Chapter 1: Introduction to Computer Vision and Raspberry Pi

Timeline of OpenCV

- Official launch of project: 1999
- Release of first alpha version: 2000
- Five beta versions: 2001-2005
- Corporate Support from Willow George: Mid 2008
- OpenCV 1.0: Oct 2008
- OpenCV 1.1 Pre-release: Oct 2009
- Development and maintenance was taken over by OpenCV.org: June 2015
- Intel Acquires Itseez: Nov 2018
- OpenCV 3.0: May 2016
- OpenCV 4.0: Nov 2018

Diagram: Venn diagram showing the intersection of Computer Vision, Machine Vision, and Artificial Intelligence.
<table>
<thead>
<tr>
<th><strong>Component</strong></th>
<th><strong>Specification</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>Broadcom BCM2711, Quad core Cortex-A72 (ARMv8) 64-bit SoC @ 1.5GHz</td>
</tr>
<tr>
<td>RAM</td>
<td>Depending on the model (1GB/2GB/4GB)</td>
</tr>
<tr>
<td>Network Connectivity</td>
<td>2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE, Gigabit Ethernet</td>
</tr>
<tr>
<td>USB</td>
<td>2 USB 3.0 ports; 2 USB 2.0 ports</td>
</tr>
<tr>
<td>GPIO Pins</td>
<td>Raspberry Pi standard 40 pin GPIO header, which is backward compatible</td>
</tr>
<tr>
<td>Video Output</td>
<td>2 x micro-HDMI ports that support up to 4k and 60 FPS</td>
</tr>
<tr>
<td>Data Storage</td>
<td>Micro-SD card slot for loading operating system and data storage</td>
</tr>
<tr>
<td>Power supply</td>
<td>3A 5V DC power through USB-C connector or GPIO header</td>
</tr>
<tr>
<td>DSI Display</td>
<td>2-lane MIPI DSI display port</td>
</tr>
<tr>
<td>Camera</td>
<td>2-lane MIPI CSI camera port</td>
</tr>
<tr>
<td>Audio</td>
<td>4-pole stereo audio</td>
</tr>
<tr>
<td>Graphics</td>
<td>Broadcom VideoCore VI @ 500 MHz</td>
</tr>
<tr>
<td>Component</td>
<td>Specification</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Processor</td>
<td>Broadcom BCM2835 (32-bit) ARMv6Z1 1 GHz Single core ARM1176JZF-S CPU</td>
</tr>
<tr>
<td>RAM</td>
<td>512 MB</td>
</tr>
<tr>
<td>Network Connectivity</td>
<td>802.11 b/g/n wireless LAN Bluetooth 4.1 Bluetooth Low Energy (BLE)</td>
</tr>
<tr>
<td>USB</td>
<td>One MiniUSB port</td>
</tr>
<tr>
<td>GPIO Pins</td>
<td>Raspberry Pi standard 40 pin GPIO header, which is backward compatible</td>
</tr>
<tr>
<td>Video Output</td>
<td>MiniHDMI</td>
</tr>
<tr>
<td>Data Storage</td>
<td>Micro-SD card slot for loading operating system and data storage</td>
</tr>
<tr>
<td>Power supply</td>
<td>2A 5V DC power through micro-USB connector or GPIO header</td>
</tr>
<tr>
<td>Camera</td>
<td>CSI camera connector</td>
</tr>
<tr>
<td>Audio</td>
<td>4-pole stereo audio</td>
</tr>
<tr>
<td>Graphics</td>
<td>Broadcom VideoCore IV @ 250 MHz</td>
</tr>
</tbody>
</table>
Buy Raspberry Pi Zero W

Country:
United States

Buy for business

These companies are all Raspberry Pi Approved Resellers. You will be taken to their site to buy this product.
Format NEW VOLUME (H:)

Capacity:
14.6 GB

File system
FAT32 (Default)

Allocation unit size
8192 bytes

Restore device defaults

Volume label
NEW VOLUME

Format options
Quick Format

Start  Close

Format NEW VOLUME (H:)

WARNING: Formatting will erase ALL data on this disk.
To format the disk, click OK. To quit, click CANCEL.

OK  Cancel

Win32 Disk Imager - 1.0

Image File
/Users/Ashwin/Downloads/2019-09-26-raspbian-buster.img

Device
(H:)

Hash
None  Generate  Copy

Read Only Allocated Partitions

Cancel  Read  Write  Verify Only  Exit

...
Confirm overwrite - 1.0

Writing to a physical device can corrupt the device.
(Target Device: [HA] "NEW VOLUME")
Are you sure you want to continue?

