Install guide: Raspberry Pi 3 + Raspbian Jessie + OpenCV 3

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by Adrian Rosebrock on April 18, 2016 in OpenCV, Raspberry Pi, Tutorials

Can you believe it’ s been over ***four years*** since the original Raspberry Pi model B was released? Back then the Pi Model B shipped with only 256MB of RAM and a 700MHz single core processor.

Just over ***one year ago*** the Raspberry Pi 2 was unleashed on the world. And man, for something called a *"Pi"*, this beast made an impact on the computer world like an asteroid. This board sported 1GB of RAM and a 900MHz ***quad-core*** processor — quite the upgrade from the original single core, 700MHz system!

In my opinion, ***the Raspberry Pi 2 is what made computer vision possible on the Pi platform*** (at least from a Python + OpenCV perspective). The original model B simply didn't have the processing capacity (or the RAM) to be powerful enough to process images video streams for anything more than trivial operations — *the Pi 2 changed all that.*

In fact, the Raspberry Pi 2 had *such a meaningful impact* on the computer vision space, that I even took the time to make a *all* code examples in *Practical Python and OpenCV* compatible with the Pi.

And now we have the Raspberry Pi 3:

- 1.2Ghz 64-bit quad-core processor.
- 1GB RAM.
- Integrated 802.11n wireless and bluetooth.

Personally, I was hoping for a bit more RAM (perhaps in the range of 1.5-2GB). But upgrading to a *64-bit processor* with *33% increased performance* is *well worth it*.

Just as I have done in previous blog posts, I'll be demonstrating **how to install OpenCV 3 with Python bindings on Raspbian Jessie**.

If you are looking for previous installation instructions for different platforms, please consult this list:

- How to install OpenCV 3.0 on ***Raspbian Jessie***.
- Installing OpenCV on your *Raspberry Pi Zero* running ***Raspbian Jessie***.
- Installing OpenCV 3.0 for both Python 2.7 and Python 3+ on ***Raspbian Wheezy.***
- Install OpenCV 2.4 for Python 2.7 on ***Raspbian Wheezy***.

Otherwise, let's proceed with getting OpenCV 3 installed on your brand new Raspberry Pi 3!

Assumptions

In this tutorial, I am going to assume that you already own a **Raspberry Pi 3** with **Raspbian Jessie installed**.

You should also have *either*:

- *Physical access* to your Raspberry Pi 3 so that you can open up a terminal and execute commands.
- *Remote access* via SSH.

I’ll be doing the majority of this tutorial via SSH, but as long as you have access to a terminal, you can easily follow along.

Installing OpenCV 3 on a Raspberry Pi 3 running Raspbian Jessie

If you’ve ever installed OpenCV on a Raspberry Pi (or any other platform before), you know that the process can be quite time consuming with many dependencies and pre-requisites that have to be installed. **The goal of this tutorial is to thus guide you step-by-step through the compile and installation process.**

In order to make the installation process go more smoothly, I’ve included timings for each step so you know when to take a break, grab a cup of coffee, and checkup on email while the Pi compiles OpenCV. That said, the *Pi 3 is substantially faster than the Pi 2*, so the time it takes to compile OpenCV has decreased ***dramatically.***

Anyway, let’s go ahead and get started installing OpenCV 3 on your brand new Raspberry Pi 3 running Raspbian Jessie.

Step #1: Expand filesystem

Are you using a *brand new* install of Raspbian Jessie?

If so, the first thing you should do is expand your filesystem to include *all available space* on your micro-SD card:

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Shell

```
$ sudo raspi-config
```

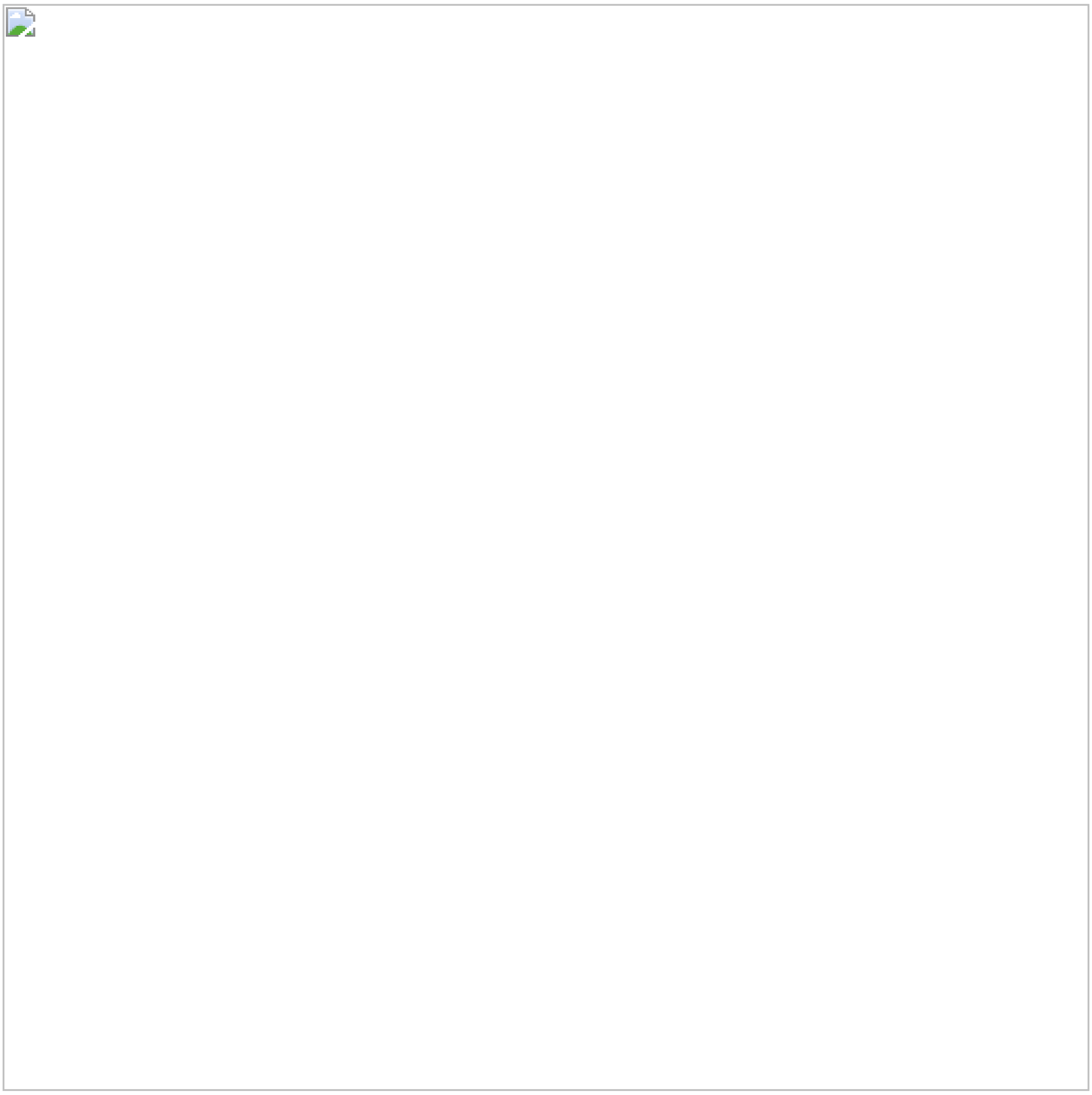

Figure 1: Expanding the filesystem on your Raspberry Pi 3.

