Image Data Analysis

- Image is a special kind of data format where data is stored in the form of matrices.
- When we have image in the form numbers arranged in a matrix, we can do all matrix operations.

In [1]:
```
import numpy as np
from matplotlib import pyplot as plt
```

List

In [2]:
```
l = [[1, 2, 3, 4, 5], [3, 4, 5, 6, 1]]
```

In [3]:
```
print(l)
```
```
[[1, 2, 3, 4, 5], [3, 4, 5, 6, 1]]
```

In [4]:
```
type(l)
```
Out[4]:
```
list
```

In [5]:
```
l * 3
```
Out[5]:
```
[[1, 2, 3, 4, 5],
 [3, 4, 5, 6, 1],
 [1, 2, 3, 4, 5],
 [3, 4, 5, 6, 1],
 [1, 2, 3, 4, 5],
 [3, 4, 5, 6, 1]]
```

In [6]:
```
lm = []
for i in l:
    r = []
    for j in i:
        r.append(j * 3)
    lm.append(r)
```

In [7]:
```
lm
```
Out[7]:
```
[[3, 6, 9, 12, 15], [9, 12, 15, 18, 3]]
```

NumPy Matrix

In [8]:
```
mat = np.matrix(
    [[1, 2, 3, 4, 5],
     [3, 4, 5, 6, 1]]
)
```

In [9]:
```
print(mat)
```
```
[[1 2 3 4 5]
 [3 4 5 6 1]]
```

In [10]:
```
type(mat)
```
Out[10]:
```
numpy.matrix
```

In [11]:
```
print(mat * 3)
```
```
[[ 3  6  9 12 15]
 [ 9 12 15 18  3]]
```

In [12]:
```
mat.shape
```
Out[12]:
```
(2, 5)
```

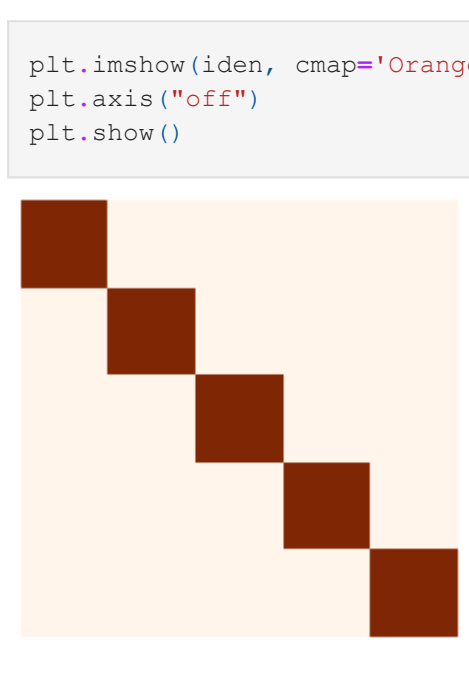
Transpose Operation

In [13]:
```
print(mat)
```
```
[[1 2 3 4 5]
 [3 4 5 6 1]]
```

In [14]:
```
print(mat.T)
```
```
[[1 3]
 [2 4]
 [3 5]
 [4 6]
 [5 1]]
```

In [15]:
```
iden = np.eye(N=5, M=5)
print(iden)
```
```
[[1. 0. 0. 0. 0.]
 [0. 1. 0. 0. 0.]
 [0. 0. 1. 0. 0.]
 [0. 0. 0. 1. 0.]
 [0. 0. 0. 0. 1.]]
```

In [16]:
```
plt.imshow(iden, cmap='Oranges')
plt.axis("off")
plt.show()
```

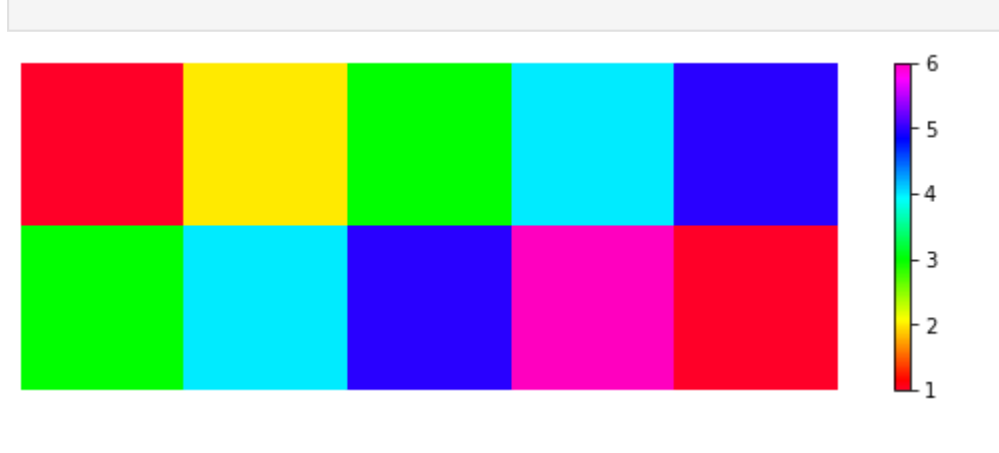


Can we convert `matrix` into `image`?

