Luma.OLED Documentation

Release 2.0.1

Richard Hull

Jan 16, 2017

Contents

CHAPTER 1

Introduction

Interfacing OLED matrix displays with the SSD1306, SSD1325, SSD1331 or SH1106 driver in Python 2 or 3 using I2C/SPI on the Raspberry Pi and other linux-based single-board computers: the library provides a Pillow-compatible drawing canvas, and other functionality to support:

- scrolling/panning capability,
- terminal-style printing,
- state management,
- color/greyscale (where supported),
- dithering to monochrome

The SSD1306 display pictured below is 128 x 64 pixels, and the board is *tiny*, and will fit neatly inside the RPi case.

See also:

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

- `SSD1306`
- `SSD1325`
- `SSD1331`
- `SH1106`

Benchmarks for tested devices can be found in the wiki.

As well as display drivers for various physical OLED devices there are emulators that run in real-time (with pygame) and others that can take screenshots, or assemble animated GIFs, as per the examples below (source code for these is available in the luma.examples git repository:

CHAPTER 2

Python usage

OLED displays can be driven with python using the varous implementations in the `luma.oled.device` package. There are several device classes available and usage is very simple if you have ever used Pillow or PIL.

First, import and initialise the device:

```
from luma.core.serial import i2c, spi
from luma.core.render import canvas
from luma.oled.device import ssd1306, ssd1325, ssd1331, sh1106

# rev.1 users set port=0
# substitute spi(device=0, port=0) below if using that interface
serial = i2c(port=1, address=0x3C)

# substitute ssd1331(...) or sh1106(...) below if using that device
device = ssd1306(serial)
```

The display device should now be configured for use. The specific `luma.oled.device.ssd1306`, `luma.oled.device.ssd1325`, `luma.oled.device.ssd1331`, or `luma.oled.device.sh1106`, classes all expose a `display()` method which takes an image with attributes consistent with the capabilities of the device. However, for most cases, for drawing text and graphics primitives, the canvas class should be used as follows:

```
with canvas(device) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="black")
    draw.text((30, 40), "Hello World", fill="white")
```

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.

2.1 Color Model

Any of the standard `PIL.ImageColor` color formats may be used, but since the SSD1306 and SH1106 OLEDs 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.canvas` object does have a `dither` flag which if set to True, will convert color drawings to a dithered monochrome effect (see the *3d_box.py* example, below).

```
with canvas(device, dither=True) as draw:
    draw.rectangle((10, 10, 30, 30), outline="white", fill="red")
```

There is no such constraint on the SSD1331 OLED which features 16-bit RGB colors: 24-bit RGB images are downsized to 16-bit using a 565 scheme.

The SSD1325 OLED supports 16 greyscale graduations: 24-bit RGB images are downsized to 4-bit using a Luma conversion which is approximately calculated as follows:

Y'=0.299R'+0.587G'+0.114B'

2.2 Landscape / Portrait Orientation

By default the display will be oriented in landscape mode (128x64 pixels for the SSD1306, for example). 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.serial import i2c
from luma.core.render import canvas
from luma.oled.device import ssd1306, ssd1325, ssd1331, sh1106

serial = i2c(port=1, address=0x3C)
device = ssd1306(serial, rotate=1)

# Box and text rendered in portrait mode
with canvas(device) as draw:
    draw.rectangle(device.bounding_box, outline="white", fill="black")
    draw.text((10, 40), "Hello World", fill="white")
```

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.

2.3 Examples

After installing the library, head over to the luma.examples repository, and try running the following examples (and more):

Example	Description
3d_box.py	Rotating 3D box wireframe & color dithering
bounce.py	Display a bouncing ball animation and frames per second
carousel.py	Showcase viewport and hotspot functionality
clock.py	An analog clockface with date & time
colors.py	Color rendering demo
crawl.py	A vertical scrolling demo, which should be familiar
demo.py	Use misc draw commands to create a simple image
game_of_life.py	Conway's game of life
grayscale.py	Greyscale rendering demo
invaders.py	Space Invaders demo
maze.py	Maze generator
perfloop.py	Simple benchmarking utility to measure performance
pi_logo.py	Display the Raspberry Pi logo (loads image as .png)
savepoint.py	Example of savepoint/restore functionality
starfield.py	3D starfield simulation
sys_info.py	Display basic system information
terminal.py	Simple println capabilities
tv_snow.py	Example image-blitting
tweet_scroll.py	Using Twitter's Streaming API to display scrolling notifications
welcome.py	Unicode font rendering & scrolling

Further details of how to run the examples is shown in the example repo's README.

2.4 Emulators

There are various display emulators available for running code against, for debugging and screen capture functionality:

- The `luma.core.emulator.capture` device will persist a numbered PNG file to disk every time its `display` method is called.
- The `luma.core.emulator.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.core.emulator.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
```

or:

```
$ python examples/clock.py -d pygame
```

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.