Once prompted, you should select the first option, ***"1. Expand File System"*** , ***hit Enter*** on your keyboard, arrow down to the ***"<Finish>"*** button, and then reboot your Pi:

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Shell

```
$ sudo reboot
```

After rebooting, your file system should have been expanded to include all available space on your micro-SD card. You can verify that the disk has been expanded by executing `df -h` and examining the output:

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Shell

```
$ df -h
Filesystem      Size  Used Avail Use% Mounted on
```

```
/dev/root       7.2G  3.3G  3.6G  48% /
devtmpfs        459M     0  459M   0% /dev
tmpfs           463M     0  463M   0% /dev/shm
tmpfs           463M  6.4M  457M   2% /run
tmpfs           5.0M  4.0K  5.0M   1% /run/lock
tmpfs           463M     0  463M   0% /sys/fs/cgroup
/dev/mmcblk0p1   60M   20M   41M  34% /boot
tmpfs            93M     0   93M   0% /run/user/1000
```

As you can see, my Raspbian filesystem has been expanded to include all 8GB of the micro-SD card.

However, even with my filesystem expanded, I have already used 48% of my 8GB card!

OpenCV, along with all its dependencies, will need a few gigabytes during the compile, so you should delete the Wolfram engine to free up some space on your Pi:

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Shell

```
$ sudo apt-get purge wolfram-engine
```

After removing the Wolfram Engine, *you can reclaim almost 700mb!*

Step #2: Install dependencies

This isn' t the first time I' ve discussed how to install OpenCV on the Raspberry Pi, so I' ll keep these instructions on the briefer side, allowing you to work through the installation process: I' ve also included the ***amount of time it takes to execute each command*** so you can plan your OpenCV + Raspberry Pi 3 install accordingly (OpenCV itself takes **1h 12m** to compile).

The first step is to update and upgrade any existing packages:

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Shell

```
$ sudo apt-get update
$ sudo apt-get upgrade
```

Timing: 1m 26s

We then need to install some developer tools, including CMake, which helps us configure the OpenCV build process:

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Shell

```
$ sudo apt-get install build-essential cmake pkg-config
```

Timing: 40s

Next, we need to install some image I/O packages that allow us to load various image file formats from disk. Examples of such file formats include JPEG, PNG, TIFF, etc.:

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Python

```
$ sudo apt-get install libjpeg-dev libtiff5-dev libjasper-dev libpng12-dev
```

Timing: 32s

Just as we need image I/O packages, we also need video I/O packages. These libraries allow us to read various video file formats from disk as well as work directly with video streams:

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Shell

```
$ sudo apt-get install libavcodec-dev libavformat-dev libswscale-dev libv4l-dev
$ sudo apt-get install libxvidcore-dev libx264-dev
```

Timing: 34s

The OpenCV library comes with a sub-module named `highgui` which is used to display images to our screen and build basic GUIs. In order to compile the `highgui` module, we need to install the GTK development library:

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Shell

```
$ sudo apt-get install libgtk2.0-dev
```

Timing: 3m 6s

Many operations inside of OpenCV (namely matrix operations) can be optimized further by installing a few extra dependencies:

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Shell

```
$ sudo apt-get install libatlas-base-dev gfortran
```

Timing: 46s

These optimization libraries are *especially important* for resource constrained devices such as the Raspberry Pi.

Lastly, let’ s install both the Python 2.7 and Python 3 header files so we can compile OpenCV with Python bindings:

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Shell

```
$ sudo apt-get install python2.7-dev python3-dev
```

Timing: 45s

If you skip this step, you may notice an error related to the `Python.h` header file not being found when running `make` to compile OpenCV.

Step #3: Download the OpenCV source code

Now that we have our dependencies installed, let’ s grab the `3.1.0` archive of OpenCV from the official [OpenCV repository](). (*Note:* As future versions of openCV are released, you can replace `3.1.0` with the latest version number):

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Shell

```
$ cd ~
$ wget -O opencv.zip https://github.com/Itseez/opencv/archive/3.1.0.zip
$ unzip opencv.zip
```

Timing: 1m 26s

We’ ll want the *full install* of OpenCV 3 (to have access to features such as SIFT and SURF, for instance), so we also need to grab the opencv_contrib repository as well:

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Shell

```
$ wget -O opencv_contrib.zip https://github.com/Itseez/opencv_contrib/archive/3.1.
$ unzip opencv_contrib.zip
```

Timing: 43s

You might need to expand the command above using the “<=>” button during your copy and paste. The `.zip` in the `3.1.0.zip` may appear to be cutoff in some browsers. The full URL of the OpenCV 3.1.0 archive is: https://github.com/Itseez/opencv_contrib/archive/3.1.0.zip

***Note:** Make sure your `opencv` and `opencv_contrib` versions are the same (in this case, `3.1.0`). If the versions numbers do not match up, then you’ ll likely run into either compile-time or runtime.*

Step #4: Python 2.7 or Python 3?

Before we can start compiling OpenCV on our Raspberry Pi 3, we first need to install `pip`, a Python package manager:

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Shell

```
$ wget https://bootstrap.pypa.io/get-pip.py
$ sudo python get-pip.py
```

Timing: 20s

If you’re a longtime PyImageSearch reader, then you’ll know that I’m a *huge fan* of both virtualenv and virtualenvwrapper. Installing these packages is not a requirement and you can *absolutely* get OpenCV installed without them, but that said, ***I highly recommend you install them*** as other PyImageSearch tutorials in the future will also leverage Python virtual environments. I’ll also be assuming that you have both `virtualenv` and `virtualenvwrapper` installed throughout the remainder of this guide.

So, given that, what’s the point of using `virtualenv` and `virtualenvwrapper`?

First, it’s important to understand that a virtual environment is a *special tool* used to keep the dependencies required by different projects in separate places by creating *isolated, independent* Python environments for each of them.

In short, it solves the *“Project X depends on version 1.x, but Project Y needs 4.x”* dilemma. It also keeps your global `site-packages` neat, tidy, and free from clutter.