`imshow()` of `plt`

In [17]:
```
mat
```
Out[17]:
```
matrix([[1, 2, 3, 4, 5],
        [3, 4, 5, 6, 1]])
```

In [18]:
```
plt.figure(figsize=(10, 3))
image_mat = plt.imshow(mat, cmap='gist_rainbow')
plt.colorbar(image_mat)
plt.axis("off")
plt.show()
```



Convert large `matrix` into `image`

- There should be 30 rows and 50 columns
- Each row of the matrix should have 50 numbers in the range of 1 and 200

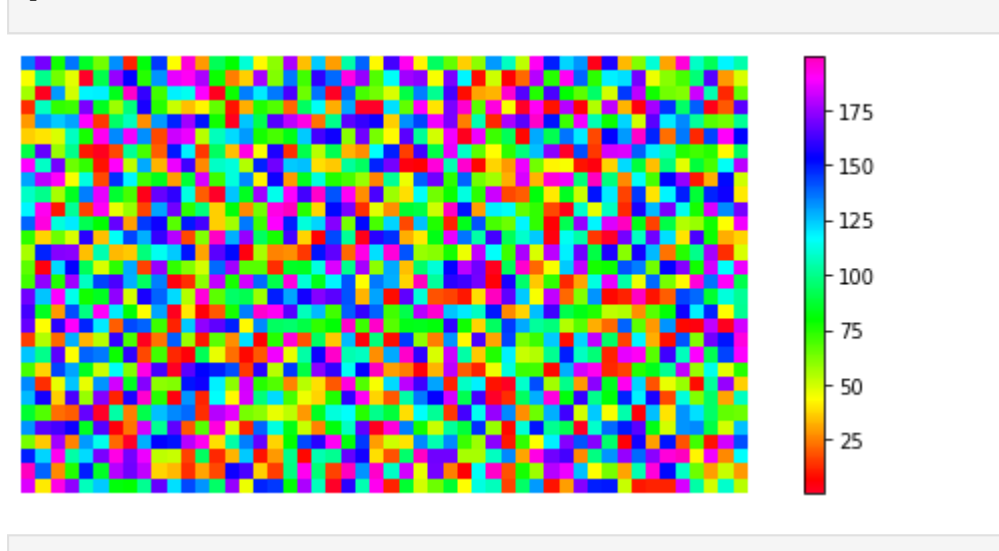
In [19]:
```
big_mat = np.random.randint(low=1, high=200, size=(30, 50))
```

In [20]:
```
big_mat
```
Out[20]:
```
array([[136, 170,  78, ...,  93, 118, 105],
       [ 45, 100,  64, ..., 165,  29,  49],
       [ 57,   3, 131, ..., 106,  13,  66],
       ...,
       [149, 123, 192, ..., 188,  27, 117],
       [199, 139,  27, ...,  30,  52,  29],
       [185,  41, 193, ...,  50, 110,  54]])
```