Yes No

Complete - 1.0

Write Successful.

OK

Welcome to Raspberry Pi

Welcome to the Raspberry Pi Desktop!

Before you start using it, there are a few things to set up.

Press 'Next' to get started.

Cancel Next

Welcome to Raspberry Pi

Set Country

Enter the details of your location. This is used to set the language, time zone, keyboard and other international settings.

Country: United Kingdom
Language: British English
Timezone: London

Use English language
Use US keyboard

Press 'Next' when you have made your selection.

Back Next

Welcome to Raspberry Pi

Change Password

The default 'pi' user account currently has the password 'raspberry'.
It is strongly recommended that you change this to a different password that only you know.

Enter new password:
Confirm new password:

Hide characters

Press 'Next' to activate your new password.

Back Next
Welcome to Raspberry Pi

Set Up Screen
The desktop should fill the entire screen.
Tick the box below if your screen has a black border at the edges.

- This screen shows a black border around the desktop

Press 'Next' to save your setting.
The change will take effect when the Pi is restarted.

Back   Next

Welcome to Raspberry Pi

Select WiFi Network
Select your WiFi network from the list.

<table>
<thead>
<tr>
<th>Network</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashwini</td>
<td></td>
</tr>
<tr>
<td>DIRECT-JDDESKTOP-FC0VL72msW</td>
<td></td>
</tr>
</tbody>
</table>

Press 'Next' to connect, or 'Skip' to continue without connecting.

Back   Skip   Next

Welcome to Raspberry Pi

Enter WiFi Password
Enter the password for the WiFi network "Ashwini".

Password: ********

Press 'Next' to connect, or 'Skip' to continue without connecting.

Back   Skip   Next

Welcome to Raspberry Pi

Update Software
The operating system and applications will now be checked and updated if necessary. This may involve a large download.

Press 'Next' to check and update software, or 'Skip' to continue without checking.

Back   Skip   Next
Welcome to Raspberry Pi

Setup Complete

Your Raspberry Pi is now set up and ready to go.
Press 'Restart' to restart your Pi now so the new settings will take effect, or press 'Later' to close the wizard and restart the Pi yourself.

Back  Later  Restart

Raspberry Pi Configuration

System  Interfaces  Performance  Localisation

Password: Change Password...

Hostname: raspberry

Boot: To Desktop  To CLI

Auto login: Login as user 'pi'

Network at Boot: Wait for network

Splash Screen: Enable  Disable

Overscan: Enable  Disable

Composite Video: Enable  Disable

Cancel  OK
### Raspberry Pi Configuration

#### Interfaces

<table>
<thead>
<tr>
<th>Interface</th>
<th>Enable</th>
<th>Disable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VNC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I2C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial Port</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serial Console</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-Wire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remote GPIO</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Performance

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overclock</td>
<td>Not available</td>
</tr>
<tr>
<td>GPU Memory</td>
<td>128</td>
</tr>
</tbody>
</table>
Raspberry Pi Configuration

Locale:
Timezone:
Keyboard:
WiFi Country:

Set Locale...
Set Timezone...
Set Keyboard...
Set WiFi Country...

Cancel OK

Shutdown options

Shut down
Reboot
Logout

Warning

SSH is enabled and the default password for the 'pi' user has not been changed.

This is a security risk - please login as the 'pi' user and run Raspberry Pi Configuration to set a new password.

OK
### Active Client Table

This table shows IP address, MAC address for each client.

### Active Wired Client Table

<table>
<thead>
<tr>
<th>Name</th>
<th>IP Address</th>
<th>MAC Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>192.168.2.2</td>
<td>50:29:d5:9d66:c1</td>
</tr>
<tr>
<td>DESKTOP-FC0VL72</td>
<td>192.168.2.5</td>
<td>d4:6e:0e:11:b2:ea</td>
</tr>
<tr>
<td>raspberryi</td>
<td>192.168.2.6</td>
<td>7cadd:90:60:e2:1e</td>
</tr>
</tbody>
</table>

### Active Wireless Client Table

<table>
<thead>
<tr>
<th>Name</th>
<th>IP Address</th>
<th>MAC Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>192.168.2.2</td>
<td>50:29:d5:9d66:c1</td>
</tr>
<tr>
<td>DESKTOP-FC0VL72</td>
<td>192.168.2.5</td>
<td>d4:6e:0e:11:b2:ea</td>
</tr>
<tr>
<td>raspberryi</td>
<td>192.168.2.6</td>
<td>7cadd:90:60:e2:1e</td>
</tr>
</tbody>
</table>
Chapter 2: Preparing Raspberry Pi for Computer Vision
Last login: Sat Feb 1 09:45:06

