Pillow (PIL Fork) Documentation

Release 5.3.0.dev0

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Contents

Pillow is the friendly PIL fork by Alex Clark and Contributors. PIL is the Python Imaging Library by Fredrik Lundh and Contributors.

CHAPTER 1

Installation

1.1 Warnings

Warning: Pillow and PIL cannot co-exist in the same environment. Before installing Pillow, please uninstall PIL.

Warning: Pillow >= 1.0 no longer supports "import Image". Please use "from PIL import Image" instead.

Warning: Pillow >= 2.1.0 no longer supports "import _imaging". Please use "from PIL.Image import core as _imaging" instead.

1.2 Notes

Note: Pillow < 2.0.0 supports Python versions 2.4, 2.5, 2.6, 2.7.

Note: Pillow >= 2.0.0 < 4.0.0 supports Python versions 2.6, 2.7, 3.2, 3.3, 3.4, 3.5

Note: Pillow >= 4.0.0 < 5.0.0 supports Python versions 2.7, 3.3, 3.4, 3.5, 3.6

Note: Pillow >= 5.0.0 < 5.2.0 supports Python versions 2.7, 3.4, 3.5, 3.6

Note: Pillow >= 5.2.0 supports Python versions 2.7, 3.4, 3.5, 3.6, 3.7

1.3 Basic Installation

Note: The following instructions will install Pillow with support for most common image formats. See *External Libraries* for a full list of external libraries supported.

Install Pillow with **pip**:

```
$ pip install Pillow
```

1.3.1 Windows Installation

We provide Pillow binaries for Windows compiled for the matrix of supported Pythons in both 32 and 64-bit versions in wheel, egg, and executable installers. These binaries have all of the optional libraries included except for raqm and libimagequant:

```
> pip install Pillow
```

1.3.2 macOS Installation

We provide binaries for macOS for each of the supported Python versions in the wheel format. These include support for all optional libraries except libimagequant. Raqm support requires libraqm, fribidi, and harfbuzz to be installed separately:

```
$ pip install Pillow
```

1.3.3 Linux Installation

We provide binaries for Linux for each of the supported Python versions in the manylinux wheel format. These include support for all optional libraries except libimagequant. Raqm support requires libraqm, fribidi, and harfbuzz to be installed separately:

```
$ pip install Pillow
```

Most major Linux distributions, including Fedora, Debian/Ubuntu and ArchLinux also include Pillow in packages that previously contained PIL e.g. `python-imaging`.

1.3.4 FreeBSD Installation

Pillow can be installed on FreeBSD via the official Ports or Packages systems:

Ports:

```
$ cd /usr/ports/graphics/py-pillow && make install clean
```

Packages:

```
$ pkg install py27-pillow
```

Note: The Pillow FreeBSD port and packages are tested by the ports team with all supported FreeBSD versions and against Python 2.7 and 3.x.

1.4 Building From Source

Download and extract the compressed archive from PyPI.

1.4.1 External Libraries

Note: You **do not need to install all supported external libraries** to use Pillow's basic features. **Zlib** and **libjpeg** are required by default.

Note: There are scripts to install the dependencies for some operating systems included in the `depends` directory. Also see the Dockerfiles in our docker images repo.

Many of Pillow's features require external libraries:

- **libjpeg** provides JPEG functionality.
  - Pillow has been tested with libjpeg versions **6b**, **8**, **9**, **9a**, and **9b** and libjpeg-turbo version **8**.
  - Starting with Pillow 3.0.0, libjpeg is required by default, but may be disabled with the `--disable-jpeg` flag.
- **zlib** provides access to compressed PNGs
  - Starting with Pillow 3.0.0, zlib is required by default, but may be disabled with the `--disable-zlib` flag.
- **libtiff** provides compressed TIFF functionality
  - Pillow has been tested with libtiff versions **3.x** and **4.0**
- **libfreetype** provides type related services
- **littlecms** provides color management
  - Pillow version 2.2.1 and below uses liblcms1, Pillow 2.3.0 and above uses liblcms2. Tested with **1.19** and **2.7**.
- **libwebp** provides the WebP format.
  - Pillow has been tested with version **0.1.3**, which does not read transparent WebP files. Versions **0.3.0** and above support transparency.
- **tcl/tk** provides support for tkinter bitmap and photo images.
- **openjpeg** provides JPEG 2000 functionality.
  - Pillow has been tested with openjpeg **2.0.0** and **2.1.0**.

  - Pillow does **not** support the earlier **1.5** series which ships with Ubuntu <= 14.04 and Debian Jessie.

- **libimagequant** provides improved color quantization
  - Pillow has been tested with libimagequant **2.6-2.11**
  - Libimagequant is licensed GPLv3, which is more restrictive than the Pillow license, therefore we will not be distributing binaries with libimagequant support enabled.
  - Windows support: Libimagequant requires VS2013/MSVC 18 to compile, so it is unlikely to work with any Python prior to 3.5 on Windows.
- **libraqm** provides complex text layout support.
  - libraqm provides bidirectional text support (using FriBiDi), shaping (using HarfBuzz), and proper script itemization. As a result, Raqm can support most writing systems covered by Unicode.
  - libraqm depends on the following libraries: FreeType, HarfBuzz, FriBiDi, make sure that you install them before install libraqm if not available as package in your system.
  - setting text direction or font features is not supported without libraqm.
  - libraqm is dynamically loaded in Pillow 5.0.0 and above, so support is available if all the libraries are installed.
  - Windows support: Raqm support is currently unsupported on Windows.

Once you have installed the prerequisites, run:

```
$ pip install Pillow
```

If the prerequisites are installed in the standard library locations for your machine (e.g. `/usr` or `/usr/local`), no additional configuration should be required. If they are installed in a non-standard location, you may need to configure setuptools to use those locations by editing `setup.py` or `setup.cfg`, or by adding environment variables on the command line:

```
$ CFLAGS="-I/usr/pkg/include" pip install pillow
```

If Pillow has been previously built without the required prerequisites, it may be necessary to manually clear the pip cache or build without cache using the `--no-cache-dir` option to force a build with newly installed external libraries.

1.4.2 Build Options

- Environment variable: `MAX_CONCURRENCY=n`. By default, Pillow will use multiprocessing to build the extension on all available CPUs, but not more than 4. Setting `MAX_CONCURRENCY` to 1 will disable parallel building.
- Build flags: `--disable-zlib`, `--disable-jpeg`, `--disable-tiff`, `--disable-freetype`, `--disable-tcl`, `--disable-tk`, `--disable-lcms`, `--disable-webp`, `--disable-webpmux`, `--disable-jpeg2000`, `--disable-imagequant`. Disable building the corresponding feature even if the development libraries are present on the building machine.
- Build flags: `--enable-zlib`, `--enable-jpeg`, `--enable-tiff`, `--enable-freetype`, `--enable-tcl`, `--enable-tk`, `--enable-lcms`, `--enable-webp`, `--enable-webpmux`, `--enable-jpeg2000`, `--enable-imagequant`. Require that the corresponding feature is built. The build will raise an exception if the libraries are not found. Webpmux (WebP metadata) relies on WebP support. Tcl and Tk also must be used together.

- Build flag: `--disable-platform-guessing`. Skips all of the platform dependent guessing of include and library directories for automated build systems that configure the proper paths in the environment variables (e.g. Buildroot).
- Build flag: `--debug`. Adds a debugging flag to the include and library search process to dump all paths searched for and found to stdout.

Sample usage:

```
$ MAX_CONCURRENCY=1 python setup.py build_ext --enable-[feature] install
```

or using pip:

```
$ pip install pillow --global-option="build_ext" --global-option="--enable-[feature]"
```

1.4.3 Building on macOS

The Xcode command line tools are required to compile portions of Pillow. The tools are installed by running `xcode-select --install` from the command line. The command line tools are required even if you have the full Xcode package installed. It may be necessary to run `sudo xcodebuild -license` to accept the license prior to using the tools.

The easiest way to install external libraries is via Homebrew. After you install Homebrew, run:

```
$ brew install libtiff libjpeg webp little-cms2
```

To install libraqm on macOS use Homebrew to install its dependencies:

```
$ brew install freetype harfbuzz fribidi
```

Then see `depends/install_raqm_cmake.sh` to install libraqm.

Now install Pillow with:

```
$ pip install Pillow
```

or from within the uncompressed source directory:

```
$ python setup.py install
```

1.4.4 Building on Windows

We don't recommend trying to build on Windows. It is a maze of twisty passages, mostly dead ends. There are build scripts and notes for the Windows build in the `winbuild` directory.

1.4.5 Building on FreeBSD

Note: Only FreeBSD 10 and 11 tested

Make sure you have Python's development libraries installed.:

```
$ sudo pkg install python2
```

Or for Python 3:

```
$ sudo pkg install python3
```

Prerequisites are installed on **FreeBSD 10 or 11** with:

```
$ sudo pkg install jpeg-turbo tiff webp lcms2 freetype2 openjpeg harfbuzz fribidi
```

Then see `depends/install_raqm_cmake.sh` to install libraqm.

1.4.6 Building on Linux

If you didn't build Python from source, make sure you have Python's development libraries installed.

In Debian or Ubuntu:

```
$ sudo apt-get install python-dev python-setuptools
```

Or for Python 3:

```
$ sudo apt-get install python3-dev python3-setuptools
```

In Fedora, the command is:

```
$ sudo dnf install python-devel redhat-rpm-config
```

Or for Python 3:

```
$ sudo dnf install python3-devel redhat-rpm-config
```

Note: `redhat-rpm-config` is required on Fedora 23, but not earlier versions.

Prerequisites are installed on **Ubuntu 14.04 LTS** with:

```
$ sudo apt-get install libtiff5-dev libjpeg8-dev zlib1g-dev \
    libfreetype6-dev liblcms2-dev libwebp-dev libharfbuzz-dev libfribidi-dev \
    tcl8.6-dev tk8.6-dev python-tk
```

Then see `depends/install_raqm.sh` to install libraqm.

Prerequisites are installed on recent **RedHat Centos** or **Fedora** with:

```
$ sudo dnf install libtiff-devel libjpeg-devel zlib-devel freetype-devel \
    lcms2-devel libwebp-devel tcl-devel tk-devel libraqm-devel \
    libimagequant-devel
```

Note that the package manager may be yum or dnf, depending on the exact distribution.

See also the `Dockerfiles` in the Test Infrastructure repo (https://github.com/python-pillow/docker-images) for a known working install process for other tested distros.

1.4.7 Building on Android

Basic Android support has been added for compilation within the Termux environment. The dependencies can be installed by:

```
$ pkg -y install python python-dev ndk-sysroot clang make \
    libjpeg-turbo-dev
```

This has been tested within the Termux app on ChromeOS, on x86.

1.5 Platform Support

Current platform support for Pillow. Binary distributions are contributed for each release on a volunteer basis, but the source should compile and run everywhere platform support is listed. In general, we aim to support all current versions of Linux, macOS, and Windows.

1.5.1 Continuous Integration Targets

These platforms are built and tested for every change.

Operating system	Tested Python versions	Tested Architecture
Alpine	2.7	x86-64
Arch	2.7	x86-64
Amazon	2.7	x86-64
Centos 6	2.7	x86-64
Centos 7	2.7	x86-64
Debian Stretch	2.7	x86
Fedora 25	2.7	x86-64
Fedora 26	2.7	x86-64
Mac OS X 10.10 Yosemite*	2.7, 3.4, 3.5, 3.6	x86-64
Ubuntu Linux 16.04 LTS	2.7	x86-64
Ubuntu Linux 14.04 LTS	2.7, 3.4, 3.5, 3.6, 3.7, pypy, pypy3	x86-64
	2.7	x86
Windows Server 2012 R2	2.7, 3.4	x86, x86-64
	pypy, 3.5/mingw	x86

* Mac OS X CI is not run for every commit, but is run for every release.

1.5.2 Other Platforms

These platforms have been reported to work at the versions mentioned.

Note: Contributors please test Pillow on your platform then update this document and send a pull request.

Operating system	Tested Python versions	Latest tested Pillow version	Tested processors
macOS 10.13 High Sierra	2.7, 3.4, 3.5, 3.6	4.2.1	x86-64
macOS 10.12 Sierra	2.7, 3.4, 3.5, 3.6	4.1.1	x86-64
Mac OS X 10.11 El Capitan	2.7, 3.3, 3.4, 3.5	4.1.0	x86-64
Mac OS X 10.9 Mavericks	2.7, 3.2, 3.3, 3.4	3.0.0	x86-64
Mac OS X 10.8 Mountain Lion	2.6, 2.7, 3.2, 3.3		x86-64
Redhat Linux 6	2.6		x86
CentOS 6.3	2.7, 3.3		x86
Fedora 23	2.7, 3.4	3.1.0	x86-64
Ubuntu Linux 12.04 LTS	2.6, 3.2, 3.3, 3.4, 3.5 PyPy5.3.1, PyPy3 v2.4.0	3.4.1	x86,x86-64
	2.7	4.3.0	x86-64
	2.7, 3.2	3.4.1	ppc
Ubuntu Linux 10.04 LTS	2.6	2.3.0	x86,x86-64
Debian 8.2 Jessie	2.7, 3.4	3.1.0	x86-64
Raspbian Jessie	2.7, 3.4	3.1.0	arm
Raspbian Stretch	2.7, 3.5	4.0.0	arm
Gentoo Linux	2.7, 3.2	2.1.0	x86-64
FreeBSD 11.1	2.7, 3.4, 3.5, 3.6	4.3.0	x86-64
FreeBSD 10.3	2.7, 3.4, 3.5	4.2.0	x86-64
FreeBSD 10.2	2.7, 3.4	3.1.0	x86-64
Windows 8.1 Pro	2.6, 2.7, 3.2, 3.3, 3.4	2.4.0	x86,x86-64
Windows 8 Pro	2.6, 2.7, 3.2, 3.3, 3.4a3	2.2.0	x86,x86-64
Windows 7 Pro	2.7, 3.2, 3.3	3.4.1	x86-64
Windows Server 2008 R2 Enterprise	3.3		x86-64

1.6 Old Versions

You can download old distributions from PyPI. Only the latest major releases for Python 2.x and 3.x are visible, but all releases are available by direct URL access e.g. https://pypi.org/project/Pillow/1.0/.

CHAPTER 2

Handbook

2.1 Overview

The **Python Imaging Library** adds image processing capabilities to your Python interpreter.

This library provides extensive file format support, an efficient internal representation, and fairly powerful image processing capabilities.

The core image library is designed for fast access to data stored in a few basic pixel formats. It should provide a solid foundation for a general image processing tool.

Let's look at a few possible uses of this library.

2.1.1 Image Archives

The Python Imaging Library is ideal for image archival and batch processing applications. You can use the library to create thumbnails, convert between file formats, print images, etc.

The current version identifies and reads a large number of formats. Write support is intentionally restricted to the most commonly used interchange and presentation formats.

2.1.2 Image Display

The current release includes Tk `PhotoImage` and `BitmapImage` interfaces, as well as a *`Windows DIB interface`* that can be used with PythonWin and other Windows-based toolkits. Many other GUI toolkits come with some kind of PIL support.

For debugging, there's also a `show()` method which saves an image to disk, and calls an external display utility.

2.1.3 Image Processing

The library contains basic image processing functionality, including point operations, filtering with a set of built-in convolution kernels, and colour space conversions.

The library also supports image resizing, rotation and arbitrary affine transforms.

There's a histogram method allowing you to pull some statistics out of an image. This can be used for automatic contrast enhancement, and for global statistical analysis.

2.2 Tutorial

2.2.1 Using the Image class

The most important class in the Python Imaging Library is the `Image` class, defined in the module with the same name. You can create instances of this class in several ways; either by loading images from files, processing other images, or creating images from scratch.

To load an image from a file, use the `open()` function in the *Image* module:

```
>>> from PIL import Image
>>> im = Image.open("hopper.ppm")
```

If successful, this function returns an `Image` object. You can now use instance attributes to examine the file contents:

```
>>> from __future__ import print_function
>>> print(im.format, im.size, im.mode)
PPM (512, 512) RGB
```

The `format` attribute identifies the source of an image. If the image was not read from a file, it is set to None. The size attribute is a 2-tuple containing width and height (in pixels). The `mode` attribute defines the number and names of the bands in the image, and also the pixel type and depth. Common modes are "L" (luminance) for greyscale images, "RGB" for true color images, and "CMYK" for pre-press images.

If the file cannot be opened, an `IOError` exception is raised.

Once you have an instance of the `Image` class, you can use the methods defined by this class to process and manipulate the image. For example, let's display the image we just loaded:

```
>>> im.show()
```

Note: The standard version of `show()` is not very efficient, since it saves the image to a temporary file and calls the **xv** utility to display the image. If you don't have **xv** installed, it won't even work. When it does work though, it is very handy for debugging and tests.

The following sections provide an overview of the different functions provided in this library.

2.2.2 Reading and writing images

The Python Imaging Library supports a wide variety of image file formats. To read files from disk, use the `open()` function in the *Image* module. You don't have to know the file format to open a file. The library automatically determines the format based on the contents of the file.

To save a file, use the `save()` method of the `Image` class. When saving files, the name becomes important. Unless you specify the format, the library uses the filename extension to discover which file storage format to use.

Convert files to JPEG

```
from __future__ import print_function
import os, sys
from PIL import Image

for infile in sys.argv[1:]:
    f, e = os.path.splitext(infile)
    outfile = f + ".jpg"
    if infile != outfile:
        try:
            Image.open(infile).save(outfile)
        except IOError:
            print("cannot convert", infile)
```

A second argument can be supplied to the `save()` method which explicitly specifies a file format. If you use a non-standard extension, you must always specify the format this way:

Create JPEG thumbnails

```
from __future__ import print_function
import os, sys
from PIL import Image

size = (128, 128)

for infile in sys.argv[1:]:
    outfile = os.path.splitext(infile)[0] + ".thumbnail"
    if infile != outfile:
        try:
            im = Image.open(infile)
            im.thumbnail(size)
            im.save(outfile, "JPEG")
        except IOError:
            print("cannot create thumbnail for", infile)
```

It is important to note that the library doesn't decode or load the raster data unless it really has to. When you open a file, the file header is read to determine the file format and extract things like mode, size, and other properties required to decode the file, but the rest of the file is not processed until later.