In [21]:
```
big_mat.shape
```
Out[21]:
```
(30, 50)
```

Matrix to Image

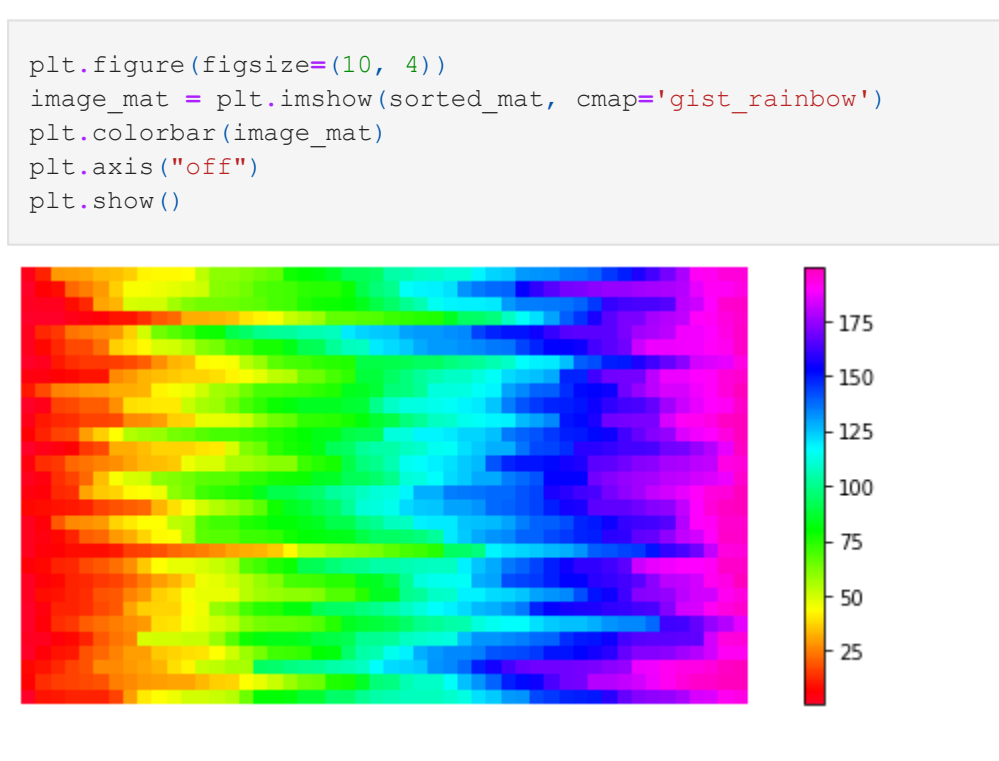
In [22]:
```
plt.figure(figsize=(10, 4))
image_mat = plt.imshow(big_mat, cmap='gist_rainbow')
plt.colorbar(image_mat)
plt.axis("off")
plt.show()
```



In [23]:
```
sorted_mat = np.sort(big_mat)
```

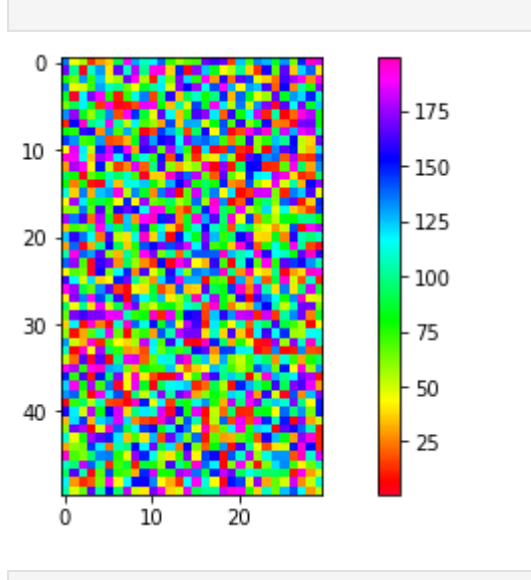
In [24]:
```
sorted_mat
```
Out[24]:
```
array([[  4,  12,  29, ..., 192, 195, 195],
       [  1,   7,   9, ..., 191, 191, 193],
       [  2,   3,   3, ..., 189, 196, 197],
       ...,
       [  8,  10,  13, ..., 195, 198, 199],
       [  7,  14,  16, ..., 197, 199, 199],
       [  1,  10,  11, ..., 185, 192, 193]])
```

In [25]:
```
plt.figure(figsize=(10, 4))
image_mat = plt.imshow(sorted_mat, cmap='gist_rainbow')
plt.colorbar(image_mat)
plt.axis("off")
plt.show()
```

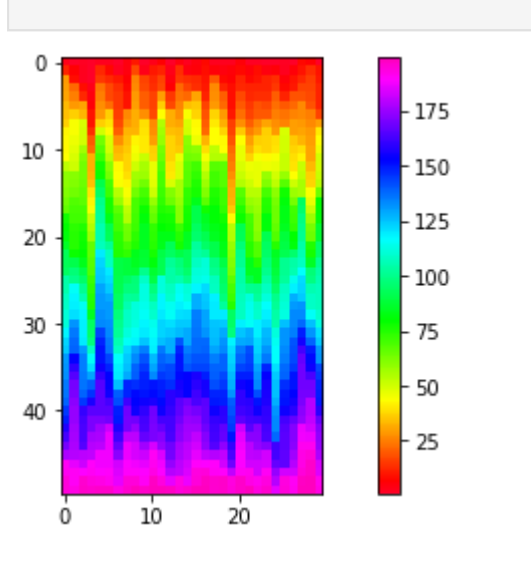


Transpose matrix to Image

In [26]:
```
plt.figure(figsize=(10, 4))
trans_mat = big_mat.T
timage_mat = plt.imshow(trans_mat, cmap='gist_rainbow')
plt.colorbar(timage_mat)
plt.show()
```