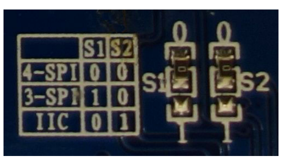
CHAPTER 3

Hardware

3.1 Identifying your serial interface

You can determine if you have an I2C or a SPI interface by counting the number of pins on your card. An I2C display will have 4 pins while an SPI interface will have 6 or 7 pins.

If you have a SPI display, check the back of your display for a configuration such as this:



For this display, the two 0 Ohm (jumper) resistors have been connected to "0" and the table shows that "0 0" is 4-wire SPI. That is the type of connection that is currently supported by the SPI mode of this library.

A list of tested devices can be found in the wiki.

3.2 I2C vs. SPI

If you have not yet purchased your display, you may be wondering if you should get an I2C or SPI display. The basic trade-off is that I2C will be easier to connect because it has fewer pins while SPI may have a faster display update rate due to running at a higher frequency and having less overhead (see benchmarks).

3.3 Tips for connecting the display

- If you don't want to solder directly on the Pi, get 2.54mm 40 pin female single row headers, cut them to length, push them onto the Pi pins, then solder wires to the headers.
- If you need to remove existing pins to connect wires, be careful to heat each pin thoroughly, or circuit board traces may be broken.

- Triple check your connections. In particular, do not reverse VCC and GND.

3.4 Pre-requisites

3.4.1 I2C

The P1 header pins should be connected as follows:

OLED Pin	Name	Remarks	RPi Pin	RPi Function
1	GND	Ground	P01-6	GND
2	VCC	+3.3V Power	P01-1	3V3
3	SCL	Clock	P01-5	GPIO 3 (SCL)
4	SDA	Data	P01-3	GPIO 2 (SDA)

You can also solder the wires directly to the underside of the RPi GPIO pins.

See also:

Alternatively, on rev.2 RPi's, right next to the male pins of the P1 header, there is a bare P5 header which features I2C channel 0, although this doesn't appear to be initially enabled and may be configured for use with the Camera module.

OLED Pin	Name	Remarks	RPi Pin	RPi Function	Location
1	GND	Ground	P5-07	GND	
2	VCC	+3.3V Power	P5-02	3V3	
3	SCL	Clock	P5-04	GPIO 29 (SCL)	
4	SDA	Data	P5-03	GPIO 28 (SDA)	

Ensure that the I2C kernel driver is enabled:

```
$ dmesg | grep i2c
[    4.925554] bcm2708_i2c 20804000.i2c: BSC1 Controller at 0x20804000 (irq 79) (baudrate 100000)
[    4.929325] i2c /dev entries driver
```

or:

```
$ lsmod | grep i2c
i2c_dev                 5769  0
i2c_bcm2708             4943  0
regmap_i2c              1661  3 snd_soc_pcm512x,snd_soc_wm8804,snd_soc_core
```

If you have no kernel modules listed and nothing is showing using `dmesg` then this implies the kernel I2C driver is not loaded. Enable the I2C as follows:

```
$ sudo raspi-config
> Advanced Options > A7 I2C
```

After rebooting re-check that the `dmesg | grep i2c` command shows whether I2C driver is loaded before proceeding. You can also enable I2C manually if the `raspi-config` utility is not available.

Optionally, to improve performance, increase the I2C baudrate from the default of 100KHz to 400KHz by altering `/boot/config.txt` to include:

```
dtparam=i2c_arm=on,i2c_baudrate=400000
```

Then reboot.

Next, add your user to the *i2c* group and install `i2c-tools`:

```
$ sudo usermod -a -G i2c pi
$ sudo apt-get install i2c-tools
```

Logout and in again so that the group membership permissions take effect, and then check that the device is communicating properly (if using a rev.1 board, use 0 for the bus, not 1):

```
$ i2cdetect -y 1
       0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
  00:          -- -- -- -- -- -- -- -- -- -- -- -- --
  10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
  20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
  30: -- -- -- -- -- -- -- -- -- -- -- UU 3c -- -- --
  40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
  50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
  60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
  70: -- -- -- -- -- -- -- --
```

According to the man-page, "UU" means that probing was skipped, because the address was in use by a driver. It suggest that there is a chip at that address. Indeed the documentation for the device indicates it uses two addresses.

3.4.2 SPI

The GPIO pins used for this SPI connection are the same for all versions of the Raspberry Pi, up to and including the Raspberry Pi 3 B.