This means that opening an image file is a fast operation, which is independent of the file size and compression type. Here's a simple script to quickly identify a set of image files:

Identify Image Files

```
from __future__ import print_function
import sys
from PIL import Image

for infile in sys.argv[1:]:
```

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```
    try:
        with Image.open(infile) as im:
            print(infile, im.format, "%dx%d" % im.size, im.mode)
    except IOError:
        pass
```

2.2.3 Cutting, pasting, and merging images

The `Image` class contains methods allowing you to manipulate regions within an image. To extract a sub-rectangle from an image, use the `crop()` method.

Copying a subrectangle from an image

```
box = (100, 100, 400, 400)
region = im.crop(box)
```

The region is defined by a 4-tuple, where coordinates are (left, upper, right, lower). The Python Imaging Library uses a coordinate system with (0, 0) in the upper left corner. Also note that coordinates refer to positions between the pixels, so the region in the above example is exactly 300x300 pixels.

The region could now be processed in a certain manner and pasted back.

Processing a subrectangle, and pasting it back

```
region = region.transpose(Image.ROTATE_180)
im.paste(region, box)
```

When pasting regions back, the size of the region must match the given region exactly. In addition, the region cannot extend outside the image. However, the modes of the original image and the region do not need to match. If they don't, the region is automatically converted before being pasted (see the section on *Color transforms* below for details).

Here's an additional example:

Rolling an image

```
def roll(image, delta):
    """Roll an image sideways."""
    xsize, ysize = image.size

    delta = delta % xsize
    if delta == 0: return image

    part1 = image.crop((0, 0, delta, ysize))
    part2 = image.crop((delta, 0, xsize, ysize))
    part1.load()
    part2.load()
    image.paste(part2, (0, 0, xsize-delta, ysize))
    image.paste(part1, (xsize-delta, 0, xsize, ysize))

    return image
```

Note that when pasting it back from the `crop()` operation, `load()` is called first. This is because cropping is a lazy operation. If `load()` was not called, then the crop operation would not be performed until the images were used in the paste commands. This would mean that `part1` would be cropped from the version of `image` already modified by the first paste.

For more advanced tricks, the paste method can also take a transparency mask as an optional argument. In this mask, the value 255 indicates that the pasted image is opaque in that position (that is, the pasted image should be used as is). The value 0 means that the pasted image is completely transparent. Values in-between indicate different levels of transparency. For example, pasting an RGBA image and also using it as the mask would paste the opaque portion of the image but not its transparent background.

The Python Imaging Library also allows you to work with the individual bands of an multi-band image, such as an RGB image. The split method creates a set of new images, each containing one band from the original multi-band image. The merge function takes a mode and a tuple of images, and combines them into a new image. The following sample swaps the three bands of an RGB image:

Splitting and merging bands

```
r, g, b = im.split()
im = Image.merge("RGB", (b, g, r))
```

Note that for a single-band image, `split()` returns the image itself. To work with individual color bands, you may want to convert the image to "RGB" first.

2.2.4 Geometrical transforms

The `PIL.Image.Image` class contains methods to `resize()` and `rotate()` an image. The former takes a tuple giving the new size, the latter the angle in degrees counter-clockwise.

Simple geometry transforms

```
out = im.resize((128, 128))
out = im.rotate(45) # degrees counter-clockwise
```

To rotate the image in 90 degree steps, you can either use the `rotate()` method or the `transpose()` method. The latter can also be used to flip an image around its horizontal or vertical axis.

Transposing an image

```
out = im.transpose(Image.FLIP_LEFT_RIGHT)
out = im.transpose(Image.FLIP_TOP_BOTTOM)
out = im.transpose(Image.ROTATE_90)
out = im.transpose(Image.ROTATE_180)
out = im.transpose(Image.ROTATE_270)
```

`transpose(ROTATE)` operations can also be performed identically with `rotate()` operations, provided the *expand* flag is true, to provide for the same changes to the image's size.

A more general form of image transformations can be carried out via the `transform()` method.

2.2.5 Color transforms

The Python Imaging Library allows you to convert images between different pixel representations using the `convert()` method.

Converting between modes

```
from PIL import Image
im = Image.open("hopper.ppm").convert("L")
```

The library supports transformations between each supported mode and the "L" and "RGB" modes. To convert between other modes, you may have to use an intermediate image (typically an "RGB" image).

2.2.6 Image enhancement

The Python Imaging Library provides a number of methods and modules that can be used to enhance images.

Filters

The *ImageFilter* module contains a number of pre-defined enhancement filters that can be used with the `filter()` method.

Applying filters

```
from PIL import ImageFilter
out = im.filter(ImageFilter.DETAIL)
```

Point Operations

The `point()` method can be used to translate the pixel values of an image (e.g. image contrast manipulation). In most cases, a function object expecting one argument can be passed to this method. Each pixel is processed according to that function:

Applying point transforms

```
# multiply each pixel by 1.2
out = im.point(lambda i: i * 1.2)
```

Using the above technique, you can quickly apply any simple expression to an image. You can also combine the `point()` and `paste()` methods to selectively modify an image:

Processing individual bands

```
# split the image into individual bands
source = im.split()

R, G, B = 0, 1, 2

# select regions where red is less than 100
mask = source[R].point(lambda i: i < 100 and 255)

# process the green band
out = source[G].point(lambda i: i * 0.7)

# paste the processed band back, but only where red was < 100
source[G].paste(out, None, mask)

# build a new multiband image
im = Image.merge(im.mode, source)
```

Note the syntax used to create the mask:

```
imout = im.point(lambda i: expression and 255)
```

Python only evaluates the portion of a logical expression as is necessary to determine the outcome, and returns the last value examined as the result of the expression. So if the expression above is false (0), Python does not look at the second operand, and thus returns 0. Otherwise, it returns 255.

Enhancement

For more advanced image enhancement, you can use the classes in the *ImageEnhance* module. Once created from an image, an enhancement object can be used to quickly try out different settings.

You can adjust contrast, brightness, color balance and sharpness in this way.

Enhancing images

```
from PIL import ImageEnhance

enh = ImageEnhance.Contrast(im)
enh.enhance(1.3).show("30% more contrast")
```

2.2.7 Image sequences

The Python Imaging Library contains some basic support for image sequences (also called animation formats). Supported sequence formats include FLI/FLC, GIF, and a few experimental formats. TIFF files can also contain more than one frame.

When you open a sequence file, PIL automatically loads the first frame in the sequence. You can use the seek and tell methods to move between different frames:

Reading sequences

```
from PIL import Image

im = Image.open("animation.gif")
im.seek(1) # skip to the second frame

try:
    while 1:
        im.seek(im.tell()+1)
        # do something to im
except EOFError:
    pass # end of sequence
```

As seen in this example, you'll get an `EOFError` exception when the sequence ends.

Note that most drivers in the current version of the library only allow you to seek to the next frame (as in the above example). To rewind the file, you may have to reopen it.

The following class lets you use the for-statement to loop over the sequence:

Using the ImageSequence Iterator class

```
from PIL import ImageSequence
for frame in ImageSequence.Iterator(im):
    # ...do something to frame...
```

2.2.8 Postscript printing

The Python Imaging Library includes functions to print images, text and graphics on Postscript printers. Here's a simple example:

Drawing Postscript

```
from PIL import Image
from PIL import PSDraw

im = Image.open("hopper.ppm")
title = "hopper"
box = (1*72, 2*72, 7*72, 10*72) # in points

ps = PSDraw.PSDraw() # default is sys.stdout
ps.begin_document(title)

# draw the image (75 dpi)
ps.image(box, im, 75)
ps.rectangle(box)

# draw title
ps.setfont("HelveticaNarrow-Bold", 36)
ps.text((3*72, 4*72), title)

ps.end_document()
```

2.2.9 More on reading images

As described earlier, the `open()` function of the *Image* module is used to open an image file. In most cases, you simply pass it the filename as an argument:

```
from PIL import Image
im = Image.open("hopper.ppm")
```

If everything goes well, the result is an `PIL.Image.Image` object. Otherwise, an `IOError` exception is raised.

You can use a file-like object instead of the filename. The object must implement `read()`, `seek()` and `tell()` methods, and be opened in binary mode.

Reading from an open file

```
from PIL import Image
with open("hopper.ppm", "rb") as fp:
    im = Image.open(fp)
```

To read an image from string data, use the `StringIO` class:

Reading from a string

```
import StringIO

im = Image.open(StringIO.StringIO(buffer))
```

Note that the library rewinds the file (using `seek(0)`) before reading the image header. In addition, seek will also be used when the image data is read (by the load method). If the image file is embedded in a larger file, such as a tar file, you can use the *ContainerIO* or *TarIO* modules to access it.

Reading from a tar archive

```
from PIL import Image, TarIO

fp = TarIO.TarIO("Tests/images/hopper.tar", "hopper.jpg")
im = Image.open(fp)
```

2.2.10 Controlling the decoder

Some decoders allow you to manipulate the image while reading it from a file. This can often be used to speed up decoding when creating thumbnails (when speed is usually more important than quality) and printing to a monochrome laser printer (when only a greyscale version of the image is needed).

The `draft()` method manipulates an opened but not yet loaded image so it as closely as possible matches the given mode and size. This is done by reconfiguring the image decoder.

Reading in draft mode

This is only available for JPEG and MPO files.

```
from PIL import Image
from __future__ import print_function
im = Image.open(file)
print("original =", im.mode, im.size)

im.draft("L", (100, 100))
print("draft =", im.mode, im.size)
```

This prints something like:

```
original = RGB (512, 512)
draft = L (128, 128)
```

Note that the resulting image may not exactly match the requested mode and size. To make sure that the image is not larger than the given size, use the thumbnail method instead.

2.3 Concepts

The Python Imaging Library handles *raster images*; that is, rectangles of pixel data.

2.3.1 Bands

An image can consist of one or more bands of data. The Python Imaging Library allows you to store several bands in a single image, provided they all have the same dimensions and depth. For example, a PNG image might have 'R', 'G', 'B', and 'A' bands for the red, green, blue, and alpha transparency values. Many operations act on each band separately, e.g., histograms. It is often useful to think of each pixel as having one value per band.

To get the number and names of bands in an image, use the `getbands()` method.

2.3.2 Modes

The `mode` of an image defines the type and depth of a pixel in the image. The current release supports the following standard modes:

- `1` (1-bit pixels, black and white, stored with one pixel per byte)
- `L` (8-bit pixels, black and white)
- `P` (8-bit pixels, mapped to any other mode using a color palette)
- `RGB` (3x8-bit pixels, true color)
- `RGBA` (4x8-bit pixels, true color with transparency mask)
- `CMYK` (4x8-bit pixels, color separation)
- `YCbCr` (3x8-bit pixels, color video format)
  - Note that this refers to the JPEG, and not the ITU-R BT.2020, standard
- `LAB` (3x8-bit pixels, the L*a*b color space)
- `HSV` (3x8-bit pixels, Hue, Saturation, Value color space)
- `I` (32-bit signed integer pixels)
- `F` (32-bit floating point pixels)

PIL also provides limited support for a few special modes, including `LA` (L with alpha), `RGBX` (true color with padding) and `RGBa` (true color with premultiplied alpha). However, PIL doesn't support user-defined modes; if you need to handle band combinations that are not listed above, use a sequence of Image objects.

You can read the mode of an image through the `mode` attribute. This is a string containing one of the above values.

2.3.3 Size

You can read the image size through the `size` attribute. This is a 2-tuple, containing the horizontal and vertical size in pixels.

2.3.4 Coordinate System

The Python Imaging Library uses a Cartesian pixel coordinate system, with (0,0) in the upper left corner. Note that the coordinates refer to the implied pixel corners; the centre of a pixel addressed as (0, 0) actually lies at (0.5, 0.5).

Coordinates are usually passed to the library as 2-tuples (x, y). Rectangles are represented as 4-tuples, with the upper left corner given first. For example, a rectangle covering all of an 800x600 pixel image is written as (0, 0, 800, 600).

2.3.5 Palette

The palette mode (`P`) uses a color palette to define the actual color for each pixel.

2.3.6 Info

You can attach auxiliary information to an image using the `info` attribute. This is a dictionary object.

How such information is handled when loading and saving image files is up to the file format handler (see the chapter on *Image file formats*). Most handlers add properties to the `info` attribute when loading an image, but ignore it when saving images.

2.3.7 Filters

For geometry operations that may map multiple input pixels to a single output pixel, the Python Imaging Library provides different resampling *filters*.

`NEAREST` Pick one nearest pixel from the input image. Ignore all other input pixels.

`BOX` Each pixel of source image contributes to one pixel of the destination image with identical weights. For upscaling is equivalent of `NEAREST`. This filter can only be used with the `resize()` and `thumbnail()` methods.

New in version 3.4.0.

`BILINEAR` For resize calculate the output pixel value using linear interpolation on all pixels that may contribute to the output value. For other transformations linear interpolation over a 2x2 environment in the input image is used.

`HAMMING` Produces a sharper image than `BILINEAR`, doesn't have dislocations on local level like with `BOX`. This filter can only be used with the `resize()` and `thumbnail()` methods.

New in version 3.4.0.

`BICUBIC` For resize calculate the output pixel value using cubic interpolation on all pixels that may contribute to the output value. For other transformations cubic interpolation over a 4x4 environment in the input image is used.

LANCZOS Calculate the output pixel value using a high-quality Lanczos filter (a truncated sinc) on all pixels that may contribute to the output value. This filter can only be used with the `resize()` and `thumbnail()` methods.

New in version 1.1.3.

Filters comparison table

Filter	Downscaling quality	Upscaling quality	Performance
NEAREST			
BOX			
BILINEAR			
HAMMING			
BICUBIC			
LANCZOS			

2.4 Appendices

Note: Contributors please include appendices as needed or appropriate with your bug fixes, feature additions and tests.

2.4.1 Image file formats

The Python Imaging Library supports a wide variety of raster file formats. Over 30 different file formats can be identified and read by the library. Write support is less extensive, but most common interchange and presentation formats are supported.

The `open()` function identifies files from their contents, not their names, but the `save()` method looks at the name to determine which format to use, unless the format is given explicitly.

Fully supported formats

Contents

BMP

PIL reads and writes Windows and OS/2 BMP files containing `1`, `L`, `P`, or `RGB` data. 16-colour images are read as `P` images. Run-length encoding is not supported.

The `open()` method sets the following `info` properties:

compression Set to `bmp_rle` if the file is run-length encoded.

EPS

PIL identifies EPS files containing image data, and can read files that contain embedded raster images (ImageData descriptors). If Ghostscript is available, other EPS files can be read as well. The EPS driver can also write EPS images. The EPS driver can read EPS images in `L`, `LAB`, `RGB` and `CMYK` mode, but Ghostscript may convert the images to `RGB` mode rather than leaving them in the original color space. The EPS driver can write images in `L`, `RGB` and `CMYK` modes.

If Ghostscript is available, you can call the `load()` method with the following parameter to affect how Ghostscript renders the EPS

scale Affects the scale of the resultant rasterized image. If the EPS suggests that the image be rendered at 100px x 100px, setting this parameter to 2 will make the Ghostscript render a 200px x 200px image instead. The relative position of the bounding box is maintained:

```
im = Image.open(...)
im.size #(100,100)
im.load(scale=2)
im.size #(200,200)
```

GIF

PIL reads GIF87a and GIF89a versions of the GIF file format. The library writes run-length encoded files in GIF87a by default, unless GIF89a features are used or GIF89a is already in use.

Note that GIF files are always read as grayscale (`L`) or palette mode (`P`) images.

The `open()` method sets the following `info` properties:

background Default background color (a palette color index).

transparency Transparency color index. This key is omitted if the image is not transparent.

version Version (either `GIF87a` or `GIF89a`).

duration May not be present. The time to display the current frame of the GIF, in milliseconds.

loop May not be present. The number of times the GIF should loop.

Reading sequences

The GIF loader supports the `seek()` and `tell()` methods. You can seek to the next frame (`im.seek(im.tell() + 1)`), or rewind the file by seeking to the first frame. Random access is not supported.

`im.seek()` raises an `EOFError` if you try to seek after the last frame.

Saving

When calling `save()`, the following options are available:

```
im.save(out, save_all=True, append_images=[im1, im2, ...])
```

save_all If present and true, all frames of the image will be saved. If not, then only the first frame of a multiframe image will be saved.

append_images A list of images to append as additional frames. Each of the images in the list can be single or multiframe images. This is currently supported for GIF, PDF, TIFF, and WebP.

It is also supported for ICNS. If images are passed in of relevant sizes, they will be used instead of scaling down the main image.

duration The display duration of each frame of the multiframe gif, in milliseconds. Pass a single integer for a constant duration, or a list or tuple to set the duration for each frame separately.

loop Integer number of times the GIF should loop.

optimize If present and true, attempt to compress the palette by eliminating unused colors. This is only useful if the palette can be compressed to the next smaller power of 2 elements.

palette Use the specified palette for the saved image. The palette should be a bytes or bytearray object containing the palette entries in RGBRGB... form. It should be no more than 768 bytes. Alternately, the palette can be passed in as an `PIL.ImagePalette.ImagePalette` object.

disposal Indicates the way in which the graphic is to be treated after being displayed.

- 0 - No disposal specified.
- 1 - Do not dispose.
- 2 - Restore to background color.

- 3 - Restore to previous content.

  Pass a single integer for a constant disposal, or a list or tuple to set the disposal for each frame separately.

Reading local images

The GIF loader creates an image memory the same size as the GIF file's *logical screen size*, and pastes the actual pixel data (the *local image*) into this image. If you only want the actual pixel rectangle, you can manipulate the `size` and `tile` attributes before loading the file:

```
im = Image.open(...)

if im.tile[0][0] == "gif":
    # only read the first "local image" from this GIF file
    tag, (x0, y0, x1, y1), offset, extra = im.tile[0]
    im.size = (x1 - x0, y1 - y0)
    im.tile = [(tag, (0, 0) + im.size, offset, extra)]
```

ICNS

PIL reads and (macOS only) writes macOS `.icns` files. By default, the largest available icon is read, though you can override this by setting the `size` property before calling `load()`. The `open()` method sets the following `info` property:

sizes A list of supported sizes found in this icon file; these are a 3-tuple, `(width, height, scale)`, where `scale` is 2 for a retina icon and 1 for a standard icon. You *are* permitted to use this 3-tuple format for the `size` property if you set it before calling `load()`; after loading, the size will be reset to a 2-tuple containing pixel dimensions (so, e.g. if you ask for `(512, 512, 2)`, the final value of `size` will be `(1024, 1024)`).

The `save()` method can take the following keyword arguments:

append_images A list of images to replace the scaled down versions of the image. The order of the images does not matter, as their use is determined by the size of each image.

New in version 5.1.0.

ICO

ICO is used to store icons on Windows. The largest available icon is read.

The `save()` method supports the following options:

sizes A list of sizes including in this ico file; these are a 2-tuple, `(width, height)`; Default to `[(16, 16), (24, 24), (32, 32), (48, 48), (64, 64), (128, 128), (256, 256)]`. Any sizes bigger than the original size or 256 will be ignored.

IM

IM is a format used by LabEye and other applications based on the IFUNC image processing library. The library reads and writes most uncompressed interchange versions of this format.

IM is the only format that can store all internal PIL formats.

JPEG

PIL reads JPEG, JFIF, and Adobe JPEG files containing `L`, `RGB`, or `CMYK` data. It writes standard and progressive JFIF files.

Using the `draft()` method, you can speed things up by converting `RGB` images to `L`, and resize images to 1/2, 1/4 or 1/8 of their original size while loading them.

The `open()` method may set the following `info` properties if available:

jfif JFIF application marker found. If the file is not a JFIF file, this key is not present.

jfif_version A tuple representing the jfif version, (major version, minor version).

jfif_density A tuple representing the pixel density of the image, in units specified by jfif_unit.

jfif_unit Units for the jfif_density:

- 0 - No Units
- 1 - Pixels per Inch
- 2 - Pixels per Centimeter

dpi A tuple representing the reported pixel density in pixels per inch, if the file is a jfif file and the units are in inches.

adobe Adobe application marker found. If the file is not an Adobe JPEG file, this key is not present.

adobe_transform Vendor Specific Tag.

progression Indicates that this is a progressive JPEG file.

icc_profile The ICC color profile for the image.

exif Raw EXIF data from the image.

The `save()` method supports the following options:

quality The image quality, on a scale from 1 (worst) to 95 (best). The default is 75. Values above 95 should be avoided; 100 disables portions of the JPEG compression algorithm, and results in large files with hardly any gain in image quality.

optimize If present and true, indicates that the encoder should make an extra pass over the image in order to select optimal encoder settings.

progressive If present and true, indicates that this image should be stored as a progressive JPEG file.

dpi A tuple of integers representing the pixel density, `(x,y)`.

icc_profile If present and true, the image is stored with the provided ICC profile. If this parameter is not provided, the image will be saved with no profile attached. To preserve the existing profile:

```
im.save(filename, 'jpeg', icc_profile=im.info.get('icc_profile'))
```

exif If present, the image will be stored with the provided raw EXIF data.

subsampling If present, sets the subsampling for the encoder.

- `keep`: Only valid for JPEG files, will retain the original image setting.
- `4:4:4`, `4:2:2`, `4:2:0`: Specific sampling values
- `-1`: equivalent to `keep`
- `0`: equivalent to `4:4:4`
- `1`: equivalent to `4:2:2`

- `2`: equivalent to `4:2:0`

qtables If present, sets the qtables for the encoder. This is listed as an advanced option for wizards in the JPEG documentation. Use with caution. `qtables` can be one of several types of values:

- a string, naming a preset, e.g. `keep`, `web_low`, or `web_high`
- a list, tuple, or dictionary (with integer keys = range(len(keys))) of lists of 64 integers. There must be between 2 and 4 tables.

New in version 2.5.0.

Note: To enable JPEG support, you need to build and install the IJG JPEG library before building the Python Imaging Library. See the distribution README for details.

JPEG 2000

New in version 2.4.0.

PIL reads and writes JPEG 2000 files containing `L`, `LA`, `RGB` or `RGBA` data. It can also read files containing `YCbCr` data, which it converts on read into `RGB` or `RGBA` depending on whether or not there is an alpha channel. PIL supports JPEG 2000 raw codestreams (`.j2k` files), as well as boxed JPEG 2000 files (`.j2p` or `.jpx` files). PIL does *not* support files whose components have different sampling frequencies.

When loading, if you set the `mode` on the image prior to the `load()` method being invoked, you can ask PIL to convert the image to either `RGB` or `RGBA` rather than choosing for itself. It is also possible to set `reduce` to the number of resolutions to discard (each one reduces the size of the resulting image by a factor of 2), and `layers` to specify the number of quality layers to load.

The `save()` method supports the following options:

offset The image offset, as a tuple of integers, e.g. (16, 16)

tile_offset The tile offset, again as a 2-tuple of integers.

tile_size The tile size as a 2-tuple. If not specified, or if set to None, the image will be saved without tiling.

quality_mode Either *"rates"* or *"dB"* depending on the units you want to use to specify image quality.

quality_layers A sequence of numbers, each of which represents either an approximate size reduction (if quality mode is *"rates"*) or a signal to noise ratio value in decibels. If not specified, defaults to a single layer of full quality.

num_resolutions The number of different image resolutions to be stored (which corresponds to the number of Discrete Wavelet Transform decompositions plus one).

codeblock_size The code-block size as a 2-tuple. Minimum size is 4 x 4, maximum is 1024 x 1024, with the additional restriction that no code-block may have more than 4096 coefficients (i.e. the product of the two numbers must be no greater than 4096).

precinct_size The precinct size as a 2-tuple. Must be a power of two along both axes, and must be greater than the code-block size.

irreversible If `True`, use the lossy Irreversible Color Transformation followed by DWT 9-7. Defaults to `False`, which means to use the Reversible Color Transformation with DWT 5-3.

progression Controls the progression order; must be one of `"LRCP"`, `"RLCP"`, `"RPCL"`, `"PCRL"`, `"CPRL"`. The letters stand for Component, Position, Resolution and Layer respectively and control the order of encoding, the idea being that e.g. an image encoded using LRCP mode can have its quality layers decoded as they arrive at

the decoder, while one encoded using RLCP mode will have increasing resolutions decoded as they arrive, and so on.

cinema_mode Set the encoder to produce output compliant with the digital cinema specifications. The options here are `"no"` (the default), `"cinema2k-24"` for 24fps 2K, `"cinema2k-48"` for 48fps 2K, and `"cinema4k-24"` for 24fps 4K. Note that for compliant 2K files, *at least one* of your image dimensions must match 2048 x 1080, while for compliant 4K files, *at least one* of the dimensions must match 4096 x 2160.

Note: To enable JPEG 2000 support, you need to build and install the OpenJPEG library, version 2.0.0 or higher, before building the Python Imaging Library.

Windows users can install the OpenJPEG binaries available on the OpenJPEG website, but must add them to their PATH in order to use PIL (if you fail to do this, you will get errors about not being able to load the `_imaging` DLL).

MSP

PIL identifies and reads MSP files from Windows 1 and 2. The library writes uncompressed (Windows 1) versions of this format.

PCX

PIL reads and writes PCX files containing `1`, `L`, `P`, or `RGB` data.

PNG

PIL identifies, reads, and writes PNG files containing `1`, `L`, `P`, `RGB`, or `RGBA` data. Interlaced files are supported as of v1.1.7.

The `open()` method sets the following `info` properties, when appropriate:

chromaticity The chromaticity points, as an 8 tuple of floats. (`White Point X`, `White Point Y`, `Red X`, `Red Y`, `Green X`, `Green Y`, `Blue X`, `Blue Y`)

gamma Gamma, given as a floating point number.

srgb The sRGB rendering intent as an integer.

- 0 Perceptual
- 1 Relative Colorimetric
- 2 Saturation
- 3 Absolute Colorimetric

transparency For `P` images: Either the palette index for full transparent pixels, or a byte string with alpha values for each palette entry.

For `L` and `RGB` images, the color that represents full transparent pixels in this image.

This key is omitted if the image is not a transparent palette image.

`Open` also sets `Image.text` to a list of the values of the `tEXt`, `zTXt`, and `iTXt` chunks of the PNG image. Individual compressed chunks are limited to a decompressed size of `PngImagePlugin.MAX_TEXT_CHUNK`, by default 1MB, to prevent decompression bombs. Additionally, the total size of all of the text chunks is limited to `PngImagePlugin.MAX_TEXT_MEMORY`, defaulting to 64MB.

The `save()` method supports the following options:

optimize If present and true, instructs the PNG writer to make the output file as small as possible. This includes extra processing in order to find optimal encoder settings.

transparency For `P`, `L`, and `RGB` images, this option controls what color image to mark as transparent.

For `P` images, this can be a either the palette index, or a byte string with alpha values for each palette entry.

dpi A tuple of two numbers corresponding to the desired dpi in each direction.

pnginfo A `PIL.PngImagePlugin.PngInfo` instance containing text tags.

compress_level ZLIB compression level, a number between 0 and 9: 1 gives best speed, 9 gives best compression, 0 gives no compression at all. Default is 6. When `optimize` option is True `compress_level` has no effect (it is set to 9 regardless of a value passed).

icc_profile The ICC Profile to include in the saved file.

bits (experimental) For `P` images, this option controls how many bits to store. If omitted, the PNG writer uses 8 bits (256 colors).

dictionary (experimental) Set the ZLIB encoder dictionary.

Note: To enable PNG support, you need to build and install the ZLIB compression library before building the Python Imaging Library. See the installation documentation for details.

PPM

PIL reads and writes PBM, PGM and PPM files containing `1`, `L` or `RGB` data.

SGI

Pillow reads and writes uncompressed `L`, `RGB`, and `RGBA` files.

SPIDER

PIL reads and writes SPIDER image files of 32-bit floating point data ("F;32F").

PIL also reads SPIDER stack files containing sequences of SPIDER images. The `seek()` and `tell()` methods are supported, and random access is allowed.

The `open()` method sets the following attributes:

format Set to `SPIDER`

istack Set to 1 if the file is an image stack, else 0.

nimages Set to the number of images in the stack.

A convenience method, `convert2byte()`, is provided for converting floating point data to byte data (mode `L`):

```
im = Image.open('image001.spi').convert2byte()
```

Writing files in SPIDER format

The extension of SPIDER files may be any 3 alphanumeric characters. Therefore the output format must be specified explicitly:

```
im.save('newimage.spi', format='SPIDER')
```

For more information about the SPIDER image processing package, see the SPIDER homepage at Wadsworth Center.

TGA

PIL reads and writes TGA images containing `L`, `LA`, `P`, `RGB`, and `RGBA` data. PIL can read and write both uncompressed and run-length encoded TGAs.

TIFF

Pillow reads and writes TIFF files. It can read both striped and tiled images, pixel and plane interleaved multi-band images. If you have libtiff and its headers installed, PIL can read and write many kinds of compressed TIFF files. If not, PIL will only read and write uncompressed files.

Note: Beginning in version 5.0.0, Pillow requires libtiff to read or write compressed files. Prior to that release, Pillow had buggy support for reading Packbits, LZW and JPEG compressed TIFFs without using libtiff.

The `open()` method sets the following `info` properties:

compression Compression mode.

New in version 2.0.0.

dpi Image resolution as an `(xdpi, ydpi)` tuple, where applicable. You can use the `tag` attribute to get more detailed information about the image resolution.

New in version 1.1.5.

resolution Image resolution as an `(xres, yres)` tuple, where applicable. This is a measurement in whichever unit is specified by the file.

New in version 1.1.5.

The `tag_v2` attribute contains a dictionary of TIFF metadata. The keys are numerical indexes from `TAGS_V2`. Values are strings or numbers for single items, multiple values are returned in a tuple of values. Rational numbers are returned as a `IFDRational` object.

New in version 3.0.0.

For compatibility with legacy code, the `tag` attribute contains a dictionary of decoded TIFF fields as returned prior to version 3.0.0. Values are returned as either strings or tuples of numeric values. Rational numbers are returned as a tuple of `(numerator, denominator)`.

Deprecated since version 3.0.0.

Saving Tiff Images

The `save()` method can take the following keyword arguments:

save_all If true, Pillow will save all frames of the image to a multiframe tiff document.

New in version 3.4.0.

append_images A list of images to append as additional frames. Each of the images in the list can be single or multiframe images. Note however, that for correct results, all the appended images should have the same `encoderinfo` and `encoderconfig` properties.

New in version 4.2.0.

tiffinfo

A `ImageFileDirectory_v2` object or dict object containing tiff tags and values. The TIFF field type is autodetected for Numeric and string values, any other types require using an `ImageFileDirectory_v2` object and setting the type in `tagtype` with the appropriate numerical value from `TiffTags.TYPES`.

New in version 2.3.0.

Metadata values that are of the rational type should be passed in using a `IFDRational` object.

New in version 3.1.0.

For compatibility with legacy code, a `ImageFileDirectory_v1` object may be passed in this field. However, this is deprecated.

New in version 3.0.0.

Note: Only some tags are currently supported when writing using libtiff. The supported list is found in `LIBTIFF_CORE`.

---

compression A string containing the desired compression method for the file. (valid only with libtiff installed) Valid compression methods are: `None`, `"tiff_ccitt"`, `"group3"`, `"group4"`, `"tiff_jpeg"`, `"tiff_adobe_deflate"`, `"tiff_thunderscan"`, `"tiff_deflate"`, `"tiff_sgilog"`, `"tiff_sgilog24"`, `"tiff_raw_16"`

These arguments to set the tiff header fields are an alternative to using the general tags available through tiffinfo.

description

software

date_time

artist

copyright Strings

resolution_unit A string of "inch", "centimeter" or "cm"

resolution

x_resolution

y_resolution

dpi Either a Float, 2 tuple of (numerator, denominator) or a `IFDRational`. Resolution implies an equal x and y resolution, dpi also implies a unit of inches.

WebP

PIL reads and writes WebP files. The specifics of PIL's capabilities with this format are currently undocumented.

The `save()` method supports the following options:

lossless If present and true, instructs the WebP writer to use lossless compression.

quality Integer, 1-100, Defaults to 80. For lossy, 0 gives the smallest size and 100 the largest. For lossless, this parameter is the amount of effort put into the compression: 0 is the fastest, but gives larger files compared to the slowest, but best, 100.

method Quality/speed trade-off (0=fast, 6=slower-better). Defaults to 0.

icc_procfile The ICC Profile to include in the saved file. Only supported if the system WebP library was built with webpmux support.

exif The exif data to include in the saved file. Only supported if the system WebP library was built with webpmux support.

Saving sequences

Note: Support for animated WebP files will only be enabled if the system WebP library is v0.5.0 or later. You can check webp animation support at runtime by calling *features.check("webp_anim")*.

When calling `save()`, the following options are available when the *save_all* argument is present and true.

append_images A list of images to append as additional frames. Each of the images in the list can be single or multiframe images.

duration The display duration of each frame, in milliseconds. Pass a single integer for a constant duration, or a list or tuple to set the duration for each frame separately.

loop Number of times to repeat the animation. Defaults to [0 = infinite].

background Background color of the canvas, as an RGBA tuple with values in the range of (0-255).

minimize_size If true, minimize the output size (slow). Implicitly disables key-frame insertion.

kmin, kmax Minimum and maximum distance between consecutive key frames in the output. The library may insert some key frames as needed to satisfy this criteria. Note that these conditions should hold: kmax > kmin and kmin >= kmax / 2 + 1. Also, if kmax <= 0, then key-frame insertion is disabled; and if kmax == 1, then all frames will be key-frames (kmin value does not matter for these special cases).

allow_mixed If true, use mixed compression mode; the encoder heuristically chooses between lossy and lossless for each frame.

XBM

PIL reads and writes X bitmap files (mode `1`).

Read-only formats

BLP

BLP is the Blizzard Mipmap Format, a texture format used in World of Warcraft. Pillow supports reading `JPEG` Compressed or raw `BLP1` images, and all types of `BLP2` images.

CUR

CUR is used to store cursors on Windows. The CUR decoder reads the largest available cursor. Animated cursors are not supported.

DCX

DCX is a container file format for PCX files, defined by Intel. The DCX format is commonly used in fax applications. The DCX decoder can read files containing `1`, `L`, `P`, or `RGB` data.

When the file is opened, only the first image is read. You can use `seek()` or *ImageSequence* to read other images.

DDS

DDS is a popular container texture format used in video games and natively supported by DirectX. Currently, DXT1, DXT3, and DXT5 pixel formats are supported and only in `RGBA` mode.

New in version 3.4.0: DXT3

FLI, FLC

PIL reads Autodesk FLI and FLC animations.

The `open()` method sets the following `info` properties:

duration The delay (in milliseconds) between each frame.

FPX

PIL reads Kodak FlashPix files. In the current version, only the highest resolution image is read from the file, and the viewing transform is not taken into account.

Note: To enable full FlashPix support, you need to build and install the IJG JPEG library before building the Python Imaging Library. See the distribution README for details.

FTEX

New in version 3.2.0.

The FTEX decoder reads textures used for 3D objects in Independence War 2: Edge Of Chaos. The plugin reads a single texture per file, in the compressed and uncompressed formats.

GBR

The GBR decoder reads GIMP brush files, version 1 and 2.

The `open()` method sets the following `info` properties:

comment The brush name.

spacing The spacing between the brushes, in pixels. Version 2 only.

GD

PIL reads uncompressed GD2 files. Note that you must use `PIL.GdImageFile.open()` to read such a file.

The `open()` method sets the following `info` properties:

transparency Transparency color index. This key is omitted if the image is not transparent.

IMT

PIL reads Image Tools images containing `L` data.

IPTC/NAA

PIL provides limited read support for IPTC/NAA newsphoto files.

MCIDAS

PIL identifies and reads 8-bit McIdas area files.

MIC

PIL identifies and reads Microsoft Image Composer (MIC) files. When opened, the first sprite in the file is loaded. You can use `seek()` and `tell()` to read other sprites from the file.

Note that there may be an embedded gamma of 2.2 in MIC files.

MPO

Pillow identifies and reads Multi Picture Object (MPO) files, loading the primary image when first opened. The `seek()` and `tell()` methods may be used to read other pictures from the file. The pictures are zero-indexed and random access is supported.

PCD

PIL reads PhotoCD files containing `RGB` data. This only reads the 768x512 resolution image from the file. Higher resolutions are encoded in a proprietary encoding.

PIXAR

PIL provides limited support for PIXAR raster files. The library can identify and read "dumped" RGB files.

The format code is `PIXAR`.

PSD

PIL identifies and reads PSD files written by Adobe Photoshop 2.5 and 3.0.

WAL

New in version 1.1.4.

PIL reads Quake2 WAL texture files.

Note that this file format cannot be automatically identified, so you must use the open function in the `WalImageFile` module to read files in this format.

By default, a Quake2 standard palette is attached to the texture. To override the palette, use the putpalette method.

XPM

PIL reads X pixmap files (mode `P`) with 256 colors or less.

The `open()` method sets the following `info` properties:

transparency Transparency color index. This key is omitted if the image is not transparent.

Write-only formats

PALM

PIL provides write-only support for PALM pixmap files.

The format code is `Palm`, the extension is `.palm`.

PDF

PIL can write PDF (Acrobat) images. Such images are written as binary PDF 1.4 files, using either JPEG or HEX encoding depending on the image mode (and whether JPEG support is available or not).

The `save()` method can take the following keyword arguments:

save_all If a multiframe image is used, by default, only the first image will be saved. To save all frames, each frame to a separate page of the PDF, the `save_all` parameter must be present and set to `True`.

New in version 3.0.0.

append_images A list of images to append as additional pages. Each of the images in the list can be single or multiframe images.

New in version 4.2.0.

append Set to True to append pages to an existing PDF file. If the file doesn't exist, an `IOError` will be raised.

New in version 5.1.0.

resolution Image resolution in DPI. This, together with the number of pixels in the image, will determine the physical dimensions of the page that will be saved in the PDF.

title The document's title.

New in version 5.1.0.

author The name of the person who created the document.

New in version 5.1.0.

subject The subject of the document.

New in version 5.1.0.

keywords Keywords associated with the document.

New in version 5.1.0.

creator If the document was converted to PDF from another format, the name of the conforming product that created the original document from which it was converted.

New in version 5.1.0.

producer If the document was converted to PDF from another format, the name of the conforming product that converted it to PDF.

New in version 5.1.0.

XV Thumbnails

PIL can read XV thumbnail files.

Identify-only formats

BUFR

New in version 1.1.3.

PIL provides a stub driver for BUFR files.

To add read or write support to your application, use `PIL.BufrStubImagePlugin.register_handler()`.

FITS

New in version 1.1.5.

PIL provides a stub driver for FITS files.

To add read or write support to your application, use `PIL.FitsStubImagePlugin.register_handler()`.

GRIB

New in version 1.1.5.

PIL provides a stub driver for GRIB files.

The driver requires the file to start with a GRIB header. If you have files with embedded GRIB data, or files with multiple GRIB fields, your application has to seek to the header before passing the file handle to PIL.

To add read or write support to your application, use `PIL.GribStubImagePlugin.register_handler()`.

HDF5

New in version 1.1.5.

PIL provides a stub driver for HDF5 files.

To add read or write support to your application, use `PIL.Hdf5StubImagePlugin.register_handler()`.

MPEG

PIL identifies MPEG files.

WMF

PIL can identify playable WMF files.

In PIL 1.1.4 and earlier, the WMF driver provides some limited rendering support, but not enough to be useful for any real application.

In PIL 1.1.5 and later, the WMF driver is a stub driver. To add WMF read or write support to your application, use `PIL.WmfImagePlugin.register_handler()` to register a WMF handler.

```
from PIL import Image
from PIL import WmfImagePlugin

class WmfHandler:
    def open(self, im):
        ...
    def load(self, im):
        ...
        return image
    def save(self, im, fp, filename):
        ...

wmf_handler = WmfHandler()

WmfImagePlugin.register_handler(wmf_handler)

im = Image.open("sample.wmf")
```

2.4.2 Writing Your Own Image Plugin

The Pillow uses a plug-in model which allows you to add your own decoders to the library, without any changes to the library itself. Such plug-ins usually have names like `XxxImagePlugin.py`, where `Xxx` is a unique format name (usually an abbreviation).

> **Warning:** Pillow >= 2.1.0 no longer automatically imports any file in the Python path with a name ending in `ImagePlugin.py`. You will need to import your image plugin manually.

Pillow decodes files in 2 stages:

1. It loops over the available image plugins in the loaded order, and calls the plugin's `accept` function with the first 16 bytes of the file. If the `accept` function returns true, the plugin's `_open` method is called to set up the image metadata and image tiles. The `_open` method is not for decoding the actual image data.
2. When the image data is requested, the `ImageFile.load` method is called, which sets up a decoder for each tile and feeds the data to it.

An image plug-in should contain a format handler derived from the `PIL.ImageFile.ImageFile` base class. This class should provide an `_open()` method, which reads the file header and sets up at least the `mode` and `size` attributes. To be able to load the file, the method must also create a list of `tile` descriptors, which contain a decoder name, extents of the tile, and any decoder-specific data. The format handler class must be explicitly registered, via a call to the *Image* module.

Note: For performance reasons, it is important that the `_open()` method quickly rejects files that do not have the appropriate contents.

Example

The following plug-in supports a simple format, which has a 128-byte header consisting of the words "SPAM" followed by the width, height, and pixel size in bits. The header fields are separated by spaces. The image data follows directly after the header, and can be either bi-level, greyscale, or 24-bit true color.

SpamImagePlugin.py:

```
from PIL import Image, ImageFile
import string

class SpamImageFile(ImageFile.ImageFile):

    format = "SPAM"
    format_description = "Spam raster image"

    def _open(self):

        # check header
        header = self.fp.read(128)
        if header[:4] != "SPAM":
            raise SyntaxError, "not a SPAM file"

        header = string.split(header)

        # size in pixels (width, height)
        self.size = int(header[1]), int(header[2])

        # mode setting
        bits = int(header[3])
        if bits == 1:
            self.mode = "1"
        elif bits == 8:
            self.mode = "L"
        elif bits == 24:
            self.mode = "RGB"
        else:
            raise SyntaxError, "unknown number of bits"
```

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```
        # data descriptor
        self.tile = [
            ("raw", (0, 0) + self.size, 128, (self.mode, 0, 1))
        ]

Image.register_open(SpamImageFile.format, SpamImageFile)

Image.register_extension(SpamImageFile.format, ".spam")
Image.register_extension(SpamImageFile.format, ".spa") # dos version
```

The format handler must always set the `size` and `mode` attributes. If these are not set, the file cannot be opened. To simplify the plugin, the calling code considers exceptions like `SyntaxError`, `KeyError`, `IndexError`, `EOFError` and `struct.error` as a failure to identify the file.

Note that the image plugin must be explicitly registered using `PIL.Image.register_open()`. Although not required, it is also a good idea to register any extensions used by this format.

The `tile` attribute

To be able to read the file as well as just identifying it, the `tile` attribute must also be set. This attribute consists of a list of tile descriptors, where each descriptor specifies how data should be loaded to a given region in the image. In most cases, only a single descriptor is used, covering the full image.

The tile descriptor is a 4-tuple with the following contents:

```
(decoder, region, offset, parameters)
```

The fields are used as follows:

decoder Specifies which decoder to use. The `raw` decoder used here supports uncompressed data, in a variety of pixel formats. For more information on this decoder, see the description below.

region A 4-tuple specifying where to store data in the image.

offset Byte offset from the beginning of the file to image data.

parameters Parameters to the decoder. The contents of this field depends on the decoder specified by the first field in the tile descriptor tuple. If the decoder doesn't need any parameters, use None for this field.

Note that the `tile` attribute contains a list of tile descriptors, not just a single descriptor.

2.4.3 Decoders

The raw decoder

The `raw` decoder is used to read uncompressed data from an image file. It can be used with most uncompressed file formats, such as PPM, BMP, uncompressed TIFF, and many others. To use the raw decoder with the `PIL.Image.frombytes()` function, use the following syntax:

```
image = Image.frombytes(
    mode, size, data, "raw",
    raw mode, stride, orientation
    )
```

When used in a tile descriptor, the parameter field should look like:

```
(raw mode, stride, orientation)
```

The fields are used as follows:

raw mode The pixel layout used in the file, and is used to properly convert data to PIL's internal layout. For a summary of the available formats, see the table below.

stride The distance in bytes between two consecutive lines in the image. If 0, the image is assumed to be packed (no padding between lines). If omitted, the stride defaults to 0.

orientation

Whether the first line in the image is the top line on the screen (1), or the bottom line (-1). If omitted, the orientation defaults to 1.

The **raw mode** field is used to determine how the data should be unpacked to match PIL's internal pixel layout. PIL supports a large set of raw modes; for a complete list, see the table in the `Unpack.c` module. The following table describes some commonly used **raw modes**:

mode	description
`1`	1-bit bilevel, stored with the leftmost pixel in the most significant bit. 0 means black, 1 means white.
`1;I`	1-bit inverted bilevel, stored with the leftmost pixel in the most significant bit. 0 means white, 1 means black.
`1;R`	1-bit reversed bilevel, stored with the leftmost pixel in the least significant bit. 0 means black, 1 means white.
`L`	8-bit greyscale. 0 means black, 255 means white.
`L;I`	8-bit inverted greyscale. 0 means white, 255 means black.
`P`	8-bit palette-mapped image.
`RGB`	24-bit true colour, stored as (red, green, blue).
`BGR`	24-bit true colour, stored as (blue, green, red).
`RGBX`	24-bit true colour, stored as (red, green, blue, pad).
`RGB;L`	24-bit true colour, line interleaved (first all red pixels, the all green pixels, finally all blue pixels).

