with the underlying serial interface.

If `persist` is `True`, the device will not be switched off.

This is a managed function, which is called when the python process is being shutdown, so shouldn't usually need be called directly in application code.

clear ()

Initializes the device memory with an empty (blank) image.

command (**cmd*)

Sends a command or sequence of commands through to the delegated serial interface.

contrast (*value*)

Sets the LED intensity to the desired level, in the range 0-255.

Parameters **level** (*int*) – Desired contrast level in the range of 0-255.

data (*data*)

Sends a data byte or sequence of data bytes through to the delegated serial interface.

display (*image*)

Takes a 32-bit RGBA `PIL.Image` and dumps it to the Unicorn HAT HD. If a pixel is not fully opaque, the alpha channel value is used to set the brightness of the respective RGB LED.

hide ()

Simulates switching the display mode OFF; this is achieved by setting the contrast level to zero.

preprocess (*image*)

Provides a preprocessing facility (which may be overridden) whereby the supplied image is rotated according to the device's rotate capability. If this method is overridden, it is important to call the `super` method.

Parameters **image** (`PIL.Image.Image`) – An image to pre-process.

Returns A new processed image.

Return type `PIL.Image.Image`

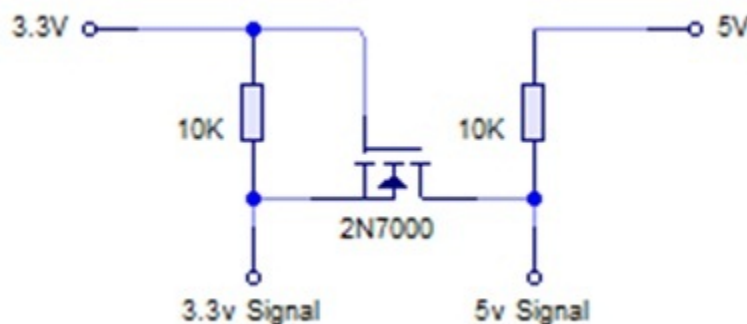
show ()

Simulates switching the display mode ON; this is achieved by restoring the contrast to the level prior to the last time `hide()` was called.

5.1 Cascading, power supply & level shifting

The MAX7219 chip supports cascading devices by connecting the DIN of one chip to the DOUT of another chip. For a long time I was puzzled as to why this didn't seem to work properly for me, despite spending a lot of time investigating and always assuming it was a bug in code.