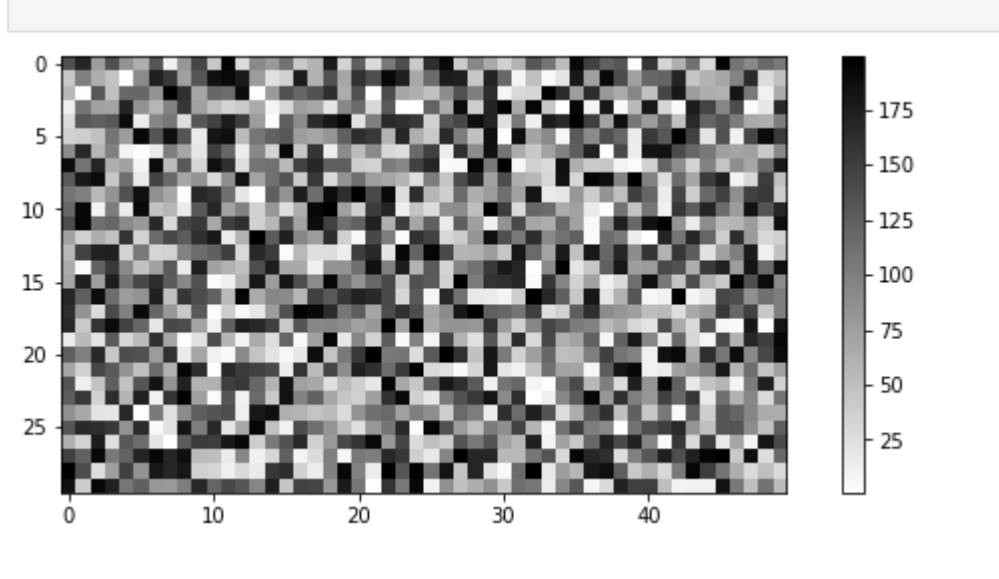


In [27]:
```
plt.figure(figsize=(10, 4))
trans_mat = sorted_mat.T
timage_mat = plt.imshow(trans_mat, cmap='gist_rainbow')
plt.colorbar(timage_mat)
plt.show()
```



`grayscale` image

In [28]:
```
plt.figure(figsize=(10, 4))
gray_image = plt.imshow(big_mat, cmap='gray_r')
plt.colorbar(gray_image)
plt.show()
```



Can we convert `image` into `matrix`?

We should use `cv2` (`opencv-python`) package in python to compute matrix operations on images.

`pip install opencv-python --user`

A typical **colored image** is comprised of pixels (which are represented as RGB pixels).

- A pixel is simply a number in the range of `0` to `255` for all `R`, `G`, and `B`.
- R → Red → 0 to 255
- G → Green → 0 to 255
- B → Blue → 0 to 255