SSH is enabled and the default
This is a security risk - please

pi@raspberrypi:~ $
Remote Desktop Connection

Enter your credentials

These credentials will be used to connect to 192.168.2.4.

pi

Password

Remember me

More choices

OK  Cancel
Chapter 3: Introduction to Python Programming

Python 3.7.3 (default, Apr 3 2019, 05:39:12)
[GC 8.2.0] on linux
Type "help", "copyright", "credits" or "license()" for more information.

```python
>>> 
```
<ASCII/Latin1>
AaBbCcDdEeFfGgHhIiJj
1234567890#:=(){}[]
£$%©@¶²øÅÀÄÁÂÇÇÄĐĐ đa

<IPA, Greek, Cyrillic>
αεηθικλμνξψυχωυο
ΑΒΓΔΕΖΗΘΙΚΚ
БГДЖЖППФЧШЩЭЮЯ

<Hebrew, Arabic>
תשלום ימיכל仪חנוזכיה
1234567890 יתוחודג

<Devanagari, Tamil>
0923456789 ஆண்டைதரவை

<East Asian>
〇一二三四五六七八九
Python 3.7.3 (default, Apr 3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license()" for more information.
>>>  
==================  RESTART: /home/pi/book/chapter03/prog06.py  
==================  
Hello World!

pi@raspberrypi:~/book/chapter03 $ python3 prog06.py
Hello World!
pi@raspberrypi:~/book/chapter03 $  

pi@raspberrypi:~ $ python3
Python 3.7.3 (default, Apr 3 2019, 05:39:12)
[GCC 8.2.0] on linux
Type "help", "copyright", "credits" or "license()" for more information.
>>>  

Figure 1
<table>
<thead>
<tr>
<th>GPIO</th>
<th>Pin</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPIO2</td>
<td>(1)</td>
<td>3V3</td>
</tr>
<tr>
<td>GPIO3</td>
<td>(2)</td>
<td>3V3</td>
</tr>
<tr>
<td>GPIO4</td>
<td>(3)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO5</td>
<td>(4)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO6</td>
<td>(5)</td>
<td>GPIO14</td>
</tr>
<tr>
<td>GPIO7</td>
<td>(6)</td>
<td>GPIO15</td>
</tr>
<tr>
<td>GPIO8</td>
<td>(7)</td>
<td>GPIO18</td>
</tr>
<tr>
<td>GPIO9</td>
<td>(8)</td>
<td>GPIO23</td>
</tr>
<tr>
<td>GPIO10</td>
<td>(9)</td>
<td>GPIO24</td>
</tr>
<tr>
<td>GPIO11</td>
<td>(10)</td>
<td>GPIO25</td>
</tr>
<tr>
<td>GPIO12</td>
<td>(11)</td>
<td>GPIO27</td>
</tr>
<tr>
<td>GPIO13</td>
<td>(12)</td>
<td>GPIO28</td>
</tr>
<tr>
<td>GPIO14</td>
<td>(13)</td>
<td>GPIO17</td>
</tr>
<tr>
<td>GPIO15</td>
<td>(14)</td>
<td>GPIO16</td>
</tr>
<tr>
<td>GPIO16</td>
<td>(15)</td>
<td>GPIO22</td>
</tr>
<tr>
<td>GPIO17</td>
<td>(16)</td>
<td>GPIO19</td>
</tr>
<tr>
<td>GPIO18</td>
<td>(17)</td>
<td>GPIO26</td>
</tr>
<tr>
<td>GPIO19</td>
<td>(18)</td>
<td>GPIO21</td>
</tr>
<tr>
<td>GPIO20</td>
<td>(19)</td>
<td>GPIO10</td>
</tr>
<tr>
<td>GPIO21</td>
<td>(20)</td>
<td>GPIO09</td>
</tr>
<tr>
<td>GPIO22</td>
<td>(21)</td>
<td>GPIO11</td>
</tr>
<tr>
<td>GPIO23</td>
<td>(22)</td>
<td>GPIO12</td>
</tr>
<tr>
<td>GPIO24</td>
<td>(23)</td>
<td>GPIO08</td>
</tr>
<tr>
<td>GPIO25</td>
<td>(24)</td>
<td>GPIO07</td>
</tr>
<tr>
<td>GPIO26</td>
<td>(25)</td>
<td>GPIO06</td>
</tr>
<tr>
<td>GPIO27</td>
<td>(26)</td>
<td>GPIO05</td>
</tr>
<tr>
<td>GPIO28</td>
<td>(27)</td>
<td>GPIO04</td>
</tr>
<tr>
<td>GPIO29</td>
<td>(28)</td>
<td>GPIO03</td>
</tr>
<tr>
<td>GPIO30</td>
<td>(29)</td>
<td>GPIO02</td>
</tr>
<tr>
<td>GPIO31</td>
<td>(30)</td>
<td>GPIO01</td>
</tr>
<tr>
<td>GPIO32</td>
<td>(31)</td>
<td>GPIO00</td>
</tr>
<tr>
<td>GPIO33</td>
<td>(32)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO34</td>
<td>(33)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO35</td>
<td>(34)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO36</td>
<td>(35)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO37</td>
<td>(36)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO38</td>
<td>(37)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO39</td>
<td>(38)</td>
<td>GND</td>
</tr>
<tr>
<td>GPIO40</td>
<td>(39)</td>
<td>GND</td>
</tr>
<tr>
<td>Month</td>
<td>Year</td>
<td>Milestone</td>
</tr>
<tr>
<td>-----------</td>
<td>------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>December</td>
<td>1989</td>
<td>Python began as a hobby programming project.</td>
</tr>
<tr>
<td>February</td>
<td>1991</td>
<td>Code was published to alt.sources.</td>
</tr>
<tr>
<td>January</td>
<td>1994</td>
<td>Version 1.0.</td>
</tr>
<tr>
<td>January</td>
<td>1994</td>
<td>The comp.lang.python newsgroup was formed.</td>
</tr>
<tr>
<td>October</td>
<td>2000</td>
<td>Python 2.0 released.</td>
</tr>
<tr>
<td>December</td>
<td>2008</td>
<td>Python 3.0 released.</td>
</tr>
<tr>
<td>December</td>
<td>2019</td>
<td>Python 2’s Sunset.</td>
</tr>
</tbody>
</table>
| January   | 2020 | Python 3 continues....  