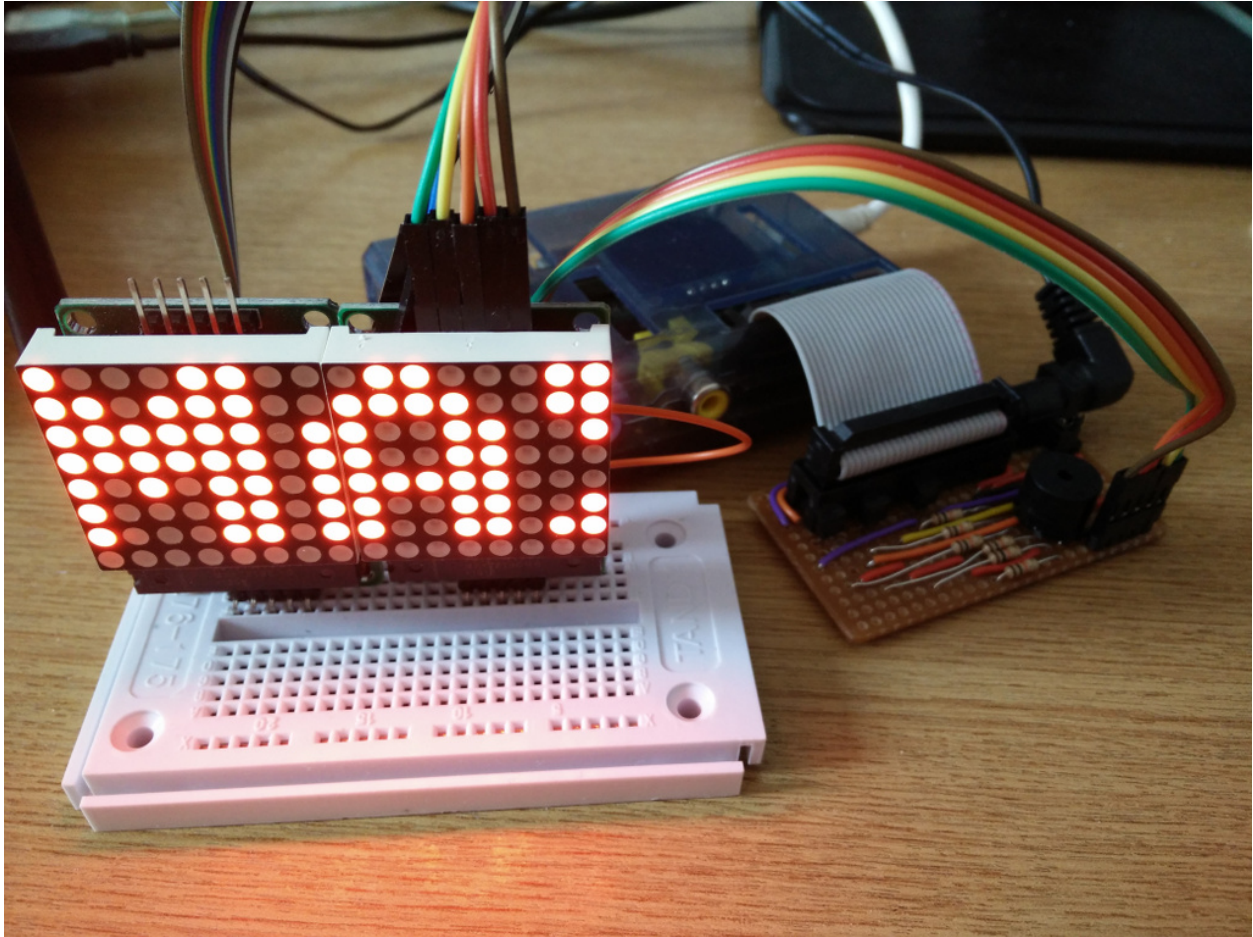
- Because the Raspberry PI can only supply a limited amount of power from the 5V rail, it is recommended that any LED matrices are powered separately by a 5V supply, and grounded with the Raspberry PI. It is possible to power one or two LED matrices directly from a Raspberry PI, but any more is likely to cause intermittent faults & crashes.
- Also because the GPIO ports used for SPI are 3.3V, a simple level shifter (as per the diagram below) should be employed on the DIN, CS and CLK inputs to boost the levels to 5V. Again it is possible to drive them directly by the 3.3V GPIO pins, it is just outside tolerance, and will result in intermittent issues.



Despite the above two points, I still had no success getting cascaded matrices to work properly. Revisiting the wiring, I had connected the devices in serial connecting the out pins of one device to the in pins of another. This just produced garbled bit patterns.

Connecting all the CS lines on the input side together and CLK lines on the input side all together worked. The same

should probably apply to GND and VCC respectively: Only the DOUT of one device should be connected to the next devices DIN pins. Connecting through the output side, never worked consistently; I can only assume that there is some noise on the clock line, or a dry solder joint somewhere.



CHAPTER 6

References

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- <http://louisthiery.com/spi-python-hardware-spi-for-raspi/>
- <http://www.brianhensley.net/2012/07/getting-spi-working-on-raspberry-pi.html>
- <http://raspi.tv/2013/8-x-8-led-array-driven-by-max7219-on-the-raspberry-pi-via-python>
- <http://quick2wire.com/non-root-access-to-spi-on-the-pi>

Pull requests (code changes / documentation / typos / feature requests / setup) are gladly accepted. If you are intending some large-scale changes, please get in touch first to make sure we're on the same page: try and include a docstring for any new methods, and try and keep method bodies small, readable and PEP8-compliant.

7.1 GitHub

The source code is available to clone at: http://github.com/rm-hull/luma.led_matrix

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CHAPTER 8

ChangeLog

Version	Description	Date
1.4.1	<ul style="list-style-type: none">• Make <code>contrast</code> an optional constructor argument	2019/12/08
1.4.0	<ul style="list-style-type: none">• Rework namespace handling for luma sub-projects	2019/06/16
1.3.1	<ul style="list-style-type: none">• Fix alpha-channel blending for Unicorn Hat HD display	2019/05/26
1.3.0	<ul style="list-style-type: none">• Add support for Pimoroni's Unicorn Hat HD	2019/05/26
1.2.0	<ul style="list-style-type: none">• Add option to control if 8x8 blocks are arranged in reverse order• Add (approximations of) more characters for 7-segment displa• Documentation updates	2019/04/20
1.1.1	<ul style="list-style-type: none">• Fix unicode warning	2018/09/26