If you would like a full explanation on why Python virtual environments are good practice, absolutely give this excellent blog post on RealPython a read.

It’s ***standard practice*** in the Python community to be using virtual environments of some sort, so I *highly recommend* that you do the same:

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Shell

```
$ sudo pip install virtualenv virtualenvwrapper
$ sudo rm -rf ~/.cache/pip
```

Timing: 9s

Now that both `virtualenv` and `virtualenvwrapper` have been installed, we need to update our `~/.profile` file to include the following lines at the *bottom* of the file:

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Shell

```
# virtualenv and virtualenvwrapper
export WORKON_HOME=$HOME/.virtualenvs
source /usr/local/bin/virtualenvwrapper.sh
```

In previous tutorials, I' ve recommended using your favorite terminal-based text editor such as `vim` , `emacs` , or `nano` to update the `~/.profile` file. If you' re comfortable with these editors, go ahead and update the file to reflect the changes mentioned above.

Otherwise, you should simply use `cat` and output redirection to handle updating `~/.profile` :

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Shell

```
$ echo -e "\n# virtualenv and virtualenvwrapper" >> ~/.profile
$ echo "export WORKON_HOME=$HOME/.virtualenvs" >> ~/.profile
$ echo "source /usr/local/bin/virtualenvwrapper.sh" >> ~/.profile
```

Now that we have our `~/.profile` updated, we need to reload it to make sure the changes take affect. You can force a reload of your `~/.profile` file by:

1. Logging out and then logging back in.
2. Closing a terminal instance and opening up a new one
3. Or my personal favorite, ***just use the*** `source` ***command:***

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Shell

```
$ source ~/.profile
```

Note: *I recommend running the* `source ~/.profile` *file* **each time** *you open up a new terminal to ensure your system variables have been setup correctly.*

Creating your Python virtual environment

Next, let' s create the Python virtual environment that we' ll use for computer vision development:

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Shell

```
$ mkvirtualenv cv -p python2
```

This command will create a new Python virtual environment named `cv` using ***Python 2.7***.

If you instead want to use ***Python 3***, you’ ll want to use this command instead:

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Shell

```
$ mkvirtualenv cv -p python3
```

Again, ***I can’ t stress this point enough:*** the `cv` Python virtual environment is ***entirely independent and sequestered*** from the default Python version included in the download of Raspbian Jessie. Any Python packages in the *global* `site-packages` directory *will not* be available to the `cv` virtual environment. Similarly, any Python packages installed in `site-packages` of `cv` *will not* be available to the global install of Python. Keep this in mind when you’ re working in your Python virtual environment and it will help avoid a lot of confusion and headaches.

How to check if you’ re in the “cv” virtual environment

If you ever reboot your Raspberry Pi; log out and log back in; or open up a new terminal, you’ ll need to use the `workon` command to re-access the `cv` virtual environment. In previous blog posts, I’ ve seen readers use the `mkvirtualenv` command — ***this is entirely unneeded!*** The `mkvirtualenv` command is meant to be executed only once: to actually *create* the virtual environment.

After that, you can use `workon` and you’ ll be dropped down into your virtual environment:

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Shell

```
$ source ~/.profile
$ workon cv
```

To validate and ensure you are in the `cv` virtual environment, examine your command line — *if you see the text `(cv)` preceding your prompt, then you **are** in the `cv` virtual environment:*

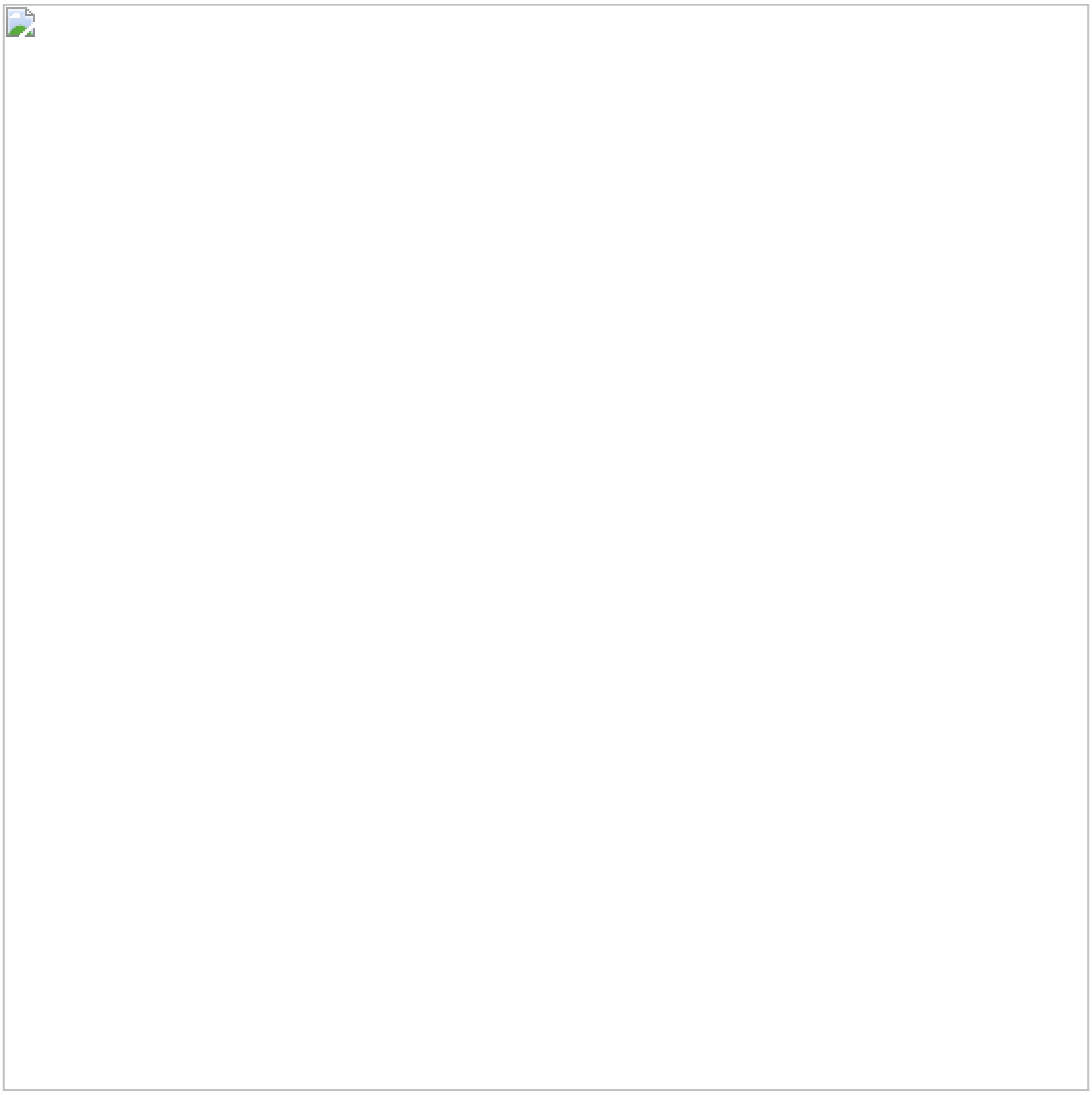

Figure 2: Make sure you see the *"(cv)"* text on your prompt, indicating that you ***are*** in the *cv* virtual environment.