Note that for the most common cases, the raw mode is simply the same as the mode.

The Python Imaging Library supports many other decoders, including JPEG, PNG, and PackBits. For details, see the `decode.c` source file, and the standard plug-in implementations provided with the library.

Decoding floating point data

PIL provides some special mechanisms to allow you to load a wide variety of formats into a mode `F` (floating point) image memory.

You can use the `raw` decoder to read images where data is packed in any standard machine data type, using one of the following raw modes:

mode	description
F	32-bit native floating point.
F;8	8-bit unsigned integer.
F;8S	8-bit signed integer.
F;16	16-bit little endian unsigned integer.
F;16S	16-bit little endian signed integer.
F;16B	16-bit big endian unsigned integer.
F;16BS	16-bit big endian signed integer.
F;16N	16-bit native unsigned integer.
F;16NS	16-bit native signed integer.
F;32	32-bit little endian unsigned integer.
F;32S	32-bit little endian signed integer.
F;32B	32-bit big endian unsigned integer.
F;32BS	32-bit big endian signed integer.
F;32N	32-bit native unsigned integer.
F;32NS	32-bit native signed integer.
F;32F	32-bit little endian floating point.
F;32BF	32-bit big endian floating point.
F;32NF	32-bit native floating point.
F;64F	64-bit little endian floating point.
F;64BF	64-bit big endian floating point.
F;64NF	64-bit native floating point.

The bit decoder

If the raw decoder cannot handle your format, PIL also provides a special "bit" decoder that can be used to read various packed formats into a floating point image memory.

To use the bit decoder with the frombytes function, use the following syntax:

```
image = frombytes(
    mode, size, data, "bit",
    bits, pad, fill, sign, orientation
    )
```

When used in a tile descriptor, the parameter field should look like:

```
(bits, pad, fill, sign, orientation)
```

The fields are used as follows:

bits Number of bits per pixel (2-32). No default.

pad Padding between lines, in bits. This is either 0 if there is no padding, or 8 if lines are padded to full bytes. If omitted, the pad value defaults to 8.

fill Controls how data are added to, and stored from, the decoder bit buffer.

fill=0 Add bytes to the LSB end of the decoder buffer; store pixels from the MSB end.

fill=1 Add bytes to the MSB end of the decoder buffer; store pixels from the MSB end.

fill=2 Add bytes to the LSB end of the decoder buffer; store pixels from the LSB end.

fill=3 Add bytes to the MSB end of the decoder buffer; store pixels from the LSB end.

If omitted, the fill order defaults to 0.

sign If non-zero, bit fields are sign extended. If zero or omitted, bit fields are unsigned.

orientation Whether the first line in the image is the top line on the screen (1), or the bottom line (-1). If omitted, the orientation defaults to 1.

2.4.4 Writing Your Own File Decoder in C

There are 3 stages in a file decoder's lifetime:

1. Setup: Pillow looks for a function in the decoder registry, falling back to a function named `[decodername]_decoder` on the internal core image object. That function is called with the `args` tuple from the `tile` setup in the `_open` method.
2. Decoding: The decoder's decode function is repeatedly called with chunks of image data.
3. Cleanup: If the decoder has registered a cleanup function, it will be called at the end of the decoding process, even if there was an exception raised.

Setup

The current conventions are that the decoder setup function is named `PyImaging_[Decodername]DecoderNew` and defined in `decode.c`. The python binding for it is named `[decodername]_decoder` and is setup from within the `_imaging.c` file in the codecs section of the function array.

The setup function needs to call `PyImaging_DecoderNew` and at the very least, set the `decode` function pointer. The fields of interest in this object are:

decode Function pointer to the decode function, which has access to `im`, `state`, and the buffer of data to be added to the image.

cleanup Function pointer to the cleanup function, has access to `state`.

im The target image, will be set by Pillow.

state An ImagingCodecStateInstance, will be set by Pillow. The **context** member is an opaque struct that can be used by the decoder to store any format specific state or options.

pulls_fd **EXPERIMENTAL** – **WARNING**, interface may change. If set to 1, `state->fd` will be a pointer to the Python file like object. The decoder may use the functions in `codec_fd.c` to read directly from the file like object rather than have the data pushed through a buffer. Note that this implementation may be refactored until this warning is removed.

New in version 3.3.0.

Decoding

The decode function is called with the target (core) image, the decoder state structure, and a buffer of data to be decoded.

Experimental – If `pulls_fd` is set, then the decode function is called once, with an empty buffer. It is the decoder's responsibility to decode the entire tile in that one call. The rest of this section only applies if `pulls_fd` is not set.

It is the decoder's responsibility to pull as much data as possible out of the buffer and return the number of bytes consumed. The next call to the decoder will include the previous unconsumed tail. The decoder function will be called multiple times as the data is read from the file like object.

If an error occurs, set `state->errcode` and return -1.

Return -1 on success, without setting the errcode.

Cleanup

The cleanup function is called after the decoder returns a negative value, or if there is a read error from the file. This function should free any allocated memory and release any resources from external libraries.

2.4.5 Writing Your Own File Decoder in Python

Python file decoders should derive from `PIL.ImageFile.PyDecoder` and should at least override the decode method. File decoders should be registered using `PIL.Image.register_decoder()`. As in the C implementation of the file decoders, there are three stages in the lifetime of a Python-based file decoder:

1. Setup: Pillow looks for the decoder in the registry, then instantiates the class.
2. Decoding: The decoder instance's `decode` method is repeatedly called with a buffer of data to be interpreted.
3. Cleanup: The decoder instance's `cleanup` method is called.

CHAPTER 3

Reference

3.1 `Image` Module

The *`Image`* module provides a class with the same name which is used to represent a PIL image. The module also provides a number of factory functions, including functions to load images from files, and to create new images.

3.1.1 Examples

Open, rotate, and display an image (using the default viewer)

The following script loads an image, rotates it 45 degrees, and displays it using an external viewer (usually xv on Unix, and the paint program on Windows).

```
from PIL import Image
im = Image.open("bride.jpg")
im.rotate(45).show()
```

Create thumbnails

The following script creates nice thumbnails of all JPEG images in the current directory preserving aspect ratios with 128x128 max resolution.

```
from PIL import Image
import glob, os

size = 128, 128

for infile in glob.glob("*.jpg"):
    file, ext = os.path.splitext(infile)
    im = Image.open(infile)
```

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```
    im.thumbnail(size)
    im.save(file + ".thumbnail", "JPEG")
```

3.1.2 Functions

Image processing

Constructing images

Registering plugins

Note: These functions are for use by plugin authors. Application authors can ignore them.

3.1.3 The Image Class

An instance of the `Image` class has the following methods. Unless otherwise stated, all methods return a new instance of the `Image` class, holding the resulting image.

The following example converts an RGB image (linearly calibrated according to ITU-R 709, using the D65 luminant) to the CIE XYZ color space:

```
rgb2xyz = (
    0.412453, 0.357580, 0.180423, 0,
    0.212671, 0.715160, 0.072169, 0,
    0.019334, 0.119193, 0.950227, 0 )
out = im.convert("RGB", rgb2xyz)
```

3.1.4 Attributes

Instances of the `Image` class have the following attributes:

`PIL.Image.`**`filename`**
: The filename or path of the source file. Only images created with the factory function *open* have a filename attribute. If the input is a file like object, the filename attribute is set to an empty string.

  Type :py:class: *string*

`PIL.Image.`**`format`**
: The file format of the source file. For images created by the library itself (via a factory function, or by running a method on an existing image), this attribute is set to `None`.

  Type `string` or `None`

`PIL.Image.`**`mode`**
: Image mode. This is a string specifying the pixel format used by the image. Typical values are “1”, “L”, “RGB”, or “CMYK.” See *Modes* for a full list.

  Type `string`

`PIL.Image.`**`size`**
: Image size, in pixels. The size is given as a 2-tuple (width, height).

Type (width, height)

PIL.Image.**width**
Image width, in pixels.

Type *int*

PIL.Image.**height**
Image height, in pixels.

Type *int*

PIL.Image.**palette**
Colour palette table, if any. If mode is "P", this should be an instance of the ImagePalette class. Otherwise, it should be set to None.

Type ImagePalette or None

PIL.Image.**info**
A dictionary holding data associated with the image. This dictionary is used by file handlers to pass on various non-image information read from the file. See documentation for the various file handlers for details.

Most methods ignore the dictionary when returning new images; since the keys are not standardized, it's not possible for a method to know if the operation affects the dictionary. If you need the information later on, keep a reference to the info dictionary returned from the open method.

Unless noted elsewhere, this dictionary does not affect saving files.

Type dict

3.2 ImageChops ("Channel Operations") Module

The ImageChops module contains a number of arithmetical image operations, called channel operations ("chops"). These can be used for various purposes, including special effects, image compositions, algorithmic painting, and more.

For more pre-made operations, see ImageOps.

At this time, most channel operations are only implemented for 8-bit images (e.g. "L" and "RGB").

3.2.1 Functions

Most channel operations take one or two image arguments and returns a new image. Unless otherwise noted, the result of a channel operation is always clipped to the range 0 to MAX (which is 255 for all modes supported by the operations in this module).

PIL.ImageChops.**offset**(*image*, *xoffset*, *yoffset=None*)
Returns a copy of the image where data has been offset by the given distances. Data wraps around the edges. If **yoffset** is omitted, it is assumed to be equal to **xoffset**.

3.3 ImageColor Module

The ImageColor module contains color tables and converters from CSS3-style color specifiers to RGB tuples. This module is used by PIL.Image.new() and the *ImageDraw* module, among others.

3.3.1 Color Names

The ImageColor module supports the following string formats:

- Hexadecimal color specifiers, given as `#rgb` or `#rrggbb`. For example, `#ff0000` specifies pure red.
- RGB functions, given as `rgb(red, green, blue)` where the color values are integers in the range 0 to 255. Alternatively, the color values can be given as three percentages (0% to 100%). For example, `rgb(255, 0,0)` and `rgb(100%,0%,0%)` both specify pure red.
- Hue-Saturation-Lightness (HSL) functions, given as `hsl(hue, saturation%, lightness%)` where hue is the color given as an angle between 0 and 360 (red=0, green=120, blue=240), saturation is a value between 0% and 100% (gray=0%, full color=100%), and lightness is a value between 0% and 100% (black=0%, normal=50%, white=100%). For example, `hsl(0,100%,50%)` is pure red.
- Hue-Saturation-Value (HSV) functions, given as `hsv(hue, saturation%, value%)` where hue and saturation are the same as HSL, and value is between 0% and 100% (black=0%, normal=100%). For example, `hsv(0,100%,100%)` is pure red. This format is also known as Hue-Saturation-Brightness (HSB), and can be given as `hsb(hue, saturation%, brightness%)`, where each of the values are used as they are in HSV.
- Common HTML color names. The *ImageColor* module provides some 140 standard color names, based on the colors supported by the X Window system and most web browsers. color names are case insensitive. For example, `red` and `Red` both specify pure red.

3.3.2 Functions

`PIL.ImageColor.`**`getrgb`**(*color*)
Convert a color string to an RGB tuple. If the string cannot be parsed, this function raises a `ValueError` exception.

New in version 1.1.4.

`PIL.ImageColor.`**`getcolor`**(*color*, *mode*)
Same as *getrgb()*, but converts the RGB value to a greyscale value if the mode is not color or a palette image. If the string cannot be parsed, this function raises a `ValueError` exception.

New in version 1.1.4.

3.4 `ImageCms` Module

The `ImageCms` module provides color profile management support using the LittleCMS2 color management engine, based on Kevin Cazabon's PyCMS library.

3.4.1 CmsProfile

The ICC color profiles are wrapped in an instance of the class *CmsProfile*. The specification ICC.1:2010 contains more information about the meaning of the values in ICC profiles.

For convenience, all XYZ-values are also given as xyY-values (so they can be easily displayed in a chromaticity diagram, for example).

`class` `PIL.ImageCms.`**`CmsProfile`**

creation_date
Date and time this profile was first created (see 7.2.1 of ICC.1:2010).

Type `datetime.datetime` or `None`

version
The version number of the ICC standard that this profile follows (e.g. *2.0*).

Type *float*

icc_version
Same as *version*, but in encoded format (see 7.2.4 of ICC.1:2010).

device_class
4-character string identifying the profile class. One of `scnr`, `mntr`, `prtr`, `link`, `spac`, `abst`, `nmcl` (see 7.2.5 of ICC.1:2010 for details).

Type `string`

xcolor_space
4-character string (padded with whitespace) identifying the color space, e.g. `XYZ␣`, `RGB␣` or `CMYK` (see 7.2.6 of ICC.1:2010 for details).

Note that the deprecated attribute `color_space` contains an interpreted (non-padded) variant of this (but can be empty on unknown input).

Type `string`

connection_space
4-character string (padded with whitespace) identifying the color space on the B-side of the transform (see 7.2.7 of ICC.1:2010 for details).

Note that the deprecated attribute `pcs` contains an interpreted (non-padded) variant of this (but can be empty on unknown input).

Type `string`

header_flags
The encoded header flags of the profile (see 7.2.11 of ICC.1:2010 for details).

Type *int*

header_manufacturer
4-character string (padded with whitespace) identifying the device manufacturer, which shall match the signature contained in the appropriate section of the ICC signature registry found at www.color.org (see 7.2.12 of ICC.1:2010).

Type `string`

header_model
4-character string (padded with whitespace) identifying the device model, which shall match the signature contained in the appropriate section of the ICC signature registry found at www.color.org (see 7.2.13 of ICC.1:2010).

Type `string`

attributes
Flags used to identify attributes unique to the particular device setup for which the profile is applicable (see 7.2.14 of ICC.1:2010 for details).

Type *int*

rendering_intent
The rendering intent to use when combining this profile with another profile (usually overridden at runtime, but provided here for DeviceLink and embedded source profiles, see 7.2.15 of ICC.1:2010).

One of `ImageCms.INTENT_ABSOLUTE_COLORIMETRIC`, `ImageCms.INTENT_PERCEPTUAL`, `ImageCms.INTENT_RELATIVE_COLORIMETRIC` and `ImageCms.INTENT_SATURATION`.

Type *int*

profile_id
A sequence of 16 bytes identifying the profile (via a specially constructed MD5 sum), or 16 binary zeroes if the profile ID has not been calculated (see 7.2.18 of ICC.1:2010).

Type `bytes`

copyright
The text copyright information for the profile (see 9.2.21 of ICC.1:2010).

Type `unicode` or `None`

manufacturer
The (english) display string for the device manufacturer (see 9.2.22 of ICC.1:2010).

Type `unicode` or `None`

model
The (english) display string for the device model of the device for which this profile is created (see 9.2.23 of ICC.1:2010).

Type `unicode` or `None`

profile_description
The (english) display string for the profile description (see 9.2.41 of ICC.1:2010).

Type `unicode` or `None`

target
The name of the registered characterization data set, or the measurement data for a characterization target (see 9.2.14 of ICC.1:2010).

Type `unicode` or `None`

red_colorant
The first column in the matrix used in matrix/TRC transforms (see 9.2.44 of ICC.1:2010).

Type `((X, Y, Z), (x, y, Y))` or `None`

green_colorant
The second column in the matrix used in matrix/TRC transforms (see 9.2.30 of ICC.1:2010).

Type `((X, Y, Z), (x, y, Y))` or `None`

blue_colorant
The third column in the matrix used in matrix/TRC transforms (see 9.2.4 of ICC.1:2010).

Type `((X, Y, Z), (x, y, Y))` or `None`

luminance
The absolute luminance of emissive devices in candelas per square metre as described by the Y channel (see 9.2.32 of ICC.1:2010).

Type `((X, Y, Z), (x, y, Y))` or `None`

chromaticity
The data of the phosphor/colorant chromaticity set used (red, green and blue channels, see 9.2.16 of ICC.1:2010).

Type `((x, y, Y), (x, y, Y), (x, y, Y))` or `None`

chromatic_adaption
The chromatic adaption matrix converts a color measured using the actual illumination conditions and relative to the actual adopted white, to an color relative to the PCS adopted white, with complete adaptation from the actual adopted white chromaticity to the PCS adopted white chromaticity (see 9.2.15 of ICC.1:2010).

Two matrices are returned, one in (X, Y, Z) space and one in (x, y, Y) space.

Type 2-tuple of 3-tuple, the first with (X, Y, Z) and the second with (x, y, Y) values

colorant_table
This tag identifies the colorants used in the profile by a unique name and set of PCSXYZ or PCSLAB values (see 9.2.19 of ICC.1:2010).

Type list of strings

colorant_table_out
This tag identifies the colorants used in the profile by a unique name and set of PCSLAB values (for DeviceLink profiles only, see 9.2.19 of ICC.1:2010).

Type list of strings

colorimetric_intent
4-character string (padded with whitespace) identifying the image state of PCS colorimetry produced using the colorimetric intent transforms (see 9.2.20 of ICC.1:2010 for details).

Type `string` or `None`

perceptual_rendering_intent_gamut
4-character string (padded with whitespace) identifying the (one) standard reference medium gamut (see 9.2.37 of ICC.1:2010 for details).

Type `string` or `None`

saturation_rendering_intent_gamut
4-character string (padded with whitespace) identifying the (one) standard reference medium gamut (see 9.2.37 of ICC.1:2010 for details).

Type `string` or `None`

technology
4-character string (padded with whitespace) identifying the device technology (see 9.2.47 of ICC.1:2010 for details).

Type `string` or `None`

media_black_point
This tag specifies the media black point and is used for generating absolute colorimetry.

This tag was available in ICC 3.2, but it is removed from version 4.

Type `((X, Y, Z), (x, y, Y))` or `None`

media_white_point_temperature
Calculates the white point temperature (see the LCMS documentation for more information).

Type *float* or `None`

viewing_condition
The (english) display string for the viewing conditions (see 9.2.48 of ICC.1:2010).

Type unicode or None

screening_description
The (english) display string for the screening conditions.

This tag was available in ICC 3.2, but it is removed from version 4.

Type unicode or None

red_primary
The XYZ-transformed of the RGB primary color red (1, 0, 0).

Type ((X, Y, Z), (x, y, Y)) or None

green_primary
The XYZ-transformed of the RGB primary color green (0, 1, 0).

Type ((X, Y, Z), (x, y, Y)) or None

blue_primary
The XYZ-transformed of the RGB primary color blue (0, 0, 1).

Type ((X, Y, Z), (x, y, Y)) or None

is_matrix_shaper
True if this profile is implemented as a matrix shaper (see documentation on LCMS).

Type bool

clut
Returns a dictionary of all supported intents and directions for the CLUT model.

The dictionary is indexed by intents (ImageCms.INTENT_ABSOLUTE_COLORIMETRIC, ImageCms.INTENT_PERCEPTUAL, ImageCms.INTENT_RELATIVE_COLORIMETRIC and ImageCms.INTENT_SATURATION).

The values are 3-tuples indexed by directions (ImageCms.DIRECTION_INPUT, ImageCms.DIRECTION_OUTPUT, ImageCms.DIRECTION_PROOF).

The elements of the tuple are booleans. If the value is True, that intent is supported for that direction.

Type dict of boolean 3-tuples

intent_supported
Returns a dictionary of all supported intents and directions.

The dictionary is indexed by intents (ImageCms.INTENT_ABSOLUTE_COLORIMETRIC, ImageCms.INTENT_PERCEPTUAL, ImageCms.INTENT_RELATIVE_COLORIMETRIC and ImageCms.INTENT_SATURATION).

The values are 3-tuples indexed by directions (ImageCms.DIRECTION_INPUT, ImageCms.DIRECTION_OUTPUT, ImageCms.DIRECTION_PROOF).

The elements of the tuple are booleans. If the value is True, that intent is supported for that direction.

Type dict of boolean 3-tuples

color_space
Deprecated but retained for backwards compatibility. Interpreted value of *xcolor_space*. May be the empty string if value could not be decoded.

Type string

pcs
Deprecated but retained for backwards compatibility. Interpreted value of *connection_space*. May be the empty string if value could not be decoded.

Type string

product_model
Deprecated but retained for backwards compatibility. ASCII-encoded value of *model*.

Type string

product_manufacturer
Deprecated but retained for backwards compatibility. ASCII-encoded value of *manufacturer*.

Type string

product_copyright
Deprecated but retained for backwards compatibility. ASCII-encoded value of *copyright*.

Type string

product_description
Deprecated but retained for backwards compatibility. ASCII-encoded value of *profile_description*.

Type string

product_desc
Deprecated but retained for backwards compatibility. ASCII-encoded value of *profile_description*.

This alias of *product_description* used to contain a derived informative string about the profile, depending on the value of the description, copyright, manufacturer and model fields).

Type string

There is one function defined on the class:

is_intent_supported(*intent*, *direction*)
Returns if the intent is supported for the given direction.

Note that you can also get this information for all intents and directions with *intent_supported*.

Parameters

- **intent** – One of ImageCms.INTENT_ABSOLUTE_COLORIMETRIC, ImageCms.INTENT_PERCEPTUAL, ImageCms.INTENT_RELATIVE_COLORIMETRIC and ImageCms.INTENT_SATURATION.
- **direction** – One of ImageCms.DIRECTION_INPUT, ImageCms.DIRECTION_OUTPUT and ImageCms.DIRECTION_PROOF

Returns Boolean if the intent and direction is supported.

3.5 ImageDraw Module

The ImageDraw module provides simple 2D graphics for Image objects. You can use this module to create new images, annotate or retouch existing images, and to generate graphics on the fly for web use.

For a more advanced drawing library for PIL, see the aggdraw module.

3.5.1 Example: Draw a gray cross over an image

```
from PIL import Image, ImageDraw

im = Image.open("hopper.jpg")

draw = ImageDraw.Draw(im)
draw.line((0, 0) + im.size, fill=128)
draw.line((0, im.size[1], im.size[0], 0), fill=128)

# write to stdout
im.save(sys.stdout, "PNG")
```

3.5.2 Concepts

Coordinates

The graphics interface uses the same coordinate system as PIL itself, with (0, 0) in the upper left corner.

Colors

To specify colors, you can use numbers or tuples just as you would use with `PIL.Image.new()` or `PIL.Image.Image.putpixel()`. For "1", "L", and "I" images, use integers. For "RGB" images, use a 3-tuple containing integer values. For "F" images, use integer or floating point values.

For palette images (mode "P"), use integers as color indexes. In 1.1.4 and later, you can also use RGB 3-tuples or color names (see below). The drawing layer will automatically assign color indexes, as long as you don't draw with more than 256 colors.

Color Names

See *Color Names* for the color names supported by Pillow.

Fonts

PIL can use bitmap fonts or OpenType/TrueType fonts.

Bitmap fonts are stored in PIL's own format, where each font typically consists of two files, one named .pil and the other usually named .pbm. The former contains font metrics, the latter raster data.

To load a bitmap font, use the load functions in the *ImageFont* module.

To load a OpenType/TrueType font, use the truetype function in the *ImageFont* module. Note that this function depends on third-party libraries, and may not available in all PIL builds.

3.5.3 Example: Draw Partial Opacity Text

```
from PIL import Image, ImageDraw, ImageFont
# get an image
base = Image.open('Pillow/Tests/images/hopper.png').convert('RGBA')
```

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```
# make a blank image for the text, initialized to transparent text color
txt = Image.new('RGBA', base.size, (255,255,255,0))

# get a font
fnt = ImageFont.truetype('Pillow/Tests/fonts/FreeMono.ttf', 40)
# get a drawing context
d = ImageDraw.Draw(txt)

# draw text, half opacity
d.text((10,10), "Hello", font=fnt, fill=(255,255,255,128))
# draw text, full opacity
d.text((10,60), "World", font=fnt, fill=(255,255,255,255))

out = Image.alpha_composite(base, txt)

out.show()
```

3.5.4 Functions

class PIL.ImageDraw.**Draw**(*im*, *mode=None*)

Creates an object that can be used to draw in the given image.