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Version	Description	Date
1.1.0	<ul style="list-style-type: none">• Add degree symbol to segment mapper charmap	2018/09/18
1.0.8	<ul style="list-style-type: none">• Use DMA channel 10 (rather than ch. 5) for WS2812 NeoPixels	2018/01/23
1.0.7	<ul style="list-style-type: none">• Use <code>extras_require</code> in <code>setup.py</code> for ARM dependencies	2017/11/26
1.0.6	<ul style="list-style-type: none">• Version number available as <code>luma.led_matrix.__version__</code> now	2017/11/23
1.0.5	<ul style="list-style-type: none">• Conditionally install WS2812 packages if Linux/ARM7L only	2017/10/22
1.0.4	<ul style="list-style-type: none">• Make wheel universal• Minor documentation fixes	2017/10/22
1.0.3	<ul style="list-style-type: none">• Explicitly state ‘UTF-8’ encoding in setup when reading files	2017/10/18
1.0.2	<ul style="list-style-type: none">• Setup fails due to programmer not understanding basic Python ...	2017/08/05
1.0.1	<ul style="list-style-type: none">• Setup on Python 3 fails due to hyphen in package name	2017/08/05
1.0.0	<ul style="list-style-type: none">• Stable release (remove all deprecated methods & parameters)	2017/07/30
0.11.1	<ul style="list-style-type: none">• Add Python3 compatibility for neopixels/neosegments	2017/07/29

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Version	Description	Date
0.11.0	<ul style="list-style-type: none"> • Alternative WS2812 low level implementation • Add support for @msurguy's modular NeoSegments 	2017/07/21
0.10.1	<ul style="list-style-type: none"> • Add block_orientation=180 option 	2017/05/01
0.10.0	<ul style="list-style-type: none"> • BREAKING CHANGE: Move sevensegment class to luma.core.virtual package 	2017/04/22
0.9.0	<ul style="list-style-type: none"> • Add support for APA102 RGB neopixels 	2017/03/30
0.8.0	<ul style="list-style-type: none"> • Change MAX7219's block_orientation to support $\pm 90^\circ$ angle correction • Deprecate "vertical" and "horizontal" block_orientation 	2017/03/19
0.7.0	<ul style="list-style-type: none"> • BREAKING CHANGE: Move sevensegment class to luma.led_matrix.virtual package • Documentation updates & corrections 	2017/03/04
0.6.2	<ul style="list-style-type: none"> • Allow MAX7219 and NeoPixel driver constructors to accept any args 	2017/03/02
0.6.1	<ul style="list-style-type: none"> • Restrict exported Python symbols from luma.led_matrix.device 	2017/03/02
0.6.0	<ul style="list-style-type: none"> • Add support for arbitrary MxN matrices rather than a single chain 	2017/02/22

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Version	Description	Date
0.5.3	<ul style="list-style-type: none">• Huge performance improvements for cascaded MAX7219 devices• Documentation updates	2017/02/21
0.5.2	<ul style="list-style-type: none">• Add apostrophe representation to seven-segment display• Deprecate <code>luma.led_matrix.legacy</code> (moved to <code>luma.core.legacy</code>)	2017/02/19
0.4.4	<ul style="list-style-type: none">• Support both common-row anode and common-row cathode LED matrices	2017/02/02
0.4.3	<ul style="list-style-type: none">• Add translation mapping to accomodate Pimoroni's 8x8 Unicorn HAT• MAX7219 optimizations	2017/01/29
0.4.2	<ul style="list-style-type: none">• Fix bug in neopixel initialization• Improved demo scripts• Additional tests	2017/01/27
0.4.0	<ul style="list-style-type: none">• Add support for WS2812 NeoPixel strips/arrays	2017/01/23
0.3.3	<ul style="list-style-type: none">• Fix for dot muncher: not handling full-stop at line end• Documentation updates	2017/01/21
0.3.2	<ul style="list-style-type: none">• Replace <code>bytearray</code> with <code>mutable_string</code> implementation• More tests	2017/01/20

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Version	Description	Date
0.3.1	<ul style="list-style-type: none">• Python 3 compatibility (fix exception in bytearray creation)• Begin to add tests & test infrastructure	2017/01/20
0.3.0	<ul style="list-style-type: none">• BREAKING CHANGE: Package rename to luma.led_matrix	2017/01/19
0.2.3	<ul style="list-style-type: none">• Bit-bang version using wiringPi	2013/01/28

CHAPTER 9

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