Otherwise, if you ***do not*** see the `(cv)` text, then you ***are not*** in the `cv` virtual environment:

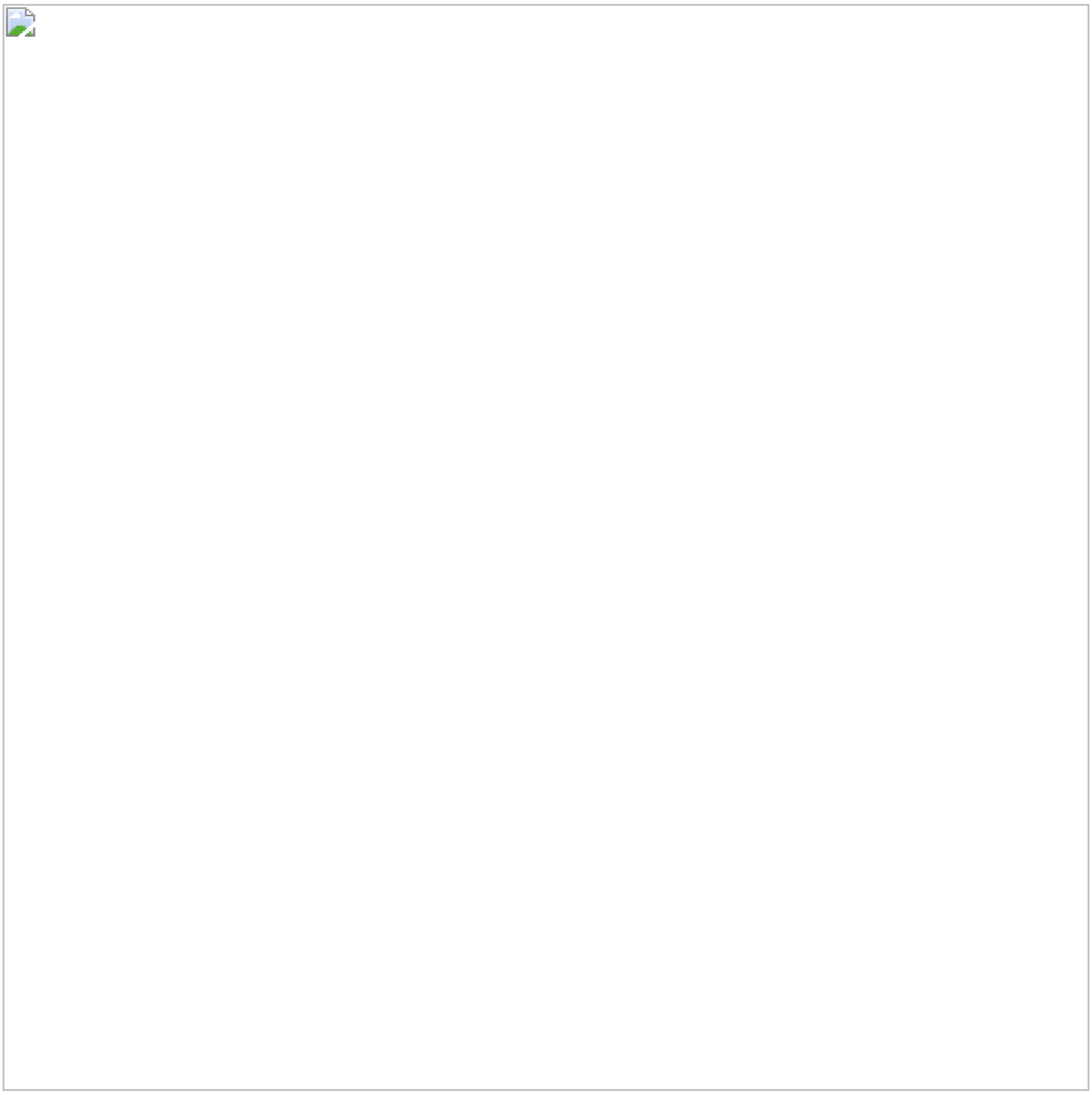

Figure 3: If you do not see the *"(cv)"* text on your prompt, then you ***are not*** in the *cv* virtual environment and need to run *"source"* and *"workon"* to resolve this issue.

To fix this, simply execute the `source` and `workon` commands mentioned above.

Installing NumPy on your Raspberry Pi

Assuming you' ve made it this far, you should now be in the `cv` virtual environment (which you should stay in for the rest of this tutorial). Our only Python dependency is NumPy, a Python package used for numerical processing:

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Shell

```
$ pip install numpy
```

Timing: 9m 39s

Be sure to grab a cup of coffee or go for a nice walk, the NumPy installation can take a bit of time.

Note: *Another question I’ve often seen is* ***“Help, my NumPy installation has hung and it’s not installing!”*** *Actually, it is installing, it just takes time to pull down the sources and compile. Be patient. The Raspberry Pi isn’t as fast as your laptop/desktop.*

Step #5: Compile and Install OpenCV

We are now ready to compile and install OpenCV! Double-check that you are in the `cv` virtual environment by examining your prompt (you should see the `(cv)` text preceding it), and if not, simply execute `workon` :

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Shell

```
$ workon cv
```

Once you have ensured you are in the `cv` virtual environment, we can setup our build using CMake:

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Shell

```
$ cd ~/opencv-3.1.0/
$ mkdir build
$ cd build
$ cmake -D CMAKE_BUILD_TYPE=RELEASE \
    -D CMAKE_INSTALL_PREFIX=/usr/local \
    -D INSTALL_PYTHON_EXAMPLES=ON \
    -D OPENCV_EXTRA_MODULES_PATH=~/opencv_contrib-3.1.0/modules \
    -D BUILD_EXAMPLES=ON ..
```

Timing: 1m 57s

Now, before we move on to the actual compilation step, ***make sure you examine the output of CMake!***

Start by scrolling down the section titled `Python 2` and `Python 3` .