Note that the image will be modified in place.

Parameters

- **im** – The image to draw in.
- **mode** – Optional mode to use for color values. For RGB images, this argument can be RGB or RGBA (to blend the drawing into the image). For all other modes, this argument must be the same as the image mode. If omitted, the mode defaults to the mode of the image.

3.5.5 Methods

PIL.ImageDraw.ImageDraw.**getfont**()

Get the current default font.

Returns An image font.

PIL.ImageDraw.ImageDraw.**arc**(*xy*, *start*, *end*, *fill=None*)

Draws an arc (a portion of a circle outline) between the start and end angles, inside the given bounding box.

Parameters

- **xy** – Two points to define the bounding box. Sequence of `[(x0, y0), (x1, y1)]` or `[x0, y0, x1, y1]`,

  where `x1 >= x0` and `y1 >= y0`.
- **start** – Starting angle, in degrees. Angles are measured from 3 o'clock, increasing clockwise.
- **end** – Ending angle, in degrees.
- **fill** – Color to use for the arc.

PIL.ImageDraw.ImageDraw.**bitmap**(*xy*, *bitmap*, *fill=None*)
Draws a bitmap (mask) at the given position, using the current fill color for the non-zero portions. The bitmap should be a valid transparency mask (mode "1") or matte (mode "L" or "RGBA").

This is equivalent to doing `image.paste(xy, color, bitmap)`.

To paste pixel data into an image, use the `paste()` method on the image itself.

PIL.ImageDraw.ImageDraw.**chord**(*xy*, *start*, *end*, *fill=None*, *outline=None*)
Same as *arc()*, but connects the end points with a straight line.

Parameters

- **xy** – Two points to define the bounding box. Sequence of `[(x0, y0), (x1, y1)]` or `[x0, y0, x1, y1]`,

  where `x1 >= x0` and `y1 >= y0`.
- **outline** – Color to use for the outline.
- **fill** – Color to use for the fill.

PIL.ImageDraw.ImageDraw.**ellipse**(*xy*, *fill=None*, *outline=None*)
Draws an ellipse inside the given bounding box.

Parameters

- **xy** – Two points to define the bounding box. Sequence of either `[(x0, y0), (x1, y1)]` or `[x0, y0, x1, y1]`,

  where `x1 >= x0` and `y1 >= y0`.
- **outline** – Color to use for the outline.
- **fill** – Color to use for the fill.

PIL.ImageDraw.ImageDraw.**line**(*xy*, *fill=None*, *width=0*)
Draws a line between the coordinates in the **xy** list.

Parameters

- **xy** – Sequence of either 2-tuples like `[(x, y), (x, y), ...]` or numeric values like `[x, y, x, y, ...]`.
- **fill** – Color to use for the line.
- **width** – The line width, in pixels. Note that line joins are not handled well, so wide polylines will not look good.

  New in version 1.1.5.

  Note: This option was broken until version 1.1.6.

PIL.ImageDraw.ImageDraw.**pieslice**(*xy*, *start*, *end*, *fill=None*, *outline=None*)
Same as arc, but also draws straight lines between the end points and the center of the bounding box.

Parameters

- **xy** – Two points to define the bounding box. Sequence of `[(x0, y0), (x1, y1)]` or `[x0, y0, x1, y1]`,

  where `x1 >= x0` and `y1 >= y0`.
- **start** – Starting angle, in degrees. Angles are measured from 3 o'clock, increasing clockwise.

- **end** – Ending angle, in degrees.
- **fill** – Color to use for the fill.
- **outline** – Color to use for the outline.

PIL.ImageDraw.ImageDraw.**point**(*xy*, *fill=None*)
Draws points (individual pixels) at the given coordinates.

Parameters

- **xy** – Sequence of either 2-tuples like `[(x, y), (x, y), ...]` or numeric values like `[x, y, x, y, ...]`.
- **fill** – Color to use for the point.

PIL.ImageDraw.ImageDraw.**polygon**(*xy*, *fill=None*, *outline=None*)
Draws a polygon.

The polygon outline consists of straight lines between the given coordinates, plus a straight line between the last and the first coordinate.

Parameters

- **xy** – Sequence of either 2-tuples like `[(x, y), (x, y), ...]` or numeric values like `[x, y, x, y, ...]`.
- **outline** – Color to use for the outline.
- **fill** – Color to use for the fill.

PIL.ImageDraw.ImageDraw.**rectangle**(*xy*, *fill=None*, *outline=None*)
Draws a rectangle.

Parameters

- **xy** – Two points to define the bounding box. Sequence of either `[(x0, y0), (x1, y1)]` or `[x0, y0, x1, y1]`. The second point is just outside the drawn rectangle.
- **outline** – Color to use for the outline.
- **fill** – Color to use for the fill.

PIL.ImageDraw.ImageDraw.**shape**(*shape*, *fill=None*, *outline=None*)

> **Warning:** This method is experimental.

Draw a shape.

PIL.ImageDraw.ImageDraw.**text**(*xy*, *text*, *fill=None*, *font=None*, *anchor=None*, *spacing=0*, *align="left"*, *direction=None*, *features=None*)
Draws the string at the given position.

Parameters

- **xy** – Top left corner of the text.
- **text** – Text to be drawn. If it contains any newline characters, the text is passed on to multiline_text()
- **fill** – Color to use for the text.
- **font** – An `ImageFont` instance.

- **spacing** – If the text is passed on to multiline_text(), the number of pixels between lines.
- **align** – If the text is passed on to multiline_text(), "left", "center" or "right".
- **direction** – Direction of the text. It can be 'rtl' (right to left), 'ltr' (left to right), 'ttb' (top to bottom) or 'btt' (bottom to top). Requires libraqm.

  New in version 4.2.0.

- **features** – A list of OpenType font features to be used during text layout. This is usually used to turn on optional font features that are not enabled by default, for example 'dlig' or 'ss01', but can be also used to turn off default font features for example '-liga' to disable ligatures or '-kern' to disable kerning. To get all supported features, see https://docs.microsoft.com/en-us/typography/opentype/spec/featurelist Requires libraqm.

  New in version 4.2.0.

PIL.ImageDraw.ImageDraw.**multiline_text**(*xy*, *text*, *fill=None*, *font=None*, *anchor=None*, *spacing=0*, *align="left"*, *direction=None*, *features=None*)

Draws the string at the given position.

Parameters

- **xy** – Top left corner of the text.
- **text** – Text to be drawn.
- **fill** – Color to use for the text.
- **font** – An `ImageFont` instance.
- **spacing** – The number of pixels between lines.
- **align** – "left", "center" or "right".
- **direction** – Direction of the text. It can be 'rtl' (right to left), 'ltr' (left to right), 'ttb' (top to bottom) or 'btt' (bottom to top). Requires libraqm.

  New in version 4.2.0.

- **features** – A list of OpenType font features to be used during text layout. This is usually used to turn on optional font features that are not enabled by default, for example 'dlig' or 'ss01', but can be also used to turn off default font features for example '-liga' to disable ligatures or '-kern' to disable kerning. To get all supported features, see https://docs.microsoft.com/en-us/typography/opentype/spec/featurelist Requires libraqm.

  New in version 4.2.0.

PIL.ImageDraw.ImageDraw.**textsize**(*text*, *font=None*, *spacing=4*, *direction=None*, *features=None*)

Return the size of the given string, in pixels.

Parameters

- **text** – Text to be measured. If it contains any newline characters, the text is passed on to multiline_textsize()
- **font** – An `ImageFont` instance.
- **spacing** – If the text is passed on to multiline_textsize(), the number of pixels between lines.
- **direction** – Direction of the text. It can be 'rtl' (right to left), 'ltr' (left to right), 'ttb' (top to bottom) or 'btt' (bottom to top). Requires libraqm.

New in version 4.2.0.

- **features** – A list of OpenType font features to be used during text layout. This is usually used to turn on optional font features that are not enabled by default, for example 'dlig' or 'ss01', but can be also used to turn off default font features for example '-liga' to disable ligatures or '-kern' to disable kerning. To get all supported features, see https://docs.microsoft.com/en-us/typography/opentype/spec/featurelist Requires libraqm.

  New in version 4.2.0.

PIL.ImageDraw.ImageDraw.**multiline_textsize**(*text*, *font=None*, *spacing=4*, *direction=None*, *features=None*)

Return the size of the given string, in pixels.

Parameters

- **text** – Text to be measured.
- **font** – An `ImageFont` instance.
- **spacing** – The number of pixels between lines.
- **direction** – Direction of the text. It can be 'rtl' (right to left), 'ltr' (left to right), 'ttb' (top to bottom) or 'btt' (bottom to top). Requires libraqm.

  New in version 4.2.0.

- **features** – A list of OpenType font features to be used during text layout. This is usually used to turn on optional font features that are not enabled by default, for example 'dlig' or 'ss01', but can be also used to turn off default font features for example '-liga' to disable ligatures or '-kern' to disable kerning. To get all supported features, see https://docs.microsoft.com/en-us/typography/opentype/spec/featurelist Requires libraqm.

  New in version 4.2.0.

PIL.ImageDraw.**getdraw**(*im=None*, *hints=None*)

> **Warning:** This method is experimental.

A more advanced 2D drawing interface for PIL images, based on the WCK interface.

Parameters

- **im** – The image to draw in.
- **hints** – An optional list of hints.

Returns A (drawing context, drawing resource factory) tuple.

PIL.ImageDraw.**floodfill**(*image*, *xy*, *value*, *border=None*, *thresh=0*)

> **Warning:** This method is experimental.

Fills a bounded region with a given color.

Parameters

- **image** – Target image.

- **xy** – Seed position (a 2-item coordinate tuple).
- **value** – Fill color.
- **border** – Optional border value. If given, the region consists of pixels with a color different from the border color. If not given, the region consists of pixels having the same color as the seed pixel.
- **thresh** – Optional threshold value which specifies a maximum tolerable difference of a pixel value from the 'background' in order for it to be replaced. Useful for filling regions of non- homogeneous, but similar, colors.

3.6 ImageEnhance Module

The ImageEnhance module contains a number of classes that can be used for image enhancement.

3.6.1 Example: Vary the sharpness of an image

```
from PIL import ImageEnhance

enhancer = ImageEnhance.Sharpness(image)

for i in range(8):
    factor = i / 4.0
    enhancer.enhance(factor).show("Sharpness %f" % factor)
```

Also see the enhancer.py demo program in the Scripts/ directory.

3.6.2 Classes

All enhancement classes implement a common interface, containing a single method:

class PIL.ImageEnhance.**_Enhance**
.. py:method:: enhance(factor)

Returns an enhanced image.

param factor A floating point value controlling the enhancement. Factor 1.0 always returns a copy of the original image, lower factors mean less color (brightness, contrast, etc), and higher values more. There are no restrictions on this value.

class PIL.ImageEnhance.**Color**(*image*)
Adjust image color balance.

This class can be used to adjust the colour balance of an image, in a manner similar to the controls on a colour TV set. An enhancement factor of 0.0 gives a black and white image. A factor of 1.0 gives the original image.

class PIL.ImageEnhance.**Contrast**(*image*)
Adjust image contrast.

This class can be used to control the contrast of an image, similar to the contrast control on a TV set. An enhancement factor of 0.0 gives a solid grey image. A factor of 1.0 gives the original image.

class PIL.ImageEnhance.**Brightness**(*image*)
Adjust image brightness.

This class can be used to control the brightness of an image. An enhancement factor of 0.0 gives a black image. A factor of 1.0 gives the original image.

class PIL.ImageEnhance.**Sharpness**(*image*)
Adjust image sharpness.

This class can be used to adjust the sharpness of an image. An enhancement factor of 0.0 gives a blurred image, a factor of 1.0 gives the original image, and a factor of 2.0 gives a sharpened image.

3.7 ImageFile Module

The ImageFile module provides support functions for the image open and save functions.

In addition, it provides a Parser class which can be used to decode an image piece by piece (e.g. while receiving it over a network connection). This class implements the same consumer interface as the standard **sgmllib** and **xmllib** modules.

3.7.1 Example: Parse an image

```
from PIL import ImageFile

fp = open("hopper.pgm", "rb")

p = ImageFile.Parser()

while 1:
    s = fp.read(1024)
    if not s:
        break
    p.feed(s)

im = p.close()

im.save("copy.jpg")
```

3.7.2 Parser

3.7.3 PyDecoder

3.8 ImageFilter Module

The ImageFilter module contains definitions for a pre-defined set of filters, which can be be used with the Image.filter() method.

3.8.1 Example: Filter an image

```
from PIL import ImageFilter

im1 = im.filter(ImageFilter.BLUR)
```

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```
im2 = im.filter(ImageFilter.MinFilter(3))
im3 = im.filter(ImageFilter.MinFilter)  # same as MinFilter(3)
```

3.8.2 Filters

The current version of the library provides the following set of predefined image enhancement filters:

- **BLUR**
- **CONTOUR**
- **DETAIL**
- **EDGE_ENHANCE**
- **EDGE_ENHANCE_MORE**
- **EMBOSS**
- **FIND_EDGES**
- **SHARPEN**
- **SMOOTH**
- **SMOOTH_MORE**

class PIL.ImageFilter.**Color3DLUT**(*size*, *table*, *channels=3*, *target_mode=None*, ***kwargs*)
Three-dimensional color lookup table.

Transforms 3-channel pixels using the values of the channels as coordinates in the 3D lookup table and interpolating the nearest elements.

This method allows you to apply almost any color transformation in constant time by using pre-calculated decimated tables.

New in version 5.2.0.

Parameters

- **size** – Size of the table. One int or tuple of (int, int, int). Minimal size in any dimension is 2, maximum is 65.
- **table** – Flat lookup table. A list of `channels * size**3` float elements or a list of `size**3` channels-sized tuples with floats. Channels are changed first, then first dimension, then second, then third. Value 0.0 corresponds lowest value of output, 1.0 highest.
- **channels** – Number of channels in the table. Could be 3 or 4. Default is 3.
- **target_mode** – A mode for the result image. Should have not less than `channels` channels. Default is `None`, which means that mode wouldn't be changed.

class PIL.ImageFilter.**BoxBlur**(*radius*)
Blurs the image by setting each pixel to the average value of the pixels in a square box extending radius pixels in each direction. Supports float radius of arbitrary size. Uses an optimized implementation which runs in linear time relative to the size of the image for any radius value.

Parameters **radius** – Size of the box in one direction. Radius 0 does not blur, returns an identical image. Radius 1 takes 1 pixel in each direction, i.e. 9 pixels in total.

class PIL.ImageFilter.**GaussianBlur**(*radius=2*)
Gaussian blur filter.

Parameters **radius** – Blur radius.

class PIL.ImageFilter.**UnsharpMask**(*radius=2*, *percent=150*, *threshold=3*)
Unsharp mask filter.

See Wikipedia's entry on digital unsharp masking for an explanation of the parameters.

Parameters

- **radius** – Blur Radius
- **percent** – Unsharp strength, in percent
- **threshold** – Threshold controls the minimum brightness change that will be sharpened

class PIL.ImageFilter.**Kernel**(*size*, *kernel*, *scale=None*, *offset=0*)
Create a convolution kernel. The current version only supports 3x3 and 5x5 integer and floating point kernels.

In the current version, kernels can only be applied to "L" and "RGB" images.

Parameters

- **size** – Kernel size, given as (width, height). In the current version, this must be (3,3) or (5,5).
- **kernel** – A sequence containing kernel weights.
- **scale** – Scale factor. If given, the result for each pixel is divided by this value. the default is the sum of the kernel weights.
- **offset** – Offset. If given, this value is added to the result, after it has been divided by the scale factor.

class PIL.ImageFilter.**RankFilter**(*size*, *rank*)
Create a rank filter. The rank filter sorts all pixels in a window of the given size, and returns the **rank**'th value.

Parameters

- **size** – The kernel size, in pixels.
- **rank** – What pixel value to pick. Use 0 for a min filter, `size * size / 2` for a median filter, `size * size - 1` for a max filter, etc.

class PIL.ImageFilter.**MedianFilter**(*size=3*)
Create a median filter. Picks the median pixel value in a window with the given size.

Parameters **size** – The kernel size, in pixels.

class PIL.ImageFilter.**MinFilter**(*size=3*)
Create a min filter. Picks the lowest pixel value in a window with the given size.

Parameters **size** – The kernel size, in pixels.

class PIL.ImageFilter.**MaxFilter**(*size=3*)
Create a max filter. Picks the largest pixel value in a window with the given size.

Parameters **size** – The kernel size, in pixels.

class PIL.ImageFilter.**ModeFilter**(*size=3*)
Create a mode filter. Picks the most frequent pixel value in a box with the given size. Pixel values that occur only once or twice are ignored; if no pixel value occurs more than twice, the original pixel value is preserved.

Parameters **size** – The kernel size, in pixels.

3.9 ImageFont Module

The ImageFont module defines a class with the same name. Instances of this class store bitmap fonts, and are used with the PIL.ImageDraw.Draw.text() method.

PIL uses its own font file format to store bitmap fonts. You can use the **pilfont** utility to convert BDF and PCF font descriptors (X window font formats) to this format.

Starting with version 1.1.4, PIL can be configured to support TrueType and OpenType fonts (as well as other font formats supported by the FreeType library). For earlier versions, TrueType support is only available as part of the imToolkit package

3.9.1 Example

```
from PIL import ImageFont, ImageDraw

draw = ImageDraw.Draw(image)

# use a bitmap font
font = ImageFont.load("arial.pil")

draw.text((10, 10), "hello", font=font)