OLED Pin	Name	Remarks	RPi Pin	RPi Function
1	VCC	+3.3V Power	P01-17	3V3
2	GND	Ground	P01-20	GND
3	D0	Clock	P01-23	GPIO 11 (SCLK)
4	D1	MOSI	P01-19	GPIO 10 (MOSI)
5	RST	Reset	P01-22	GPIO 25
6	DC	Data/Command	P01-18	GPIO 24
7	CS	Chip Select	P01-24	GPIO 8 (CE0)

Note:

- When using the 4-wire SPI connection, Data/Command is an "out of band" signal that tells the controller if you're sending commands or display data. This line is not a part of SPI and the library controls it with a separate GPIO pin. With 3-wire SPI and I2C, the Data/Command signal is sent "in band".
- If you're already using the listed GPIO pins for Data/Command and/or Reset, you can select other pins and pass a `bcm_DC` and/or a `bcm_RST` argument specifying the new *BCM* pin numbers in your serial interface create call.
- The use of the terms 4-wire and 3-wire SPI are a bit confusing because, in most SPI documentation, the terms are used to describe the regular 4-wire configuration of SPI and a 3-wire mode where the input and output lines, MOSI and MISO, have been combined into a single line called SISO. However, in the context of these OLED controllers, 4-wire means MOSI + Data/Command and 3-wire means Data/Command sent as an extra bit over MOSI.
- Because CS is connected to CE0, the display is available on SPI port 0. You can connect it to CE1 to have it available on port 1. If so, pass `port=1` in your serial interface create call.

Enable the SPI port:

```
$ sudo raspi-config
> Advanced Options > A6 SPI
```

If `raspi-config` is not available, enabling the SPI port can be done manually.

Ensure that the SPI kernel driver is enabled:

```
$ ls -l /dev/spi*
crw-rw---- 1 root spi 153, 0 Nov 25 08:32 /dev/spidev0.0
crw-rw---- 1 root spi 153, 1 Nov 25 08:32 /dev/spidev0.1
```

or:

```
$ lsmod | grep spi
spi_bcm2835             6678  0
```

Then add your user to the *spi* and *gpio* groups:

```
$ sudo usermod -a G spi pi
$ sudo usermod -a G gpio pi
```

Log out and back in again to ensure that the group permissions are applied successfully.

CHAPTER 4

Installation

Warning: Ensure that the *Pre-requisites* from the previous section have been performed, checked and tested before proceeding.

Note: The library has been tested against Python 2.7, 3.4 and 3.5.

For **Python3** installation, substitute the following in the instructions below.

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

It was *originally* tested with Raspbian on a rev.2 model B, with a vanilla kernel version 4.1.16+, and has subsequently been tested on Raspberry Pi model A, model B2 and 3B (Debian Jessie) and OrangePi Zero (Armbian Jessie).

4.1 From PyPI

Note: This is the preferred installation mechanism.

Install the latest version of the library directly from PyPI:

```
$ sudo apt-get install python-dev python-pip libfreetype6-dev libjpeg8-dev libsdl1.2-
↪dev
$ sudo pip install --upgrade luma.oled
```

4.2 From source

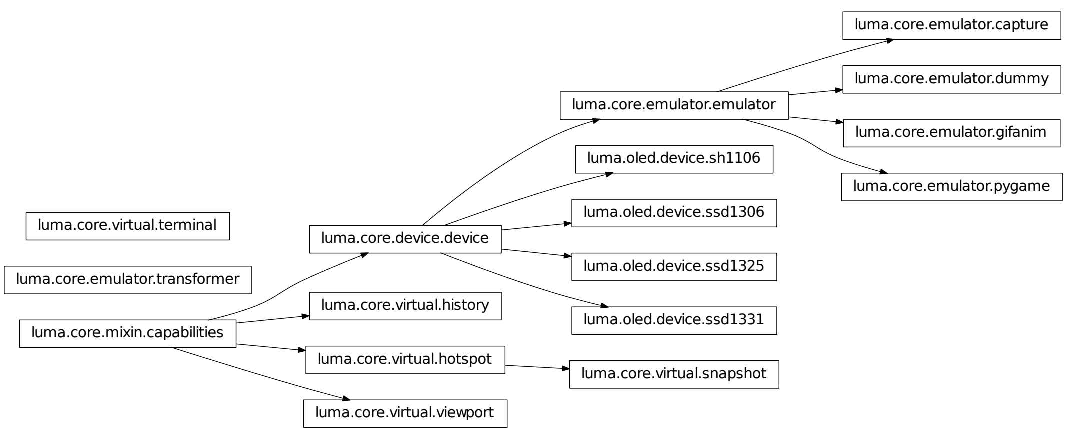
For Python 2, from the bash prompt, enter:

```
$ sudo apt-get install python-dev python-pip libfreetype6-dev libjpeg8-dev libsdl1.2-
↪dev
$ sudo python setup.py install
```

CHAPTER 5

API Documentation

OLED display driver for SSD1306, SSD1325, SSD1331 and SH1106 devices.