If you are compiling OpenCV 3 for Python 2.7, then make sure your `Python 2` section includes valid paths to the `Interpreter` , `Libraries` , `numpy` and `packages path` , similar to my screenshot below:

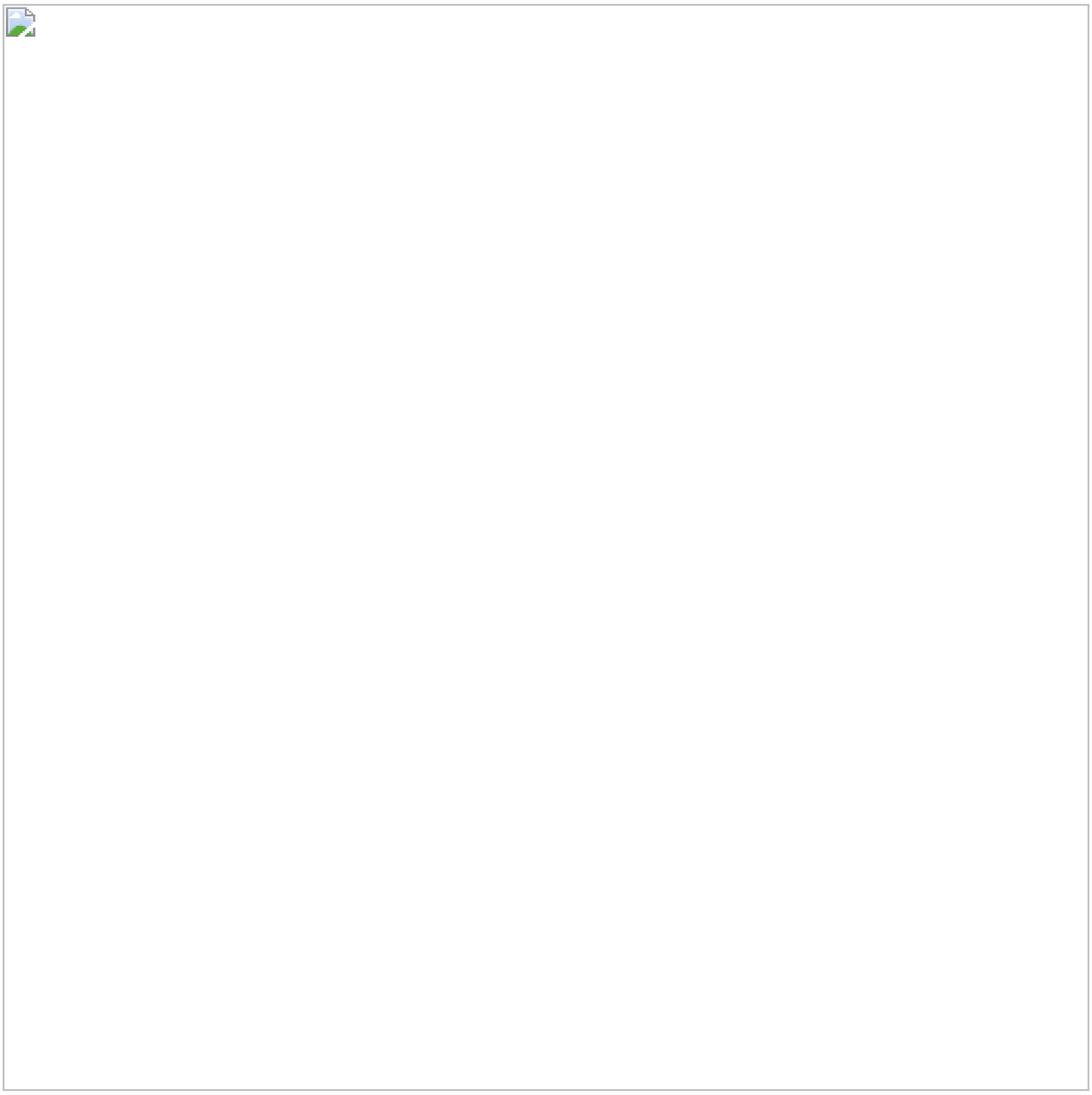

Figure 4: Ensuring that Python 2.7 will be used when compiling OpenCV 3 for Raspbian Jessie on the Raspberry Pi 3.

Notice how the `Interpreter` points to our `python2.7` binary located in the `cv` virtual environment. The `numpy` variable also points to the NumPy installation in the `cv` environment.

Similarly, ***if you’ re compiling OpenCV for Python 3***, make sure the `Python 3` section looks like the figure below:

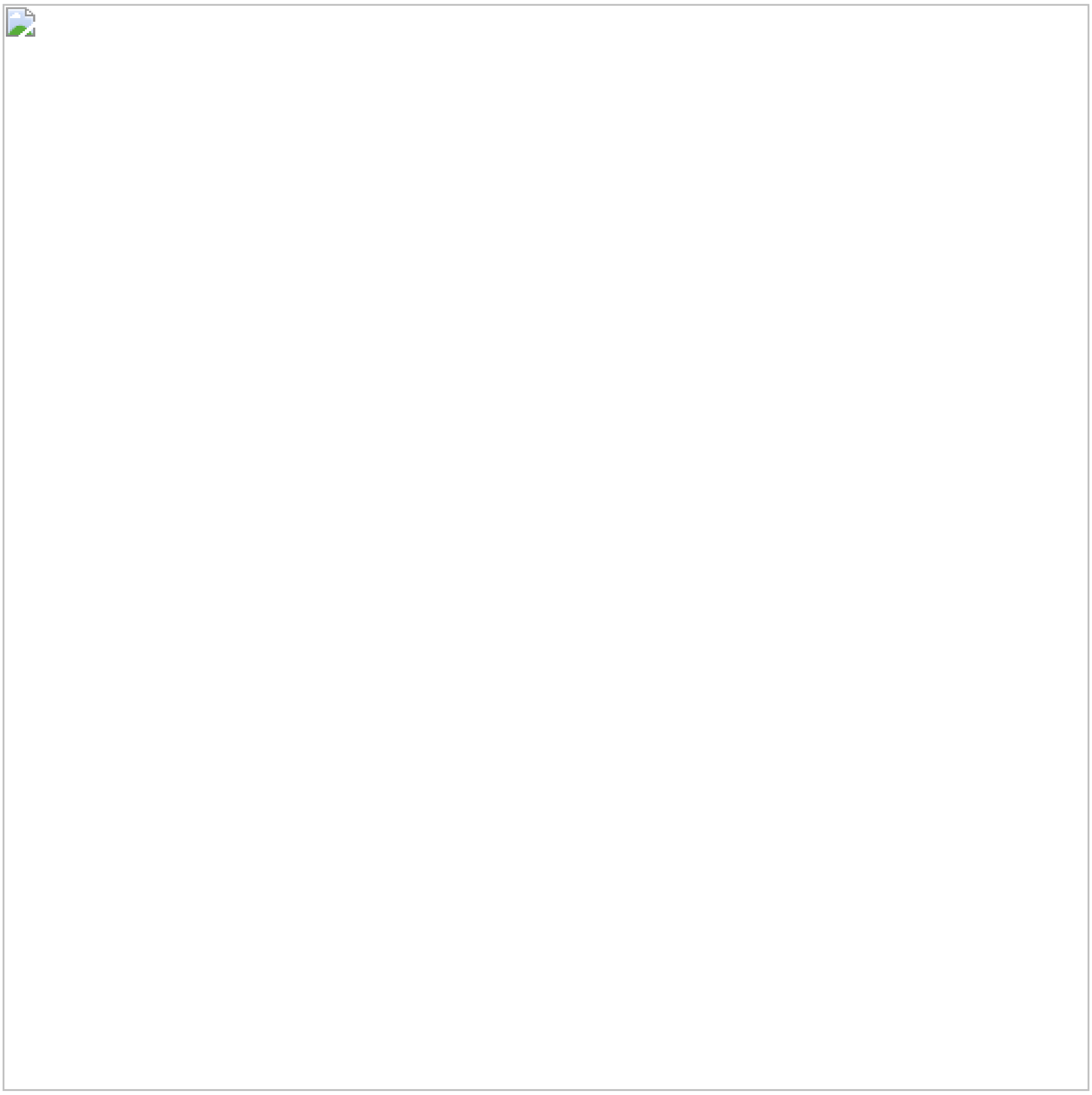

Figure 5: Checking that Python 3 will be used when compiling OpenCV 3 for Raspbian Jessie on the Raspberry Pi 3.

Again, the `Interpreter` points to our `python3.4` binary located in the `cv` virtual environment while `numpy` points to our NumPy install.

In either case, if you ***do not*** see the `cv` virtual environment in these variables paths, ***it’ s almost certainly because you are NOT in the*** `cv` ***virtual environment prior to running CMake!***

If this is the case, access the `cv` virtual environment using `workon cv` and re-run the `cmake` command outlined above.

Finally, we are now ready to compile OpenCV:

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Shell

```
$ make -j4
```

Timing: 1h 12m

***Note:** Compiling OpenCV in 72 minutes on the Raspberry Pi 3 is a **24%** improvement over the previous 95 minutes for the Raspberry Pi 2. That extra 300MHz makes a big difference!*

The `-j4` command controls the number of cores to leverage when compiling OpenCV 3. The Raspberry Pi 3 has *four cores*, thus we supply a value of `4` to allow OpenCV to compile faster.

However, due to race conditions, there are times when `make` errors out when using multiple cores. If this happens to you, I suggest starting the compilation over again and using only *one* core:

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Shell

```
$ make clean
$ make
```

Once OpenCV 3 has finished compiling, your output should look similar to mine below:

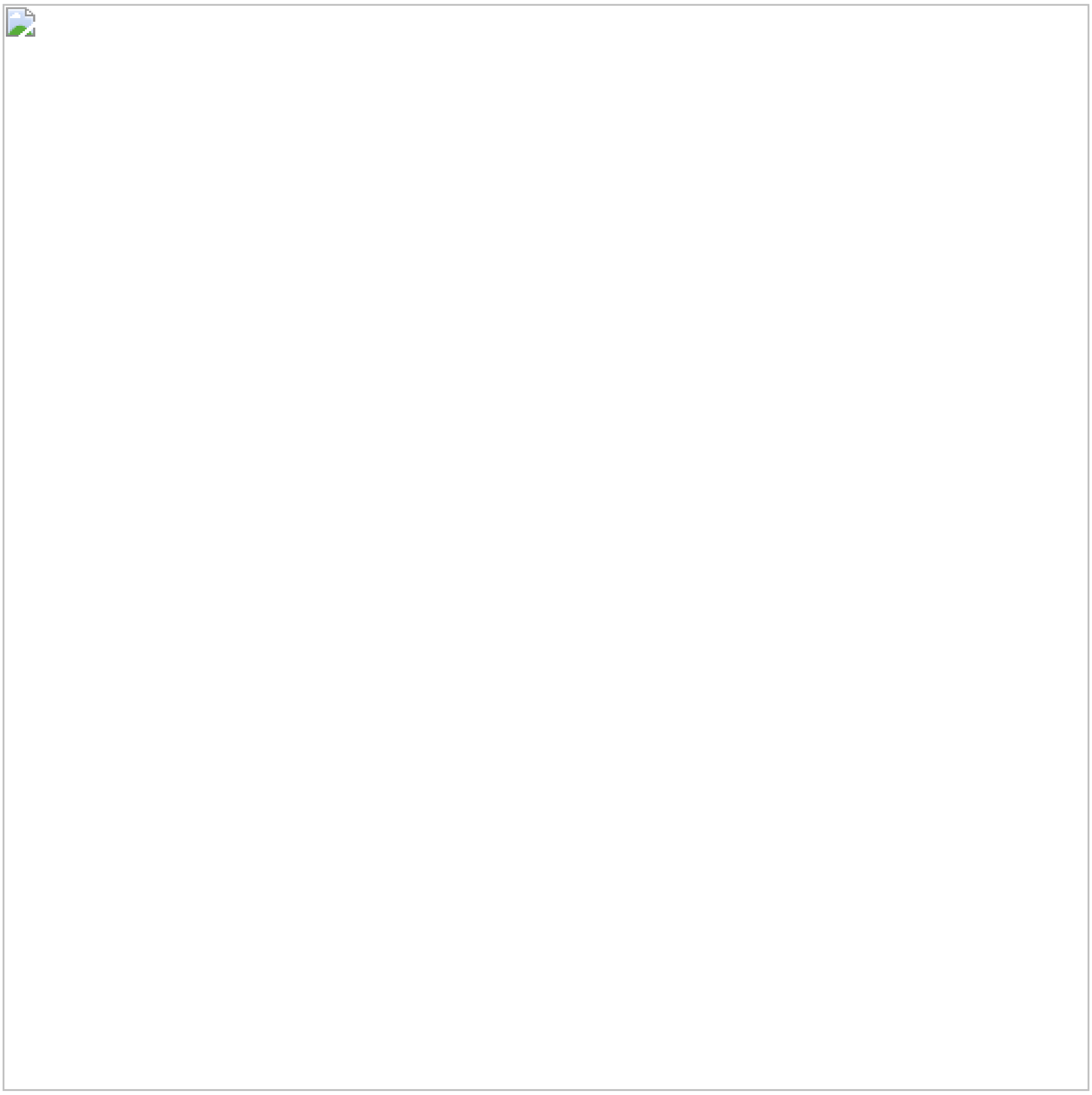

Figure 5: Our OpenCV 3 compile on Raspbian Jessie has completed successfully.