Chapter 4: Getting Started with Computer Vision
Chapter 5: Basics of Image Processing
Chapter 5: Basics of Image Processing
Chapter 6: Colorspaces, Transformations, and Thresholding

Figure 1
Chapter 7: Let's Make Some Noise

Salt and Pepper Sprinkled

Gaussian (Normally distributed) Noise
Poisson Noise

Random Normal Noise

Original Image  Blurred Image  Sharpened Image
Chapter 8: High-Pass Filters and Feature Detection

<table>
<thead>
<tr>
<th>Source image depth</th>
<th>Target image depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV_8U</td>
<td>-1/CV_16S/CV_32F/CV_64F</td>
</tr>
<tr>
<td>CV_16U/CV_16S</td>
<td>-1/CV_32F/CV_64F</td>
</tr>
<tr>
<td>CV_32F</td>
<td>-1/CV_32F/CV_64F</td>
</tr>
<tr>
<td>CV_64F</td>
<td>-1/CV_64F</td>
</tr>
</tbody>
</table>
Chapter 9: Image Restoration, Segmentation, and Depth Map
Chapter 10: Histograms, Contours, and Morphological Transformations
<table>
<thead>
<tr>
<th>Element</th>
<th>Frequency of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
Chapter 11: Real-Life Applications of Computer Vision
Chapter 12: Working with Mahotas and Jupyter
piberraspberrypi:~/book/chapter12 $ jupyter notebook
[1 19:45:22.784 NotebookApp] The Jupyter Notebook is running at:
http://localhost:8888/?token=3d8c07f1a94e19f6f6a0649bc5e784c39301cefe93acc3
[1 19:45:22.784 NotebookApp] or http://127.0.0.1:8888/?token=3d8c07f1a94e19f6f6a0649bc5e784c39301cefe93acc3
[1 19:45:22.784 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[1 19:45:22.856 NotebookApp]
To access the notebook, open this file in a browser:
file:///home/pi/.local/share/jupyter/runtime/nbserver-3233-open.html
Or copy and paste one of these URLs:
http://localhost:8888/?token=3d8c07f1a94e19f6f6a0649bc5e784c39301cefe93acc3
or http://127.0.0.1:8888/?token=3d8c07f1a94e19f6f6a0649bc5e784c39301cefe93acc3

Notebook:

Python 3

Other:

Text File
Folder
Terminal
SSH is enabled and the default password for the 'pi' user has not been changed. This is a security risk - please login as the 'pi' user and type `passwd` to set a new password.

```
pi@raspberrypi:~/book/chapter12 $
```
Rename Notebook

Enter a new notebook name:

test01

[Image of a Jupyter Notebook window]

```
In [1]: print('Hello World!')
Hello World!

In []: 
```