# use a truetype font
font = ImageFont.truetype("arial.ttf", 15)

draw.text((10, 25), "world", font=font)
```

3.9.2 Functions

3.9.3 Methods

PIL.ImageFont.ImageFont.**getsize**(*text*)

Returns (width, height)

PIL.ImageFont.ImageFont.**getmask**(*text*, *mode=''*, *direction=None*, *features=[]*)

Create a bitmap for the text.

If the font uses antialiasing, the bitmap should have mode "L" and use a maximum value of 255. Otherwise, it should have mode "1".

Parameters

- **text** – Text to render.
- **mode** – Used by some graphics drivers to indicate what mode the driver prefers; if empty, the renderer may return either mode. Note that the mode is always a string, to simplify C-level implementations.

  New in version 1.1.5.
- **direction** – Direction of the text. It can be 'rtl' (right to left), 'ltr' (left to right), 'ttb' (top to bottom) or 'btt' (bottom to top). Requires libraqm.

  New in version 4.2.0.

- **features** – A list of OpenType font features to be used during text layout. This is usually used to turn on optional font features that are not enabled by default, for example 'dlig' or 'ss01', but can be also used to turn off default font features for example '-liga' to disable ligatures or '-kern' to disable kerning. To get all supported features, see https://docs.microsoft.com/en-us/typography/opentype/spec/featurelist Requires libraqm.

  New in version 4.2.0.

Returns An internal PIL storage memory instance as defined by the `PIL.Image.core` interface module.

3.10 `ImageGrab` Module (macOS and Windows only)

The `ImageGrab` module can be used to copy the contents of the screen or the clipboard to a PIL image memory.

Note: The current version works on macOS and Windows only.

New in version 1.1.3.

`PIL.ImageGrab.`**`grab`**(*bbox=None*)
Take a snapshot of the screen. The pixels inside the bounding box are returned as an "RGB" image on Windows or "RGBA" on macOS. If the bounding box is omitted, the entire screen is copied.

New in version 1.1.3: (Windows), 3.0.0 (macOS)

Parameters **bbox** – What region to copy. Default is the entire screen.

Returns An image

`PIL.ImageGrab.`**`grabclipboard`**()
Take a snapshot of the clipboard image, if any.

New in version 1.1.4: (Windows), 3.3.0 (macOS)

Returns

On Windows, an image, a list of filenames, or None if the clipboard does not contain image data or filenames. Note that if a list is returned, the filenames may not represent image files.

On Mac, an image, or None if the clipboard does not contain image data.

3.11 `ImageMath` Module

The `ImageMath` module can be used to evaluate "image expressions". The module provides a single eval function, which takes an expression string and one or more images.

3.11.1 Example: Using the `ImageMath` module

```
from PIL import Image, ImageMath

im1 = Image.open("image1.jpg")
im2 = Image.open("image2.jpg")
```

(continues on next page)

(continued from previous page)

```
out = ImageMath.eval("convert(min(a, b), 'L')", a=im1, b=im2)
out.save("result.png")
```

PIL.ImageMath.**eval**(*expression*, *environment*)
Evaluate expression in the given environment.

In the current version, *ImageMath* only supports single-layer images. To process multi-band images, use the `split()` method or `merge()` function.

Parameters

- **expression** – A string which uses the standard Python expression syntax. In addition to the standard operators, you can also use the functions described below.
- **environment** – A dictionary that maps image names to Image instances. You can use one or more keyword arguments instead of a dictionary, as shown in the above example. Note that the names must be valid Python identifiers.

Returns An image, an integer value, a floating point value, or a pixel tuple, depending on the expression.

3.11.2 Expression syntax

Expressions are standard Python expressions, but they're evaluated in a non-standard environment. You can use PIL methods as usual, plus the following set of operators and functions:

Standard Operators

You can use standard arithmetical operators for addition (+), subtraction (-), multiplication (*), and division (/).

The module also supports unary minus (-), modulo (%), and power (**) operators.

Note that all operations are done with 32-bit integers or 32-bit floating point values, as necessary. For example, if you add two 8-bit images, the result will be a 32-bit integer image. If you add a floating point constant to an 8-bit image, the result will be a 32-bit floating point image.

You can force conversion using the `convert()`, `float()`, and `int()` functions described below.

Bitwise Operators

The module also provides operations that operate on individual bits. This includes and (&), or (|), and exclusive or (^). You can also invert (~) all pixel bits.

Note that the operands are converted to 32-bit signed integers before the bitwise operation is applied. This means that you'll get negative values if you invert an ordinary greyscale image. You can use the and (&) operator to mask off unwanted bits.

Bitwise operators don't work on floating point images.

Logical Operators

Logical operators like `and`, `or`, and `not` work on entire images, rather than individual pixels.

An empty image (all pixels zero) is treated as false. All other images are treated as true.

Note that `and` and `or` return the last evaluated operand, while not always returns a boolean value.

Built-in Functions

These functions are applied to each individual pixel.

abs(*image*)
Absolute value.

convert(*image*, *mode*)
Convert image to the given mode. The mode must be given as a string constant.

float(*image*)
Convert image to 32-bit floating point. This is equivalent to convert(image, "F").

int(*image*)
Convert image to 32-bit integer. This is equivalent to convert(image, "I").

Note that 1-bit and 8-bit images are automatically converted to 32-bit integers if necessary to get a correct result.

max(*image1*, *image2*)
Maximum value.

min(*image1*, *image2*)
Minimum value.

3.12 `ImageMorph` Module

The `ImageMorph` module provides morphology operations on images.

3.13 `ImageOps` Module

The `ImageOps` module contains a number of 'ready-made' image processing operations. This module is somewhat experimental, and most operators only work on L and RGB images.

Only bug fixes have been added since the Pillow fork.

New in version 1.1.3.

3.14 `ImagePalette` Module

The `ImagePalette` module contains a class of the same name to represent the color palette of palette mapped images.

Note: This module was never well-documented. It hasn't changed since 2001, though, so it's probably safe for you to read the source code and puzzle out the internals if you need to.

The `ImagePalette` class has several methods, but they are all marked as "experimental." Read that as you will. The `[source]` link is there for a reason.

3.15 ImagePath Module

The ImagePath module is used to store and manipulate 2-dimensional vector data. Path objects can be passed to the methods on the *ImageDraw* module.

class PIL.ImagePath.**Path**
A path object. The coordinate list can be any sequence object containing either 2-tuples [(x, y), . . .] or numeric values [x, y, . . .].

You can also create a path object from another path object.

In 1.1.6 and later, you can also pass in any object that implements Python's buffer API. The buffer should provide read access, and contain C floats in machine byte order.

The path object implements most parts of the Python sequence interface, and behaves like a list of (x, y) pairs. You can use len(), item access, and slicing as usual. However, the current version does not support slice assignment, or item and slice deletion.

Parameters **xy** – A sequence. The sequence can contain 2-tuples [(x, y), . . .] or a flat list of numbers [x, y, . . .].

PIL.ImagePath.Path.**compact**(*distance=2*)
Compacts the path, by removing points that are close to each other. This method modifies the path in place, and returns the number of points left in the path.

distance is measured as Manhattan distance and defaults to two pixels.

PIL.ImagePath.Path.**getbbox**()
Gets the bounding box of the path.

Returns (x0, y0, x1, y1)

PIL.ImagePath.Path.**map**(*function*)
Maps the path through a function.

PIL.ImagePath.Path.**tolist**(*flat=0*)
Converts the path to a Python list [(x, y), . . .].

Parameters **flat** – By default, this function returns a list of 2-tuples [(x, y), . . .]. If this argument is *True*, it returns a flat list [x, y, . . .] instead.

Returns A list of coordinates. See **flat**.

PIL.ImagePath.Path.**transform**(*matrix*)
Transforms the path in place, using an affine transform. The matrix is a 6-tuple (a, b, c, d, e, f), and each point is mapped as follows:

```
xOut = xIn * a + yIn * b + c
yOut = xIn * d + yIn * e + f
```

3.16 ImageQt Module

The ImageQt module contains support for creating PyQt4, PyQt5 or PySide QImage objects from PIL images.

New in version 1.1.6.

class ImageQt.**ImageQt**(*image*)
Creates an ImageQt object from a PIL Image object. This class is a subclass of QtGui.QImage, which means that you can pass the resulting objects directly to PyQt4/PyQt5/PySide API functions and methods.

This operation is currently supported for mode 1, L, P, RGB, and RGBA images. To handle other modes, you need to convert the image first.

3.17 ImageSequence Module

The ImageSequence module contains a wrapper class that lets you iterate over the frames of an image sequence.

3.17.1 Extracting frames from an animation

```
from PIL import Image, ImageSequence

im = Image.open("animation.fli")

index = 1
for frame in ImageSequence.Iterator(im):
    frame.save("frame%d.png" % index)
    index += 1
```

3.17.2 The Iterator class

class PIL.ImageSequence.**Iterator**(*im*)

This class implements an iterator object that can be used to loop over an image sequence.

You can use the [] operator to access elements by index. This operator will raise an IndexError if you try to access a nonexistent frame.

Parameters **im** – An image object.

3.18 ImageStat Module

The ImageStat module calculates global statistics for an image, or for a region of an image.

class PIL.ImageStat.**Stat**(*image_or_list*, *mask=None*)

Calculate statistics for the given image. If a mask is included, only the regions covered by that mask are included in the statistics. You can also pass in a previously calculated histogram.

Parameters

- **image** – A PIL image, or a precalculated histogram.
- **mask** – An optional mask.

extrema

Min/max values for each band in the image.

count

Total number of pixels for each band in the image.

sum

Sum of all pixels for each band in the image.

sum2

Squared sum of all pixels for each band in the image.

mean
Average (arithmetic mean) pixel level for each band in the image.

median
Median pixel level for each band in the image.

rms
RMS (root-mean-square) for each band in the image.

var
Variance for each band in the image.

stddev
Standard deviation for each band in the image.

3.19 ImageTk Module

The ImageTk module contains support to create and modify Tkinter BitmapImage and PhotoImage objects from PIL images.

For examples, see the demo programs in the Scripts directory.

3.20 ImageWin Module (Windows-only)

The ImageWin module contains support to create and display images on Windows.

ImageWin can be used with PythonWin and other user interface toolkits that provide access to Windows device contexts or window handles. For example, Tkinter makes the window handle available via the winfo_id method:

```
from PIL import ImageWin

dib = ImageWin.Dib(...)

hwnd = ImageWin.HWND(widget.winfo_id())
dib.draw(hwnd, xy)
```

3.21 ExifTags Module

The ExifTags module exposes two dictionaries which provide constants and clear-text names for various well-known EXIF tags.

class PIL.ExifTags.**TAGS**
The TAG dictionary maps 16-bit integer EXIF tag enumerations to descriptive string names. For instance:

```
>>> from PIL.ExifTags import TAGS
>>> TAGS[0x010e]
'ImageDescription'
```

class PIL.ExifTags.**GPSTAGS**
The GPSTAGS dictionary maps 8-bit integer EXIF gps enumerations to descriptive string names. For instance:

```
>>> from PIL.ExifTags import GPSTAGS
>>> GPSTAGS[20]
'GPSDestLatitude'
```

3.22 TiffTags Module

The TiffTags module exposes many of the standard TIFF metadata tag numbers, names, and type information.

PIL.TiffTags.**lookup**(*tag*)

Parameters **tag** – Integer tag number

Returns Taginfo namedtuple, From the TAGS_V2 info if possible, otherwise just populating the value and name from TAGS. If the tag is not recognized, "unknown" is returned for the name

New in version 3.1.0.

class PIL.TiffTags.**TagInfo**

__init__(*self*, *value=None*, *name="unknown"*, *type=None*, *length=0*, *enum=None*)

Parameters

- **value** – Integer Tag Number
- **name** – Tag Name
- **type** – Integer type from *PIL.TiffTags.TYPES*
- **length** – Array length: 0 == variable, 1 == single value, n = fixed
- **enum** – Dict of name:integer value options for an enumeration

cvt_enum(*self*, *value*)

Parameters **value** – The enumerated value name

Returns The integer corresponding to the name.

New in version 3.0.0.

PIL.TiffTags.**TAGS_V2**
The TAGS_V2 dictionary maps 16-bit integer tag numbers to PIL.TagTypes.TagInfo tuples for metadata fields defined in the TIFF spec.

New in version 3.0.0.

PIL.TiffTags.**TAGS**
The TAGS dictionary maps 16-bit integer TIFF tag number to descriptive string names. For instance:

```
>>> from PIL.TiffTags import TAGS
>>> TAGS[0x010e]
'ImageDescription'
```

This dictionary contains a superset of the tags in TAGS_V2, common EXIF tags, and other well known metadata tags.

PIL.TiffTags.**TYPES**
The TYPES dictionary maps the TIFF type short integer to a human readable type name.

3.23 PSDraw Module

The PSDraw module provides simple print support for Postscript printers. You can print text, graphics and images through this module.

3.24 PixelAccess Class

The PixelAccess class provides read and write access to *PIL.Image* data at a pixel level.

Note: Accessing individual pixels is fairly slow. If you are looping over all of the pixels in an image, there is likely a faster way using other parts of the Pillow API.

3.24.1 Example

The following script loads an image, accesses one pixel from it, then changes it.

```
from PIL import Image
im = Image.open('hopper.jpg')
px = im.load()
print (px[4,4])
px[4,4] = (0,0,0)
print (px[4,4])
```

Results in the following:

```
(23, 24, 68)
(0, 0, 0)
```

3.24.2 PixelAccess Class

class PixelAccess

__setitem__(self, xy, color):
Modifies the pixel at x,y. The color is given as a single numerical value for single band images, and a tuple for multi-band images

Parameters

- **xy** – The pixel coordinate, given as (x, y).
- **color** – The pixel value according to its mode. e.g. tuple (r, g, b) for RGB mode)

__getitem__(self, xy):

Returns the pixel at x,y. The pixel is returned as a single value for single band images or a tuple for multiple band images

param xy The pixel coordinate, given as (x, y).

returns a pixel value for single band images, a tuple of pixel values for multiband images.

putpixel(self, xy, color):

Modifies the pixel at x,y. The color is given as a single numerical value for single band images, and a tuple for multi-band images

Parameters

- **xy** – The pixel coordinate, given as (x, y).
- **color** – The pixel value according to its mode. e.g. tuple (r, g, b) for RGB mode)

getpixel(self, xy):

Returns the pixel at x,y. The pixel is returned as a single value for single band images or a tuple for multiple band images

param xy The pixel coordinate, given as (x, y).

returns a pixel value for single band images, a tuple of pixel values for multiband images.

3.25 PyAccess Module

The PyAccess module provides a CFFI/Python implementation of the *PixelAccess Class*. This implementation is far faster on PyPy than the PixelAccess version.

Note: Accessing individual pixels is fairly slow. If you are looping over all of the pixels in an image, there is likely a faster way using other parts of the Pillow API.

3.25.1 Example

The following script loads an image, accesses one pixel from it, then changes it.

```
from PIL import Image
im = Image.open('hopper.jpg')
px = im.load()
print (px[4,4])
px[4,4] = (0,0,0)
print (px[4,4])
```

Results in the following:

```
(23, 24, 68)
(0, 0, 0)
```

3.25.2 PyAccess Class

3.26 PIL Package (autodoc of remaining modules)

Reference for modules whose documentation has not yet been ported or written can be found here.

3.26.1 BdfFontFile Module

3.26.2 ContainerIO Module

class PIL.ContainerIO.**ContainerIO**(*file*, *offset*, *length*)
Bases: object

isatty()

read(*n=0*)
Read data.

Parameters **n** – Number of bytes to read. If omitted or zero, read until end of region.

Returns An 8-bit string.

readline()
Read a line of text.

Returns An 8-bit string.

readlines()
Read multiple lines of text.

Returns A list of 8-bit strings.

seek(*offset*, *mode=0*)
Move file pointer.

Parameters

- **offset** – Offset in bytes.
- **mode** – Starting position. Use 0 for beginning of region, 1 for current offset, and 2 for end of region. You cannot move the pointer outside the defined region.

tell()
Get current file pointer.

Returns Offset from start of region, in bytes.

3.26.3 FontFile Module

3.26.4 GdImageFile Module

3.26.5 GimpGradientFile Module

class PIL.GimpGradientFile.**GimpGradientFile**(*fp*)
Bases: *PIL.GimpGradientFile.GradientFile*

class PIL.GimpGradientFile.**GradientFile**
Bases: object

getpalette(*entries=256*)

gradient = None

PIL.GimpGradientFile.**curved**(*middle*, *pos*)

PIL.GimpGradientFile.**linear**(*middle*, *pos*)

PIL.GimpGradientFile.**sine**(*middle*, *pos*)

PIL.GimpGradientFile.**sphere_decreasing**(*middle*, *pos*)

PIL.GimpGradientFile.**sphere_increasing**(*middle*, *pos*)

3.26.6 GimpPaletteFile Module

class PIL.GimpPaletteFile.**GimpPaletteFile**(*fp*)

Bases: object

getpalette()

rawmode = 'RGB'

3.26.7 ImageDraw2 Module

3.26.8 ImageShow Module

3.26.9 ImageTransform Module

3.26.10 JpegPresets Module

JPEG quality settings equivalent to the Photoshop settings.

More presets can be added to the presets dict if needed.

Can be use when saving JPEG file.

To apply the preset, specify:

```
quality="preset_name"
```

To apply only the quantization table:

```
qtables="preset_name"
```

To apply only the subsampling setting:

```
subsampling="preset_name"
```

Example:

```
im.save("image_name.jpg", quality="web_high")
```

Subsampling

Subsampling is the practice of encoding images by implementing less resolution for chroma information than for luma information. (ref.: https://en.wikipedia.org/wiki/Chroma_subsampling)

Possible subsampling values are 0, 1 and 2 that correspond to 4:4:4, 4:2:2 and 4:2:0.

You can get the subsampling of a JPEG with the *JpegImagePlugin.get_subsampling(im)* function.

Quantization tables

They are values use by the DCT (Discrete cosine transform) to remove *unnecessary* information from the image (the lossy part of the compression). (ref.: https://en.wikipedia.org/wiki/Quantization_matrix#Quantization_matrices, https://en.wikipedia.org/wiki/JPEG#Quantization)

You can get the quantization tables of a JPEG with:

```
im.quantization
```

This will return a dict with a number of arrays. You can pass this dict directly as the qtables argument when saving a JPEG.

The tables format between im.quantization and quantization in presets differ in 3 ways:

1. The base container of the preset is a list with sublists instead of dict. dict[0] -> list[0], dict[1] -> list[1], ...
2. Each table in a preset is a list instead of an array.
3. The zigzag order is remove in the preset (needed by libjpeg >= 6a).

You can convert the dict format to the preset format with the *JpegImagePlugin.convert_dict_qtables(dict_qtables)* function.

Libjpeg ref.: https://web.archive.org/web/20120328125543/http://www.jpegcameras.com/libjpeg/libjpeg-3.html

3.26.11 PaletteFile Module

class PIL.PaletteFile.**PaletteFile**(*fp*)
Bases: object

getpalette()

rawmode = 'RGB'

3.26.12 PcfFontFile Module

3.26.13 PngImagePlugin.iTXt Class

3.26.14 PngImagePlugin.PngInfo Class

3.26.15 TarIO Module

class PIL.TarIO.**TarIO**(*tarfile*, *file*)
Bases: *PIL.ContainerIO.ContainerIO*

3.26.16 WalImageFile Module

3.26.17 _binary Module

PIL._binary.**i16be**(*c*, *o=0*)

PIL._binary.**i16le**(*c*, *o=0*)
Converts a 2-bytes (16 bits) string to an unsigned integer.

c: string containing bytes to convert o: offset of bytes to convert in string

PIL._binary.**i32be**(*c*, *o=0*)

PIL._binary.**i32le**(*c*, *o=0*)
Converts a 4-bytes (32 bits) string to an unsigned integer.

c: string containing bytes to convert o: offset of bytes to convert in string

PIL._binary.**i8**(*c*)

PIL._binary.**o16be**(*i*)

PIL._binary.**o16le**(*i*)

PIL._binary.**o32be**(*i*)

PIL._binary.**o32le**(*i*)

PIL._binary.**o8**(*i*)

PIL._binary.**si16le**(*c*, *o=0*)
Converts a 2-bytes (16 bits) string to a signed integer.

c: string containing bytes to convert o: offset of bytes to convert in string

PIL._binary.**si32le**(*c*, *o=0*)
Converts a 4-bytes (32 bits) string to a signed integer.

c: string containing bytes to convert o: offset of bytes to convert in string

3.27 Plugin reference

3.27.1 BmpImagePlugin Module

3.27.2 BufrStubImagePlugin Module

3.27.3 CurImagePlugin Module

3.27.4 DcxImagePlugin Module

3.27.5 EpsImagePlugin Module

3.27.6 FitsStubImagePlugin Module

3.27.7 FliImagePlugin Module

3.27.8 FpxImagePlugin Module

3.27.9 GbrImagePlugin Module

3.27.10 GifImagePlugin Module

3.27.11 GribStubImagePlugin Module

3.27.12 Hdf5StubImagePlugin Module

3.27.13 IcnsImagePlugin Module

3.27.14 IcoImagePlugin Module

3.27.15 ImImagePlugin Module

3.27.16 ImtImagePlugin Module

3.27.17 IptcImagePlugin Module

3.27.18 JpegImagePlugin Module

3.27.19 Jpeg2KImagePlugin Module

3.27.20 McIdasImagePlugin Module

3.27.21 MicImagePlugin Module

3.27.22 MpegImagePlugin Module

3.27.23 MspImagePlugin Module

3.27.24 PalmImagePlugin Module

3.27.25 PcdImagePlugin Module

3.27.26 PcxImagePlugin Module

The first four of these items are equivalent, the last is dangerous and may fail:

```
from PIL import Image
import io
import pathlib

im = Image.open('test.jpg')

im2 = Image.open(pathlib.Path('test.jpg'))

f = open('test.jpg', 'rb')
im3 = Image.open(f)

with open('test.jpg', 'rb') as f:
    im4 = Image.open(io.BytesIO(f.read()))