From there, all you need to do is install OpenCV 3 on your Raspberry Pi 3:

`Install guide: Raspberry Pi 3 + Raspbian Jessie + OpenCV 3`

Shell

```
$ sudo make install
$ sudo ldconfig
```

Timing: 52s

Step #6: Finish installing OpenCV on your Pi

We’ re almost done — just a few more steps to go and you’ ll be ready to use your Raspberry Pi 3 with OpenCV 3.

For Python 2.7:

Provided your **Step #5** finished without error, OpenCV should now be installed in `/usr/local/lib/python2.7/site-pacakges` . You can verify this using the `ls` command:

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Shell

```
$ ls -l /usr/local/lib/python2.7/site-packages/
total 1852
-rw-r--r-- 1 root staff 1895772 Mar 20 20:00 cv2.so
```

***Note:** In some cases, OpenCV can be installed in `/usr/local/lib/python2.7/dist-packages` (note the `dist-packages` rather than `site-packages`. If you do not find the `cv2.so` bindings in `site-packages`, we be sure to check `dist-packages`.*

Our final step is to sym-link the OpenCV bindings into our `cv` virtual environment for Python 2.7:

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Shell

```
$ cd ~/.virtualenvs/cv/lib/python2.7/site-packages/
$ ln -s /usr/local/lib/python2.7/site-packages/cv2.so cv2.so
```

For Python 3:

After running `make install`, your OpenCV + Python bindings should be installed in `/usr/local/lib/python3.4/site-packages`. Again, you can verify this with the `ls` command:

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Shell

```
$ ls -l /usr/local/lib/python3.4/site-packages/
total 1852
-rw-r--r-- 1 root staff 1895932 Mar 20 21:51 cv2.cpython-34m.so
```

I honestly don’ t know why, perhaps it’ s a bug in the CMake script, but when compiling OpenCV 3 bindings for Python 3+, the output `.so` file is named `cv2.cpython-34m.so` (or some variant of) rather than simply `cv2.so` (like in the Python 2.7 bindings).

Again, I’ m not sure exactly *why* this happens, but it’ s an easy fix. All we need to do is rename the file:

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Shell

```
$ cd /usr/local/lib/python3.4/site-packages/
$ sudo mv cv2.cpython-34m.so cv2.so
```

After renaming to `cv2.so`, we can sym-link our OpenCV bindings into the `cv` virtual environment for Python 3.4:

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Shell

```
$ cd ~/.virtualenvs/cv/lib/python3.4/site-packages/
$ ln -s /usr/local/lib/python3.4/site-packages/cv2.so cv2.so
```

Step #7: Testing your OpenCV 3 install

Congratulations, you now have OpenCV 3 installed on your Raspberry Pi 3 running Raspbian Jessie!

But before we pop the champagne and get drunk on our victory, let’ s first verify that your OpenCV installation is working properly.

Open up a new terminal, execute the `source` and `workon` commands, and then finally attempt to import the Python + OpenCV bindings:

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Shell

```
$ source ~/.profile
$ workon cv
$ python
>>> import cv2
>>> cv2.__version__
'3.1.0'
>>>
```

As you can see from the screenshot of my own terminal, **OpenCV 3 has been successfully installed on my Raspberry Pi 3 + Python 2.7 environment:**

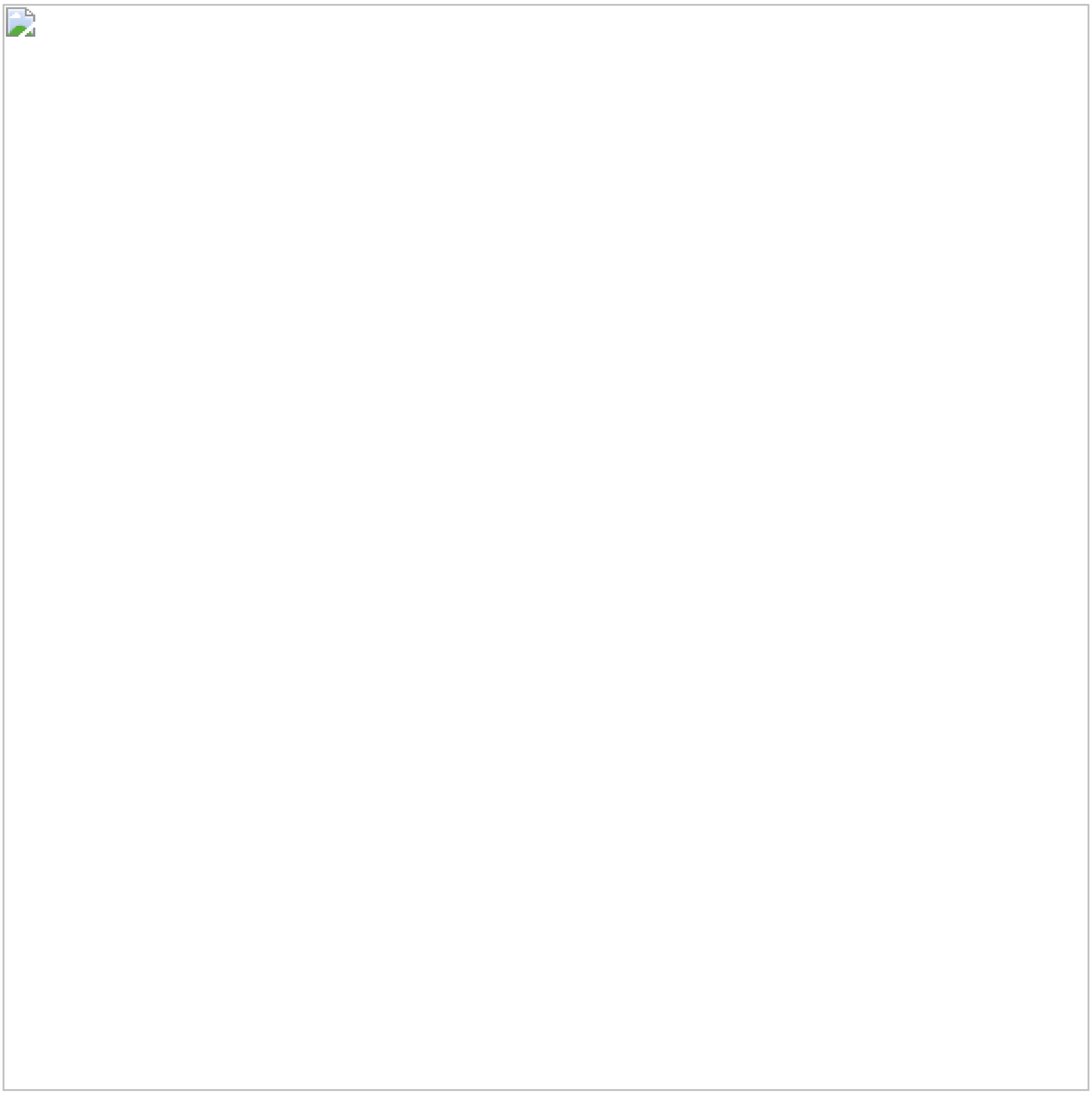

Figure 5: Confirming OpenCV 3 has been successfully installed on my Raspberry Pi 3 running Raspbian Jessie.