[Menu options for different notebook types]
Test

In [ ]:

```
ls -la
```

```
total 48
drwxr-xr-x  3 pi pi 4096 Feb 21 10:37 .
drwxr-xr-x 15 pi pi 4096 Feb 19 11:08 ..
drwxr-xr-x  2 pi pi 4096 Feb 20 21:30 .ipynb_checkpoints
-rw-r--r--  1 pi pi  132 Feb 20 14:17 prog00.py
-rw-r--r--  1 pi pi  219 Feb 20 14:26 prog01.py
-rw-r--r--  1 pi pi  164 Feb 20 14:38 prog02.py
-rw-r--r--  1 pi pi  247 Feb 20 15:07 prog03.py
-rw-r--r--  1 pi pi  241 Feb 20 15:08 prog04.py
-rw-r--r--  1 pi pi  314 Feb 20 15:40 prog05.py
-rw-r--r--  1 pi pi  173 Feb 20 16:12 prog06.py
-rw-r--r--  1 pi pi  384 Feb 20 18:10 prog07.py
-rw-r--r--  1 pi pi 1082 Feb 21 10:37 test01.ipynb
```

In [ ]:

```
import matplotlib
```

```
import cv2
import matplotlib.pyplot as plt
```

In [2]:
```
img = cv2.imread('/home/pi/book/dataset/7.1.02.tif', 0)
plt.imshow(img, cmap='gray')
plt.show()
```
Chapter 13: Appendix

![SD Card Formatter]

**SD Card Formatter**

Formatting will erase all data on this card. Do you want to continue?

Note: As formatting can take some time (especially when overwrite option is selected), please make sure that your computer is connected to a power supply and that sleep mode is disabled.

![Disk Management]

**Disk Management**

- **Disk 2**:
  - Basic: 476.92 GB
  - Online
  - Layout: NTFS
  - Status: Healthy (OS Partition)
- **Disk 3**:
  - Removable: 14.92 GB
  - Online
  - Layout: NTFS
  - Status: Healthy (Boot Partition)
### Raspberry Pi Software Configuration Tool (raspi-config)

#### B1 Desktop / CLI
Choose whether to boot into a desktop

#### B2 Wait for Network at Boot
Choose whether to wait for network con

#### B3 Splash Screen
Choose graphical splash screen or text

#### I1 Change Locale
Set up language and regional settings to

#### I2 Change Timezone
Set up timezone to match your location

#### I3 Change Keyboard Layout
Set the keyboard layout to match your ke

#### I4 Change Wi-fi Country
Set the legal channels used in your coun

#### P1 Camera
Enable/Disable connection to the Raspberry Pi Camer

#### P2 SSH
Enable/Disable remote command line access to your P

#### P3 VNC
Enable/Disable graphical remote access to your Pi u

#### P4 SPI
Enable/Disable automatic loading of SPI kernel modu

#### P5 I2C
Enable/Disable automatic loading of I2C kernel modu

#### P6 Serial
Enable/Disable shell and kernel messages on the ser

#### P7 1-Wire
Enable/Disable one-wire interface

#### P8 Remote GPIO
Enable/Disable remote access to GPIO pins

#### A1 Expand Filesystem
Ensures that all of the SD card storage is av

#### A2 Overscan
You may need to configure overscan if black b

#### A3 Memory Split
Change the amount of memory made available to

#### A4 Audio
Force audio out through HDMI or 3.5mm jack

#### A5 Resolution
Set a specific screen resolution

#### A6 Screen Blanking
Enable/Disable screen blanking

#### A7 Pixel Doubling
Enable/Disable 2x2 pixel mapping

#### A8 GL Driver
Enable/Disable experimental desktop GL driver

#### A9 Compositor
Enable/Disable xcompmgr composition manager

#### AA Pi 4 Video Output
Video output options for Pi 4

#### AB Overlay FS
Enable/Disable read-only file system
Python is a programming language that lets you work quickly and integrate systems more effectively. ❯❯ Learn More

- Install Python 3.8.1 (32-bit)
  - Select Install Now to install Python with default settings, or choose Customize to enable or disable features.
  - Include installation of IDLE, pip and documentation.
  - Creates shortcuts and file associations.
  - Customize installation location and features.
  - Install launcher for all users (recommended)
  - Add Python 3.8 to PATH

- Optional Features
  - Documentation
    - Installs the Python documentation file.
  - pip
    - Installs pip, which can download and install other Python packages.
  - tk/tk and IDLE
    - Installs tkinter and the IDLE development environment.
  - Python test suite
    - Installs the standard library test suite.
  - py launcher for all users (requires elevation)
    - Installs the global ‘py’ launcher to make it easier to start Python.