# Dangerous FAIL:
with open('test.jpg', 'rb') as f:
    im5 = Image.open(f)
im5.load() # FAILS, closed file
```

The documentation specifies that the file will be closed after the `Image.Image.load()` method is called. This is an aspirational specification rather than an accurate reflection of the state of the code.

Pillow cannot in general close and reopen a file, so any access to that file needs to be prior to the close.

Issues

The current open file handling is inconsistent at best:

- Most of the image plugins do not close the input file.
- Multi-frame images behave badly when seeking through the file, as it's legal to seek backward in the file until the last image is read, and then it's not.
- Using the file context manager to provide a file-like object to Pillow is dangerous unless the context of the image is limited to the context of the file.

Image Lifecycle

- `Image.open()` called. Path-like objects are opened as a file. Metadata is read from the open file. The file is left open for further usage.
- `Image.Image.load()` when the pixel data from the image is required, `load()` is called. The current frame is read into memory. The image can now be used independently of the underlying image file.
- `Image.Image.seek()` in the case of multi-frame images (e.g. multipage TIFF and animated GIF) the image file left open so that seek can load the appropriate frame. When the last frame is read, the image file is closed (at least in some image plugins), and no more seeks can occur.
- `Image.Image.close()` Closes the file pointer and destroys the core image object. This is used in the Pillow context manager support. e.g.:

  ```
  with Image.open('test.jpg') as img:
     ...  # image operations here.
  ```

The lifecycle of a single frame image is relatively simple. The file must remain open until the `load()` or `close()` function is called.

Multi-frame images are more complicated. The `load()` method is not a terminal method, so it should not close the underlying file. The current behavior of `seek()` closing the underlying file on accessing the last frame is presumably a heuristic for closing the file after iterating through the entire sequence. In general, Pillow does not know if there are going to be any requests for additional data until the caller has explicitly closed the image.

Complications

- TiffImagePlugin has some code to pass the underlying file descriptor into libtiff (if working on an actual file). Since libtiff closes the file descriptor internally, it is duplicated prior to passing it into libtiff.
- `decoder.handles_eof` This slightly misnamed flag indicates that the decoder wants to be called with a 0 length buffer when reads are done. Despite the comments in `ImageFile.load()`, the only decoder that actually uses this flag is the Jpeg2K decoder. The use of this flag in Jpeg2K predated the change to the decoder that added the pulls_fd flag, and is therefore not used.
- I don't think that there's any way to make this safe without changing the lazy loading:

```
# Dangerous FAIL:
with open('test.jpg', 'rb') as f:
    im5 = Image.open(f)
im5.load() # FAILS, closed file
```

Proposed File Handling

- `Image.Image.load()` should close the image file, unless there are multiple frames.
- `Image.Image.seek()` should never close the image file.
- Users of the library should call `Image.Image.close()` on any multi-frame image to ensure that the underlying file is closed.

3.28.2 Limits

This page is documentation to the various fundamental size limits in the Pillow implementation.

Internal Limits

- Image sizes cannot be negative. These are checked both in `Storage.c` and `Image.py`
- Image sizes may be 0. (Although not in 3.4)
- Maximum pixel dimensions are limited to INT32, or 2^31 by the sizes in the image header.
- Individual allocations are limited to 2GB in `Storage.c`
- The 2GB allocation puts an upper limit to the xsize of the image of either 2^31 for 'L' or 2^29 for 'RGB'
- Individual memory mapped segments are limited to 2GB in map.c based on the overflow checks. This requires that any memory mapped image is smaller than 2GB, as calculated by `y*stride` (so 2Gpx for 'L' images, and .5Gpx for 'RGB'
- Any call to internal python size functions for buffers or strings are currently returned as int32, not py_ssize_t. This limits the maximum buffer to 2GB for operations like frombytes and frombuffer.
- This also limits the size of buffers converted using a decoder. (decode.c:127)

Format Size Limits

- ICO: Max size is 256x256
- Webp: 16383x16383 (underlying library size limit: https://developers.google.com/speed/webp/docs/api)

3.28.3 Block Allocator

Previous Design

Historically there have been two image allocators in Pillow: `ImagingAllocateBlock` and `ImagingAllocateArray`. The first works for images smaller than 16MB of data and allocates one large chunk of memory of `im->linesize * im->ysize` bytes. The second works for large images and make one allocation for each scan line of size `im->linesize` bytes. This makes for a very sharp transition between one allocation and potentially thousands of small allocations, leading to unpredictable performance penalties around the transition.

New Design

`ImagingAllocateArray` now allocates space for images as a chain of blocks with a maximum size of 16MB. If there is a memory allocation error, it falls back to allocating a 4KB block, or at least one scan line. This is now the default for all internal allocations.

`ImagingAllocateBlock` is now only used for those cases when we are specifically requesting a single segment of memory for sharing with other code.

Memory Pools

There is now a memory pool to contain a supply of recently freed blocks, which can then be reused without going back to the OS for a fresh allocation. This caching of free blocks is currently disabled by default, but can be enabled and tweaked using three environment variables:

- `PILLOW_ALIGNMENT`, in bytes. Specifies the alignment of memory allocations. Valid values are powers of 2 between 1 and 128, inclusive. Defaults to 1.
- `PILLOW_BLOCK_SIZE`, in bytes, K, or M. Specifies the maximum block size for `ImagingAllocateArray`. Valid values are integers, with an optional *k* or *m* suffix. Defaults to 16M.
- `PILLOW_BLOCKS_MAX` Specifies the number of freed blocks to retain to fill future memory requests. Any freed blocks over this threshold will be returned to the OS immediately. Defaults to 0.

CHAPTER 4

Porting

Porting existing PIL-based code to Pillow

Pillow is a functional drop-in replacement for the Python Imaging Library. To run your existing PIL-compatible code with Pillow, it needs to be modified to import the `Image` module from the `PIL` namespace *instead* of the global namespace. Change this:

```
import Image
```

to this:

```
from PIL import Image
```

The `_imaging` module has been moved. You can now import it like this:

```
from PIL.Image import core as _imaging
```

The image plugin loading mechanism has changed. Pillow no longer automatically imports any file in the Python path with a name ending in `ImagePlugin.py`. You will need to import your image plugin manually.

Pillow will raise an exception if the core extension can't be loaded for any reason, including a version mismatch between the Python and extension code. Previously PIL allowed Python only code to run if the core extension was not available.

CHAPTER 5

About

5.1 Goals

The fork author's goal is to foster and support active development of PIL through:

- Continuous integration testing via Travis CI and AppVeyor
- Publicized development activity on GitHub
- Regular releases to the Python Package Index

5.2 License

Like PIL, Pillow is licensed under the open source PIL Software License

5.3 Why a fork?

PIL is not setuptools compatible. Please see this Image-SIG post for a more detailed explanation. Also, PIL's current bi-yearly (or greater) release schedule is too infrequent to accommodate the large number and frequency of issues reported.

5.4 What about PIL?

Note: Prior to Pillow 2.0.0, very few image code changes were made. Pillow 2.0.0 added Python 3 support and includes many bug fixes from many contributors.

As more time passes since the last PIL release (1.1.7 in 2009), the likelihood of a new PIL release decreases. However, we've yet to hear an official "PIL is dead" announcement. So if you still want to support PIL, please report issues here first, then open corresponding Pillow tickets here.

Please provide a link to the first ticket so we can track the issue(s) upstream.

CHAPTER 6

Release Notes

Note: Contributors please include release notes as needed or appropriate with your bug fixes, feature additions and tests.

6.1 5.2.0

6.1.1 API Changes

Deprecations

These version constants have been deprecated. `VERSION` will be removed in Pillow 6.0.0, and `PILLOW_VERSION` will be removed after that.

- `PIL.VERSION` (old PIL version 1.1.7)
- `PIL.PILLOW_VERSION`
- `PIL.Image.VERSION`
- `PIL.Image.PILLOW_VERSION`

Use `PIL.__version__` instead.

6.1.2 API Additions

3D color lookup tables

Support for 3D color lookup table transformations has been added.

- https://en.wikipedia.org/wiki/3D_lookup_table

`Color3DLUT.generate` transforms 3-channel pixels using the values of the channels as coordinates in the 3D lookup table and interpolating the nearest elements.

It allows you to apply almost any color transformation in constant time by using pre-calculated decimated tables.

`Color3DLUT.transform()` allows altering table values with a callback.

If NumPy is installed, the performance of argument conversion is dramatically improved when a source table supports buffer interface (NumPy && arrays in Python >= 3).

ImageColor.getrgb

Previously `Image.rotate` only supported HSL color strings. Now HSB and HSV strings are also supported, as well as float values. For example, `ImageColor.getrgb("hsv(180,100%,99.5%)")`.

ImageFile.get_format_mimetype

`ImageFile.get_format_mimetype` has been added to return the MIME type of an image file, where available. For example, `Image.open("hopper.jpg").get_format_mimetype()` returns `"image/jpeg"`.

ImageFont.getsize_multiline

A new method to return the size of multiline text, for example `font.getsize_multiline("ABC\nAaaa")`

Image.rotate

A new named parameter, `fillcolor`, has been added to `Image.rotate`. This color specifies the background color to use in the area outside the rotated image. This parameter takes the same color specifications as used in `Image.new`.

TGA file format

Pillow can now read and write LA data (in addition to L, P, RGB and RGBA), and write RLE data (in addition to uncompressed).

6.1.3 Other Changes

Support added for Python 3.7

Pillow 5.2 supports Python 3.7.

Build macOS wheels with Xcode 6.4, supporting older macOS versions

The macOS wheels for Pillow 5.1.0 were built with Xcode 9.2, meaning 10.12 Sierra was the lowest supported version.

Prior to Pillow 5.1.0, Xcode 8 was used, supporting El Capitan 10.11.

Instead, Pillow 5.2.0 is built with the oldest available Xcode 6.4 to support at least 10.10 Yosemite.

Fix _i2f compilation with some GCC versions

For example, this allows compilation with GCC 4.8 on NetBSD.

Resolve confusion getting PIL / Pillow version string

Re: "version constants deprecated" listed above, as user gnbl notes in #3082:

- it's confusing that PIL.VERSION returns the version string of the former PIL instead of Pillow's
- there does not seem to be documentation on this version number (why this, will it ever change, ..) e.g. at https://pillow.readthedocs.io/en/5.1.x/about.html#why-a-fork
- it's confusing that PIL.version is a module and does not return the version information directly or hints on how to get it
- the package information header is essentially useless (placeholder, does not even mention Pillow, nor the version)
- PIL._version module documentation comment could explain how to access the version information

We have attempted to resolve these issues in #3083, #3090 and #3218.

6.2 5.1.0

6.2.1 New File Format

BLP File Format

Pillow now supports reading the BLP "Blizzard Mipmap" file format used for tiles in Blizzard's engine.

6.2.2 API Changes

Optional channels for TIFF files

Pillow can now open TIFF files with base modes of `RGB`, `YCbCr`, and `CMYK` with up to 6 8-bit channels, discarding any extra channels if the content is tagged as UNSPECIFIED. Pillow still does not store more than 4 8-bit channels of image data.

Append to PDF Files

Images can now be appended to PDF files in place by passing in `append=True` when saving the image.

6.2.3 Other Changes

WebP memory leak

A memory leak when opening `WebP` files has been fixed.

6.3 5.0.0

6.3.1 Backwards Incompatible Changes

Python 3.3 Dropped

Python 3.3 is EOL and no longer supported due to moving testing from nose, which is deprecated, to pytest, which doesn't support Python 3.3. We will not be creating binaries, testing, or retaining compatibility with this version. The final version of Pillow for Python 3.3 is 4.3.0.

Decompression Bombs now raise Exceptions

Pillow has previously emitted warnings for images that are unexpectedly large and may be a denial of service. These warnings are now upgraded to `DecompressionBombErrors` for images that are twice the size of images that trigger the `DecompressionBombWarning`. The default threshold is 128Mpx, or 0.5GB for an `RGB` or `RGBA` image. This can be disabled or changed by setting `Image.MAX_IMAGE_PIXELS = None`.

Scripts

The scripts formerly installed by Pillow have been split into a separate package, pillow-scripts, living at https://github.com/python-pillow/pillow-scripts .

6.3.2 API Changes

OleFileIO.py

The olefile module is no longer a required dependency when installing Pillow. Support for plugins requiring olefile will not be loaded if it is not installed. This allows library consumers to avoid installing this dependency if they choose. Some library consumers have little interest in the format support and would like to keep dependencies to a minimum.

Further, the vendored version was removed in Pillow 4.0.0 and replaced with a deprecation warning that PIL.OleFileIO would be removed in a future version. This warning has been upgraded to an import error pending future removal.

Check parameter on _save

Several image plugins supported a named `check` parameter on their nominally private `_save` method to preflight if the image could be saved in that format. That parameter has been removed.

6.3.3 API Additions

Image.transform

A new named parameter, `fillcolor`, has been added to `Image.transform`. This color specifies the background color to use in the area outside the transformed area in the output image. This parameter takes the same color specifications as used in `Image.new`.

GIF Disposal

Multiframe GIF images now take an optional disposal parameter to specify the disposal option for changed pixels.

6.3.4 Other Changes

Compressed TIFF Images

Previously, there were some compression modes (JPEG, Packbits, and LZW) that were supported with Pillow's internal TIFF decoder. All compressed TIFFs are now read using the `libtiff` decoder, as it implements the compression schemes more correctly.

Libraqm is now Dynamically Linked

The libraqm dependency for complex text scripts is now linked dynamically at runtime rather than at packaging time. This allows us to release binaries with support for libraqm if it is installed on the user's machine.

Source Layout Changes

The Pillow source is now stored within the `src` directory of the distribution. This prevents accidental imports of the PIL directory when running Python from the project directory.

Setup.py Changes

Multiarch support on Linux should be more robust, especially on Debian derivatives on ARM platforms. Debian's multiarch platform configuration is run in preference to the sniffing of machine platform and architecture.

6.4 4.3.0

6.4.1 API Changes

Deprecations

Several undocumented functions in ImageOps have been deprecated: `gaussian_blur`, `gblur`, `unsharp_mask`, `usm` and `box_blur`. Use the equivalent operations in ImageFilter instead. These functions will be removed in a future release.

TIFF Metadata Changes

- TIFF tags with unknown type/quantity now default to being bare values if they are 1 element, where previously they would be a single element tuple. This is only with the new api, not the legacy api. This normalizes the handling of fields, so that the metadata with inferred or image specified counts are handled the same as metadata with count specified in the TIFF spec.
- The `PhotoshopInfo`, `XMP`, and `JPEGTables` tags now have a defined type (bytes) and a count of 1.
- The `ImageJMetaDataByteCounts` tag now has an arbitrary number of items, as there can be multiple items, one for UTF-8, and one for UTF-16.

Core Image API Changes

These are internal functions that should not have been used by user code, but they were accessible from the python layer.

Debugging code within `Image.core.grabclipboard` was removed. It had been marked as `will be removed in future versions` since PIL. When enabled, it identified the format of the clipboard data.

The `PIL.Image.core.copy` and `PIL.Image.Image.im.copy2` methods have been removed.

The `PIL.Image.core.getcount` methods have been removed, use `PIL.Image.core.get_stats()['new_count']` property instead.

6.4.2 API Additions

Get One Channel From Image

A new method `PIL.Image.Image.getchannel()` has been added to return a single channel by index or name. For example, `image.getchannel("A")` will return alpha channel as separate image. `getchannel` should work up to 6 times faster than `image.split()[0]` in previous Pillow versions.

Box Blur

A new filter, *PIL.ImageFilter.BoxBlur*, has been added. This is a filter with similar results to a Gaussian blur, but is much faster.

Partial Resampling

Added new argument `box` for `PIL.Image.Image.resize()`. This argument defines a source rectangle from within the source image to be resized. This is very similar to the `image.crop(box).resize(size)` sequence except that `box` can be specified with subpixel accuracy.

New Transpose Operation

The `Image.TRANSVERSE` operation has been added to `PIL.Image.Image.transpose()`. This is equivalent to a transpose operation about the opposite diagonal.

Multiband Filters

There is a new `PIL.ImageFilter.MultibandFilter` base class for image filters that can run on all channels of an image in one operation. The original `PIL.ImageFilter.Filter` class remains for image filters that can process only single band images, or require splitting of channels prior to filtering.

6.4.3 Other Changes

Loading 16-bit TIFF Images

Pillow now can read 16-bit multichannel TIFF files including files with alpha transparency. The image data is truncated to 8-bit precision.

Pillow now can read 16-bit signed integer single channel TIFF files. The image data is promoted to 32-bit for storage and processing.

SGI Images

Pillow can now read and write uncompressed 16-bit multichannel SGI images to and from RGB and RGBA formats. The image data is truncated to 8-bit precision.

Pillow can now read RLE encoded SGI images in both 8 and 16-bit precision.

Performance

This release contains several performance improvements:

- Many memory bandwidth-bounded operations such as crop, image allocation, conversion, split into bands and merging from bands are up to 2x faster.
- Upscaling of multichannel images (such as RGB) is accelerated by 5-10%
- JPEG loading is accelerated up to 15% and JPEG saving up to 20% when using a recent version of libjpeg-turbo.
- `Image.transpose` has been accelerated 15% or more by using a cache friendly algorithm.
- ImageFilters based on Kernel convolution are significantly faster due to the new MultibandFilter feature.
- All memory allocation for images is now done in blocks, rather than falling back to an allocation for each scan line for images larger than the block size.

CMYK Conversion

The basic CMYK->RGB conversion has been tweaked to match the formula from Google Chrome. This produces an image that is generally lighter than the previous formula, and more in line with what color managed applications produce.

6.5 4.2.1

There are no functional changes in this release.

6.5.1 Fixed Windows PyPy Build

A change in the 4.2.0 cycle broke the Windows PyPy build. This has been fixed, and PyPy is now part of the Windows CI matrix.

6.6 4.2.0

6.6.1 Added Complex Text Rendering

Pillow now supports complex text rendering for scripts requiring glyph composition and bidirectional flow. This optional feature adds three dependencies: harfbuzz, fribidi, and raqm. See the install documentation for further details. This feature is tested and works on Unix and Mac, but has not yet been built on Windows platforms.

6.6.2 New Optional Parameters

- `PIL.ImageDraw.floodfill()` has a new optional parameter: threshold. This specifies a tolerance for the color to replace with the flood fill.
- The TIFF and PDF image writers now support the `append_images` optional parameter for specifying additional images to create multipage outputs.

6.6.3 New DecompressionBomb Warning

`PIL.Image.Image.crop()` now may raise a DecompressionBomb warning if the crop region enlarges the image over the threshold specified by `PIL.Image.MAX_PIXELS`.

6.6.4 Removed Deprecated Items

Several deprecated items have been removed.

- The methods `PIL.ImageWin.Dib.fromstring()`, `PIL.ImageWin.Dib.tostring()` and `PIL.TiffImagePlugin.ImageFileDirectory_v2.as_dict()` have been removed.
- Before Pillow 4.2.0, attempting to save an RGBA image as JPEG would discard the alpha channel. From Pillow 3.4.0, a deprecation warning was shown. From Pillow 4.2.0, the deprecation warning is removed and an `IOError` is raised.

6.6.5 Removed Core Image Function

The unused function `Image.core.new_array` was removed. This is an internal function that should not have been used by user code, but it was accessible from the python layer.

6.7 4.1.1

6.7.1 Fix Regression with reading DPI from EXIF data

Some JPEG images don't contain DPI information in the image metadata, but do contain it in the EXIF data. A patch was added in 4.1.0 to read from the EXIF data, but it did not accept all possible types that could be included there. This fix adds the ability to read ints as well as rational values.

6.7.2 Incompatibility between 3.6.0 and 3.6.1

CPython 3.6.1 added a new symbol, PySlice_GetIndicesEx, which was not present in 3.6.0. This had the effect of causing binaries compiled on CPython 3.6.1 to not work on installations of C-Python 3.6.0. This fix undefines PySlice_GetIndicesEx if it exists to restore compatibility with both 3.6.0 and 3.6.1. See https://bugs.python.org/issue29943 for more details.

6.8 4.1.0

6.8.1 Removed Deprecated Items

Several deprecated items have been removed.

- Support for spaces in tiff kwargs in the parameters for 'x resolution', 'y resolution', 'resolution unit', and 'date time' has been removed. Underscores should be used instead.
- The methods `PIL.ImageDraw.ImageDraw.setink()`, `PIL.ImageDraw.ImageDraw.setfill()`, and `PIL.ImageDraw.ImageDraw.setfont()` have been removed.

6.8.2 Closing Files When Opening Images

The file handling when opening images has been overhauled. Previously, Pillow would attempt to close some, but not all image formats after loading the image data. Now, the following behavior is specified:

- For images where an open file is passed in, it is the responsibility of the calling code to close the file.
- For images where Pillow opens the file and the file is known to have only one frame, the file is closed after loading.
- If the file has more than one frame, or if it can't be determined, then the file is left open to permit seeking to subsequent frames. It will be closed, eventually, in the `close` or `__del__` methods.
- If the image is memory mapped, then we can't close the mapping to the underlying file until we are done with the image. The mapping will be closed in the `close` or `__del__` method.

6.8.3 Changes to GIF Handling When Saving

The `PIL.GifImagePlugin` code has been refactored to fix the flow when saving images. There are two external changes that arise from this:

- An `PIL.ImagePalette.ImagePalette` object is now accepted as a specified palette argument in `PIL.Image.Image.save()`.
- The image to be saved is no longer modified in place by any of the operations of the save function. Previously it was modified when optimizing the image palette.

This refactor fixed some bugs with palette handling when saving multiple frame GIFs.

6.8.4 New Method: Image.remap_palette

The method `PIL.Image.Image.remap_palette()` has been added. This method was hoisted from the GifImagePlugin code used to optimize the palette.

6.8.5 Added Decoder Registry and Support for Python Based Decoders

There is now a decoder registry similar to the image plugin registries. Image plugins can register a decoder, and it will be called when the decoding is requested. This allows for the creation of pure Python decoders. While the Python decoders will not be as fast as their C based counterparts, they may be easier and quicker to develop or safer to run.

6.8.6 Tests

Many tests have been added, including correctness tests for image formats that have been previously untested.

We are now running automated tests in Docker containers against more Linux versions than are provided on Travis CI, which is currently Ubuntu 14.04 x64. This Pillow release is tested on 64-bit Alpine, Arch, Ubuntu 12.04 and 16.04, and 32-bit Debian Stretch and Ubuntu 14.04. This also covers a wider range of dependency versions than are provided on Travis natively.

6.9 4.0.0

6.9.1 Python 2.6 and 3.2 Dropped

Pillow 4.0 no longer supports Python 2.6 and 3.2. We will not be creating binaries, testing, or retaining compatibility with these releases. This release removes some workarounds for those Python releases, so the final working version of Pillow on 2.6 or 3.2 is 3.4.2.

6.9.2 Support added for Python 3.6

Pillow 4.0 supports Python 3.6.

6.9.3 OleFileIO.py

OleFileIO.py has been removed as a vendored file and is now installed from the upstream olefile pypi package. All internal dependencies are redirected to the olefile package. Direct accesses to `PIL.OlefileIO` raises a deprecation warning, then patches the upstream olefile into `sys.modules` in its place.

6.9.4 SGI image save

It is now possible to save images in modes `L`, `RGB`, and `RGBA` to the uncompressed SGI image format.

6.9.5 Zero sized images

Pillow 3.4.0 removed support for creating images with (0,0) size. This has been reenabled, restoring pre 3.4 behavior.

6.9.6 Internal handles_eof flag

The `handles_eof flag` for decoding images has been removed, as there were no internal users of the flag. Anyone maintaining image decoders outside of the Pillow source tree should consider using the cleanup function pointers instead.

6.9.7 Image.core.stretch removed

The stretch function on the core image object has been removed. This used to be for enlarging the image, but has been aliased to resize recently.

6.10 3.4.0

6.10.1 New resizing filters

Two new filters available for `Image.resize()` and `Image.thumbnail()` functions: `BOX` and `HAMMING`. `BOX` is the high-performance filter with two times shorter window than `BILINEAR`. It can be used for image reduction 3 and more times and produces a sharper result than `BILINEAR`.

`HAMMING` filter has the same performance as `BILINEAR` filter while providing the image downscaling quality comparable to `BICUBIC`. Both new filters don't show good quality for the image upscaling.

6.10.2 Deprecation Warning when Saving JPEGs

JPEG images cannot contain an alpha channel. Pillow prior to 3.4.0 silently drops the alpha channel. With this release Pillow will now issue a `DeprecationWarning` when attempting to save a `RGBA` mode image as a JPEG. This will become an error in Pillow 4.2.

6.10.3 New DDS Decoders

Pillow can now decode DXT3 images, as well as the previously supported DXT1 and DXT5 formats. All three formats are now decoded in C code for better performance.

6.10.4 Append images to GIF

Additional frames can now be appended when saving a GIF file, through the `append_images` argument. The new frames are passed in as a list of images, which may be have multiple frames themselves.

Note that the `append_images` argument is only used if `save_all` is also in effect, e.g.:

```
im.save(out, save_all=True, append_images=[im1, im2, ...])
```

6.10.5 Save multiple frame TIFF

Multiple frames can now be saved in a TIFF file by using the `save_all` option. e.g.:

```
im.save("filename.tiff", format="TIFF", save_all=True)
```

6.10.6 Image.core.open_ppm removed

The nominally private/debugging function `Image.core.open_ppm` has been removed. If you were using this function, please use `Image.open` instead.

6.11 3.3.2

6.11.1 Integer overflow in Map.c

Pillow prior to 3.3.2 may experience integer overflow errors in map.c when reading specially crafted image files. This may lead to memory disclosure or corruption.

Specifically, when parameters from the image are passed into `Image.core.map_buffer`, the size of the image was calculated with `xsize * ysize * bytes_per_pixel`. This will overflow if the result is larger than SIZE_MAX. This is possible on a 32-bit system.

Furthermore this `size` value was added to a potentially attacker provided `offset` value and compared to the size of the buffer without checking for overflow or negative values.

These values were then used for creating pointers, at which point Pillow could read the memory and include it in other images. The image was marked readonly, so Pillow would not ordinarily write to that memory without duplicating the image first.

This issue was found by Cris Neckar at Divergent Security.

6.11.2 Sign Extension in Storage.c

Pillow prior to 3.3.2 and PIL 1.1.7 (at least) do not check for negative image sizes in `ImagingNew` in `Storage.c`. A negative image size can lead to a smaller allocation than expected, leading to arbitrary writes.

This issue was found by Cris Neckar at Divergent Security.

6.12 3.3.0

6.12.1 Libimagequant support

There is now support for using libimagequant as a higher quality quantization option in `Image.quantize()` on Unix-like platforms. This support requires building Pillow from source against libimagequant. We cannot distribute binaries due to licensing differences.

6.12.2 New Setup.py options

There are two new options to control the `build_ext` task in `setup.py`:

- `--debug` dumps all of the directories and files that are checked when searching for libraries or headers when building the extensions.
- `--disable-platform-guessing` removes many of the directories that are checked for libraries and headers for build systems or cross compilers that specify that information in via environment variables.

6.12.3 Resizing

Image resampling for 8-bit per channel images was rewritten using only integer computings. This is faster on most platforms and doesn't introduce precision errors on the wide range of scales. With other performance improvements, this makes resampling 60% faster on average.

Color calculation for images in the `LA` mode on semitransparent pixels was fixed.

6.12.4 Rotation

Rotation for angles divisible by 90 degrees now always uses transposition. This greatly improves both quality and performance in this case. Also, the bug with wrong image size calculation when rotating by 90 degrees was fixed.

6.12.5 Image Metadata

The return type for binary data in version 2 Exif and Tiff metadata has been changed from a tuple of integers to bytes. This is a change from the behavior since `3.0.0`.

6.13 3.2.0

6.13.1 New DDS and FTEX Image Plugins

The `DdsImagePlugin` reading DXT1 and DXT5 encoded `.dds` images was added. DXT3 images are not currently supported.

The `FtexImagePlugin` reads textures used for 3D objects in Independence War 2: Edge Of Chaos. The plugin reads a single texture per file, in the `.ftc` (compressed) and `.ftu` (uncompressed) formats.

6.13.2 Updates to the GbrImagePlugin

The `GbrImagePlugin` (GIMP brush format) has been updated to fix support for version 1 files and add support for version 2 files.

6.13.3 Passthrough Parameters for ImageDraw.text

`ImageDraw.multiline_text` and `ImageDraw.multiline_size` take extra spacing parameters above what are used in `ImageDraw.text` and `ImageDraw.size`. These parameters can now be passed into `ImageDraw.text` and `ImageDraw.size` and they will be passed through to the corresponding multiline functions.

6.13.4 ImageSequence.Iterator changes

`ImageSequence.Iterator` is now an actual iterator implementing the Iterator protocol. It is also now possible to seek to the first image of the file when using direct indexing.

6.14 3.1.2

6.14.1 CVE-2016-3076 – Buffer overflow in Jpeg2KEncode.c

Pillow between 2.5.0 and 3.1.1 may overflow a buffer when writing large Jpeg2000 files, allowing for code execution or other memory corruption.

This occurs specifically in the function `j2k_encode_entry`, at the line:

```
state->buffer = malloc (tile_width * tile_height * components * prec / 8);
```

This vulnerability requires a particular value for `height * width` such that `height * width * components * precision` overflows, at which point the malloc will be for a smaller value than expected. The buffer that is allocated will be `((height * width * components * precision) mod (2^31) / 8)`, where components is 1-4 and precision is either 8 or 16. Common values would be 4 components at precision 8 for a standard `RGBA` image.

The unpackers then split an image that is laid out:

```
RGBARGBARGBA....
```

into:

```
RRR.
GGG.
BBB.
AAA.
```

If this buffer is smaller than expected, the jpeg2k unpacker functions will write outside the allocation and onto the heap, corrupting memory.

This issue was found by Alyssa Besseling at Atlassian.

6.15 3.1.1

6.15.1 CVE-2016-0740 – Buffer overflow in TiffDecode.c

Pillow 3.1.0 and earlier when linked against libtiff >= 4.0.0 on x64 may overflow a buffer when reading a specially crafted tiff file.

Specifically, libtiff >= 4.0.0 changed the return type of `TIFFScanlineSize` from `int32` to machine dependent `int32|64`. If the scanline is sized so that it overflows an `int32`, it may be interpreted as a negative number, which will then pass the size check in `TiffDecode.c` line 236. To do this, the logical scanline size has to be > 2gb, and for the test file, the allocated buffer size is 64k against a roughly 4gb scan line size. Any image data over 64k is written over the heap, causing a segfault.

This issue was found by security researcher FourOne.

6.15.2 CVE-2016-0775 – Buffer overflow in FliDecode.c

In all versions of Pillow, dating back at least to the last PIL 1.1.7 release, FliDecode.c has a buffer overflow error.

Around line 192:

```
case 16:
    /* COPY chunk */
    for (y = 0; y < state->ysize; y++) {
        UINT8* buf = (UINT8*) im->image[y];
        memcpy(buf+x, data, state->xsize);
        data += state->xsize;
    }
    break;
```

The memcpy has error where `x` is added to the target buffer address. `X` is used in several internal temporary variable roles, but can take a value up to the width of the image. `Im->image[y]` is a set of row pointers to segments of memory that are the size of the row. At the max `y`, this will write the contents of the line off the end of the memory buffer, causing a segfault.

This issue was found by Alyssa Besseling at Atlassian

6.15.3 CVE-2016-2533 – Buffer overflow in PcdDecode.c

In all versions of Pillow, dating back at least to the last PIL 1.1.7 release, `PcdDecode.c` has a buffer overflow error.

The `state.buffer` for `PcdDecode.c` is allocated based on a 3 bytes per pixel sizing, where `PcdDecode.c` wrote into the buffer assuming 4 bytes per pixel. This writes 768 bytes beyond the end of the buffer into other Python object storage. In some cases, this causes a segfault, in others an internal Python malloc error.

6.15.4 Integer overflow in Resample.c

If a large value was passed into the new size for an image, it is possible to overflow an int32 value passed into malloc.

kk = malloc(xsize * kmax * sizeof(float)); . . . xbounds = malloc(xsize * 2 * sizeof(int));

`xsize` is trusted user input. These multiplications can overflow, leading the malloc'd buffer to be undersized. These allocations are followed by a loop that writes out of bounds. This can lead to corruption on the heap of the Python process with attacker controlled float data.

This issue was found by Ned Williamson.

6.16 3.1.0

6.16.1 ImageDraw arc, chord and pieslice can now use floats

There is no longer a need to ensure that the start and end arguments for *arc*, *chord* and *pieslice* are integers.

Note that these numbers are not simply rounded internally, but are actually utilised in the drawing process.

6.16.2 Consistent multiline text spacing

When using the `ImageDraw` multiline methods, the spacing between lines was inconsistent, based on the combination on ascenders and descenders.

This has now been fixed, so that lines are offset by their baselines, not the absolute height of each line.

There is also now a default spacing of 4px between lines.

6.16.3 Exif, Jpeg and Tiff Metadata

There were major changes in the TIFF ImageFileDirectory support in Pillow 3.0 that led to a number of regressions. Some of them have been fixed in Pillow 3.1, and some of them have been extended to have different behavior.

TiffImagePlugin.IFDRational

Pillow 3.0 changed rational metadata to use a float. In Pillow 3.1, this has changed to allow the expression of 0/0 as a valid piece of rational metadata to reflect usage in the wild.

Rational metadata is now encapsulated in an `IFDRational` instance. This class extends the Rational class to allow a denominator of 0. It compares as a float or a number, but does allow access to the raw numerator and denominator values through attributes.

When used in a `ImageFileDirectory_v1`, a 2 item tuple is returned of the numerator and denominator, as was done previously.

This class should be used when adding a rational value to an ImageFileDirectory for saving to image metadata.

JpegImagePlugin._getexif

In Pillow 3.0, the dictionary returned from the private, experimental, but generally widely used `_getexif` function changed to reflect the ImageFileDirectory_v2 format, without a fallback to the previous format.

In Pillow 3.1, `_getexif` now returns a dictionary compatible with Pillow 2.9 and earlier, built with `ImageFileDirectory_v1` instances. Additionally, any single item tuples have been unwrapped and return a bare element.

The format returned by Pillow 3.0 has been abandoned. A more fully featured interface for EXIF is anticipated in a future release.

Out of Spec Metadata

In Pillow 3.0 and 3.1, images that contain metadata that is internally consistent, but not in agreement with the TIFF spec, may cause an exception when reading the metadata. This can happen when a tag that is specified to have a single value is stored with an array of values.

It is anticipated that this behavior will change in future releases.

6.17 3.0.0

6.17.1 Saving Multipage Images

There is now support for saving multipage images in the *GIF* and *PDF* formats. To enable this functionality, pass in *save_all=True* as a keyword argument to the save:

```
im.save('test.pdf', save_all=True)
```

6.17.2 Tiff ImageFileDirectory Rewrite

The Tiff ImageFileDirectory metadata code has been rewritten. Where previously it returned a somewhat arbitrary set of values and tuples, it now returns bare values where appropriate and tuples when the metadata item is a sequence or collection.

The original metadata is still available in the TiffImage.tags, the new values are available in the TiffImage.tags_v2 member. The old structures will be deprecated at some point in the future. When saving Tiff metadata, new code should use the TiffImagePlugin.ImageFileDirectory_v2 class.

6.17.3 Deprecated Methods

Several methods that have been marked as deprecated for many releases have been removed in this release:

```
Image.tostring()
Image.fromstring()
Image.offset()
ImageDraw.setink()
ImageDraw.setfill()
```

(continues on next page)

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```
The ImageFileIO module
The ImageFont.FreeTypeFont and ImageFont.truetype `file` keyword arg
The ImagePalette private _make functions
ImageWin.fromstring()
ImageWin.tostring()
```

6.17.4 LibJpeg and Zlib are Required by Default

The external dependencies on libjpeg and zlib are now required by default. If the headers or libraries are not found, then installation will abort with an error. This behaviour can be disabled with the `--disable-libjpeg` and `--disable-zlib` flags.

6.18 2.8.0

6.18.1 Open HTTP response objects with Image.open

HTTP response objects returned from *urllib2.urlopen(url)* or *requests.get(url, stream=True).raw* are 'file-like' but do not support *.seek()* operations. As a result PIL was unable to open them as images, requiring a wrap in *cStringIO* or *BytesIO*.

Now new functionality has been added to *Image.open()* by way of an *.seek(0)* check and catch on exception *AttributeError* or *io.UnsupportedOperation*. If this is caught we attempt to wrap the object using *io.BytesIO* (which will only work on buffer-file-like objects).

This allows opening of files using both *urllib2* and *requests*, e.g.:

```
Image.open(urllib2.urlopen(url))
Image.open(requests.get(url, stream=True).raw)
```

If the response uses content-encoding (compression, either gzip or deflate) then this will fail as both the urllib2 and requests raw file object will produce compressed data in that case. Using Content-Encoding on images is rather non-sensical as most images are already compressed, but it can still happen.

For requests the work-around is to set the decode_content attribute on the raw object to True:

```
response = requests.get(url, stream=True)
response.raw.decode_content = True
image = Image.open(response.raw)
```

6.19 2.7.0

6.19.1 Sane Plugin

The Sane plugin has now been split into its own repo: https://github.com/python-pillow/Sane .

6.19.2 Png text chunk size limits

To prevent potential denial of service attacks using compressed text chunks, there are now limits to the decompressed size of text chunks decoded from PNG images. If the limits are exceeded when opening a PNG image a `ValueError`

will be raised.

Individual text chunks are limited to `PIL.PngImagePlugin.MAX_TEXT_CHUNK`, set to 1MB by default. The total decompressed size of all text chunks is limited to `PIL.PngImagePlugin.MAX_TEXT_MEMORY`, which defaults to 64MB. These values can be changed prior to opening PNG images if you know that there are large text blocks that are desired.

6.19.3 Image resizing filters

Image resizing methods `resize()` and `thumbnail()` take a *resample* argument, which tells which filter should be used for resampling. Possible values are: `PIL.Image.NEAREST`, `PIL.Image.BILINEAR`, `PIL.Image.BICUBIC` and `PIL.Image.ANTIALIAS`. Almost all of them were changed in this version.

Bicubic and bilinear downscaling

From the beginning `BILINEAR` and `BICUBIC` filters were based on affine transformations and used a fixed number of pixels from the source image for every destination pixel (2x2 pixels for `BILINEAR` and 4x4 for `BICUBIC`). This gave an unsatisfactory result for downscaling. At the same time, a high quality convolutions-based algorithm with flexible kernel was used for `ANTIALIAS` filter.

Starting from Pillow 2.7.0, a high quality convolutions-based algorithm is used for all of these three filters.

If you have previously used any tricks to maintain quality when downscaling with `BILINEAR` and `BICUBIC` filters (for example, reducing within several steps), they are unnecessary now.

Antialias renamed to Lanczos

A new `PIL.Image.LANCZOS` constant was added instead of `ANTIALIAS`.

When `ANTIALIAS` was initially added, it was the only high-quality filter based on convolutions. It's name was supposed to reflect this. Starting from Pillow 2.7.0 all resize method are based on convolutions. All of them are antialias from now on. And the real name of the `ANTIALIAS` filter is Lanczos filter.

The `ANTIALIAS` constant is left for backward compatibility and is an alias for `LANCZOS`.

Lanczos upscaling quality

The image upscaling quality with `LANCZOS` filter was almost the same as `BILINEAR` due to bug. This has been fixed.

Bicubic upscaling quality

The `BICUBIC` filter for affine transformations produced sharp, slightly pixelated image for upscaling. Bicubic for convolutions is more soft.

Resize performance

In most cases, convolution is more a expensive algorithm for downscaling because it takes into account all the pixels of source image. Therefore `BILINEAR` and `BICUBIC` filters' performance can be lower than before. On the other hand the quality of `BILINEAR` and `BICUBIC` was close to `NEAREST`. So if such quality is suitable for your tasks you can switch to `NEAREST` filter for downscaling, which will give a huge improvement in performance.

At the same time performance of convolution resampling for downscaling has been improved by around a factor of two compared to the previous version. The upscaling performance of the `LANCZOS` filter has remained the same. For `BILINEAR` filter it has improved by 1.5 times and for `BICUBIC` by four times.

Default filter for thumbnails

In Pillow 2.5 the default filter for `thumbnail()` was changed from `NEAREST` to `ANTIALIAS`. Antialias was chosen because all the other filters gave poor quality for reduction. Starting from Pillow 2.7.0, `ANTIALIAS` has been replaced with `BICUBIC`, because it's faster and `ANTIALIAS` doesn't give any advantages after downscaling with libjpeg, which uses supersampling internally, not convolutions.

6.19.4 Image transposition

A new method `PIL.Image.TRANSPOSE` has been added for the `transpose()` operation in addition to `FLIP_LEFT_RIGHT`, `FLIP_TOP_BOTTOM`, `ROTATE_90`, `ROTATE_180`, `ROTATE_270`. `TRANSPOSE` is an algebra transpose, with an image reflected across its main diagonal.

The speed of `ROTATE_90`, `ROTATE_270` and `TRANSPOSE` has been significantly improved for large images which don't fit in the processor cache.

6.19.5 Gaussian blur and unsharp mask

The *GaussianBlur()* implementation has been replaced with a sequential application of box filters. The new implementation is based on "Theoretical foundations of Gaussian convolution by extended box filtering" from the Mathematical Image Analysis Group. As *UnsharpMask()* implementations use Gaussian blur internally, all changes from this chapter are also applicable to it.

Blur radius

There was an error in the previous version of Pillow, where blur radius (the standard deviation of Gaussian) actually meant blur diameter. For example, to blur an image with actual radius 5 you were forced to use value 10. This has been fixed. Now the meaning of the radius is the same as in other software.

If you used a Gaussian blur with some radius value, you need to divide this value by two.

Blur performance

Box filter computation time is constant relative to the radius and depends on source image size only. Because the new Gaussian blur implementation is based on box filter, its computation time also doesn't depend on the blur radius.

For example, previously, if the execution time for a given test image was 1 second for radius 1, 3.6 seconds for radius 10 and 17 seconds for 50, now blur with any radius on same image is executed for 0.2 seconds.

Blur quality

The previous implementation takes into account only source pixels within 2 * standard deviation radius for every destination pixel. This was not enough, so the quality was worse compared to other Gaussian blur software.

The new implementation does not have this drawback.

6.19.6 TIFF Parameter Changes

Several kwarg parameters for saving TIFF images were previously specified as strings with included spaces (e.g. 'x resolution'). This was difficult to use as kwargs without constructing and passing a dictionary. These parameters now use the underscore character instead of space. (e.g. 'x_resolution')

CHAPTER 7

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