Once OpenCV has been installed, you can remove both the `opencv-3.1.0` and `opencv_contrib-3.1.0` directories to free up a bunch of space on your disk:

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Shell

```
$ rm -rf opencv-3.1.0 opencv_contrib-3.1.0
```

However, be cautious with this command! Make sure OpenCV has been properly installed on your system before blowing away these directories. A mistake here could cost you ***hours*** in compile time.

Troubleshooting and FAQ

Q. When I try to execute `mkvirtualenv` and `workon` , I get a “command not found error” .

A. There are three reasons why this could be happening, all of them related to **Step #4**:

1. Make certain that you have installed `virtualenv` and `virtualenvwrapper` via `pip` . You can check this by running `pip freeze` and then examining the output, ensuring you see occurrences of both `virtualenv` and `virtualenvwrapper` .
2. You might not have updated your `~/.profile` correctly. Use a text editor such as `nano` to view your `~/.profile` file and ensure that the proper `export` and `source` commands are present (again, check **Step #4** for the contents that should be appended to `~/.profile` .
3. You did not `source` your `~/.profile` after editing it, rebooting, opening a new terminal, etc. Any time you open a new terminal and want to use a virtual environment, make sure you execute `source ~/.profile` to load the contents — this will give you access to the `mkvirtualenv` and `workon` commands.

Q. After I open a new terminal, logout, or reboot my Pi, I cannot execute `mkvirtualenv` or `workon` .

A. See **reason #3** from the previous question.

Q. When I (1) open up a Python shell that imports OpenCV or (2) execute a Python script that calls OpenCV, I get an error: `ImportError: No module named cv2` .

A. Unfortunately, this error is extremely hard to diagnose, mainly because there are multiple issues that could be causing the problem. To start, make sure you are in the `cv` virtual environment by using `workon cv` . If the `workon` command fails, then see the first question in this FAQ. If you’ re *still* getting an error, investigate the contents of the `site-packages` directory for your `cv` virtual environment. You can find the `site-packages` directory in `~/.virtualenvs/cv/lib/python2.7/site-packages/` or `~/.virtualenvs/cv/lib/python3.4/site-packages/` (depending on which Python version you used for the install). Make sure that your sym-link to the `cv2.so` file is valid and points to an existing file.

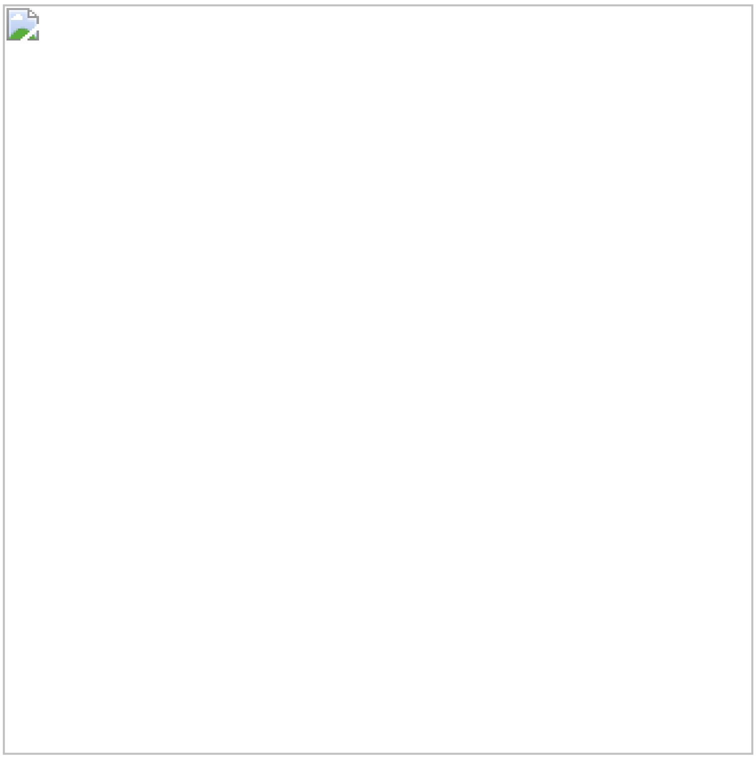
So, what’ s next?

Congrats! You have a brand new, fresh install of OpenCV on your Raspberry Pi — and I’ m sure you’ re just itching to leverage your Raspberry Pi to build some awesome computer vision apps.

But I’ m also willing to bet that *you’ re just getting started learning computer vision and OpenCV*, and you’ re probably feeling a bit confused and overwhelmed on where exactly to start.

Personally, I’ m a big fan of **learning by example**, so a good first step would be to read this blog post on accessing your Raspberry Pi Camera with the `picamera` module. This tutorial details the *exact steps* you need to take to (1) capture photos from the camera module and (2) access the raw video stream.

And if you’ re *really interested* in leveling-up your computer vision skills, you should definitely check out my book, *Practical Python and OpenCV + Case Studies*. My book not only *covers the basics of computer vision and image processing*, but also teaches you how to solve real world computer vision problems including ***face detection in images and video streams***, ***object tracking in video***, and ***handwriting recognition.***



All code examples covered in the book are guaranteed to run on the Raspberry Pi 2 and Pi 3 as well! Most programs will also run on the B+ and Zero models, but might be a bit slow due to the limited computing power of the B+ and Zero.

So let’s put your fresh install of OpenCV on your Raspberry Pi to good use — ***just click here to learn more about the real-world projects you can solve using your Raspberry Pi + Practical Python and OpenCV .***

Summary

In this blog post, we learned how to install ***OpenCV 3*** with either Python 2.7 or Python 3 bindings on your ***Raspberry Pi 3*** running ***Raspbian Jessie***.

If you are running a different version of Raspbian (such as *Raspbian Wheezy*) or want to install a different version of OpenCV (such as OpenCV 2.4), please consult the following tutorials:

- How to install OpenCV 3.0 on ***Raspbian Jessie***.
- Installing OpenCV on your *Raspberry Pi Zero* running ***Raspbian Jessie***.
- Installing OpenCV 3.0 for both Python 2.7 and Python 3+ on ***Raspbian Wheezy***.
- Install OpenCV 2.4 for Python 2.7 on ***Raspbian Wheezy***.

But before you go…

I tend to utilize the Raspberry Pi quite a bit on this blog, so if you’re interested in learning more about the Raspberry Pi + computer vision, ***enter your email address in the form below to be notified when these posts go live!***