5.1 Breaking changes

Warning: Version 2.0.0 was released on 11 January 2017: this came with a rename of the project in github from **ssd1306** to **luma.oled** to reflect the changing nature of the codebase. It introduces some structural changes to the package structure, namely breaking the library up into smaller components and renaming existing packages.

This should largely be restricted to having to update import statements only. To upgrade any existing code that uses the old package structure:

- rename instances of `oled.device` to `luma.oled.device`.
- rename any other usages of `oled.*` to `luma.core.*`.

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

5.2 `luma.oled.device`

class `luma.oled.device.`**`sh1106`**(*serial_interface=None*, *width=128*, *height=64*, *rotate=0*)
Bases: `luma.core.device.device`

Encapsulates the serial interface to the monochrome SH1106 OLED display hardware. 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.

`display`(*image*)
Takes a 1-bit `PIL.Image` and dumps it to the SH1106 OLED display.

class `luma.oled.device.`**`ssd1306`**(*serial_interface=None*, *width=128*, *height=64*, *rotate=0*)
Bases: `luma.core.device.device`

Encapsulates the serial interface to the monochrome SSD1306 OLED display hardware. 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.

`display`(*image*)
Takes a 1-bit `PIL.Image` and dumps it to the SSD1306 OLED display.

class `luma.oled.device.`**`ssd1325`**(*serial_interface=None*, *width=128*, *height=64*, *rotate=0*)
Bases: `luma.core.device.device`

Encapsulates the serial interface to the 4-bit greyscale SSD1325 OLED display hardware. 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.

`display`(*image*)
Takes a 24-bit RGB `PIL.Image` and dumps it to the SSD1325 OoledLED display, converting the image pixels to 4-bit greyscale using a simplified Luma calculation, based on *Y'=0.299R'+0.587G'+0.114B'*.

class `luma.oled.device.`**`ssd1331`**(*serial_interface=None*, *width=96*, *height=64*, *rotate=0*)
Bases: `luma.core.device.device`

Encapsulates the serial interface to the 16-bit color (5-6-5 RGB) SSD1331 OLED display hardware. 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.

`contrast`(*level*)
Switches the display contrast to the desired level, in the range 0-255. Note that setting the level to a low (or zero) value will not necessarily dim the display to nearly off. In other words, this method is **NOT** suitable for fade-in/out animation.

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

`display`(*image*)
Takes a 24-bit RGB `PIL.Image` and dumps it to the SSD1331 OLED display.

CHAPTER 6

References

- https://learn.adafruit.com/monochrome-oled-breakouts
- https://github.com/adafruit/Adafruit_Python_SSD1306
- http://www.dafont.com/bitmap.php
- http://raspberrypi.znix.com/hipidocs/topic_i2cbus_2.htm
- http://martin-jones.com/2013/08/20/how-to-get-the-second-raspberry-pi-i2c-bus-to-work/
- https://projects.drogon.net/understanding-spi-on-the-raspberry-pi/
- https://pinout.xyz/
- https://learn.sparkfun.com/tutorials/serial-peripheral-interface-spi
- http://code.activestate.com/recipes/577187-python-thread-pool/

CHAPTER 7

Contributing

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

7.1 GitHub

The source code is available to clone at: https://github.com/rm-hull/luma.oled.git

7.2 Contributors

- Thijs Triemstra (@thijstriemstra)
- Christoph Handel (@fragfutter)
- Boeeerb (@Boeeerb)
- xes (@xes)
- Roger Dahl (@rogerdahl)
- Václav Šmilauer (@eudoxos)
- Claus Bjerre (@bjerrep)

CHAPTER 8

ChangeLog

Version	Description	Date
Upcoming	• Simplify/optimize SSD1306 display logic	
2.0.1	• Moved examples to separate git repo • Add notes about breaking changes	2017/01/15
2.0.0	• Package rename to `luma.oled` (**Note:** Breaking changes)	2017/01/11
1.5.0	• Performance improvements for SH1106 driver (2x frame rate!) • Support for 4-bit greyscale OLED (SSD1325) • Landscape/portrait orientation with rotate=N parameter	2017/01/09
1.4.0	• Add savepoint/restore functionality • Add terminal functionality • Canvas image dithering • Additional & improved examples • Load config settings from file (for examples) • Universal wheel distribution • Improved/simplified error reporting • Documentation updates	2016/12/23
1.3.1	• Add ability to adjust bright-	2016/12/11

CHAPTER 9

The MIT License (MIT)

Python Module Index

l

Index

C

D

L

S