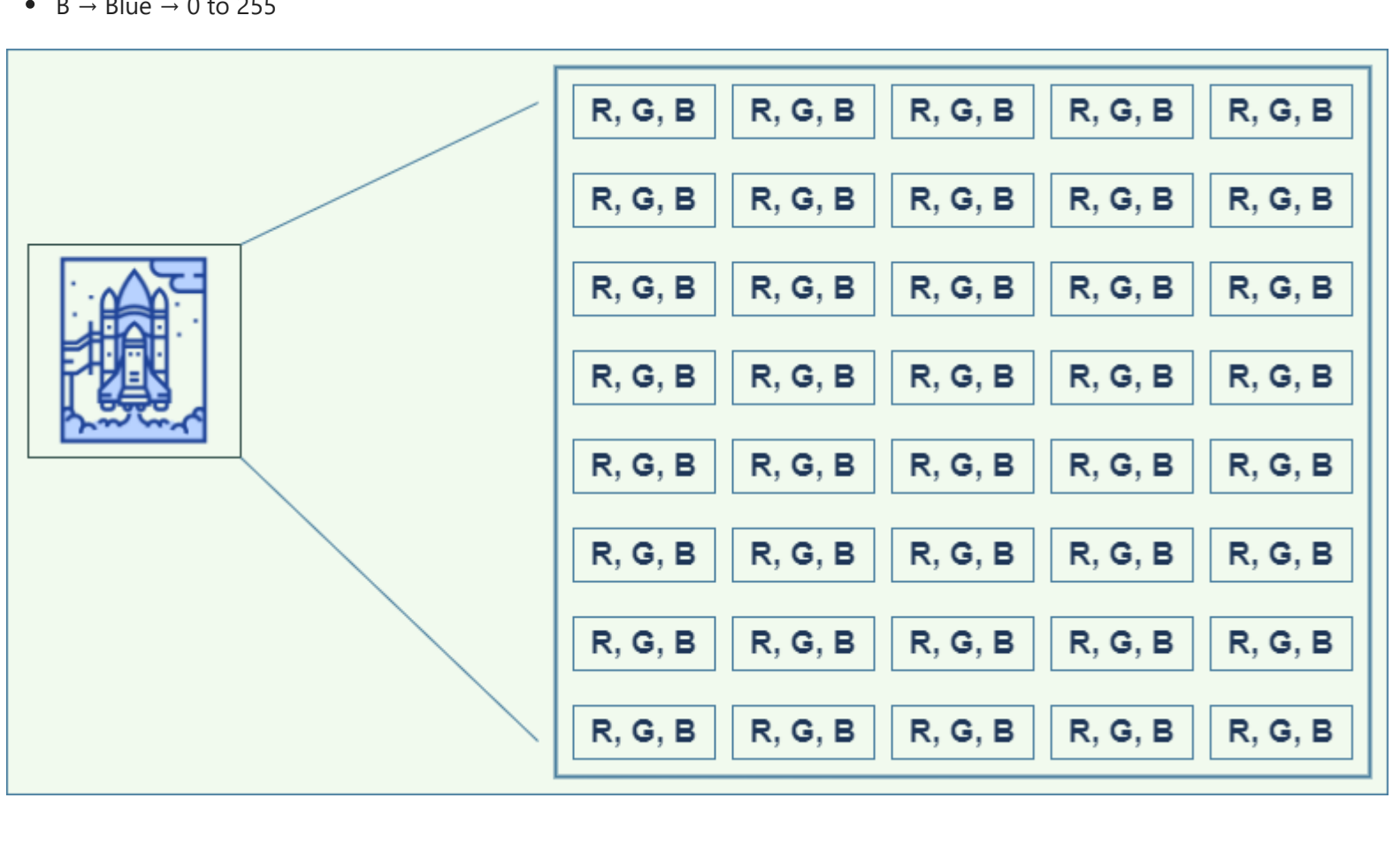


Image by Author

Some important colors and their RGB values -

Pixel	R	G	B
White	255	255	255
Red	255	0	0
Green	0	255	0
Blue	0	0	255
Black	0	0	0
Yellow	255	255	0

- **All colors** → https://www.colorhexa.com/color-names

Let's read the `image` and convert into `matrix`

The image that we will read is -

Image Link → lena_image.png

Read the `image` in the form of `matrix`

In [29]:
```
import cv2
```

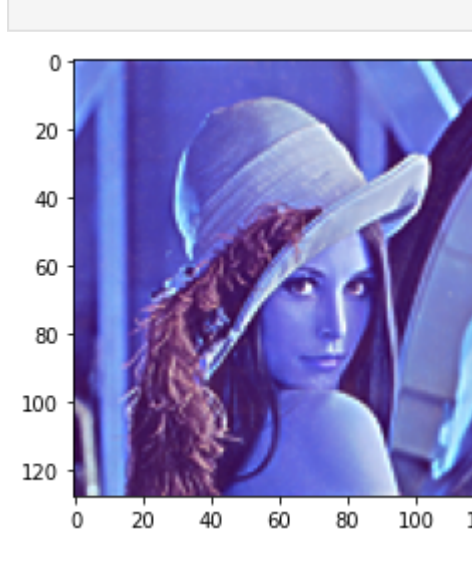
`BGR`

In [30]:
```
image_mat = cv2.imread('lena_image.png')
```

The image matrix would be like -

```
[[[159 183 255] ... [142 202 255]]
 [[140 169 255] ... [ 87  74 159]]
 [[118 164 255] ... [ 62  14  81]]
 ...
 [[ 64  30  96] ... [ 61  33 119]]
 [[ 61  27  92] ... [ 74  65 178]]
 [[ 60  25  89] ... [ 80  72 202]]]
```

In [31]:
```
plt.imshow(image_mat)
plt.show()
```



- By default, the image is read in BGR format.
- We need to convert it into RGB format for our convenience.

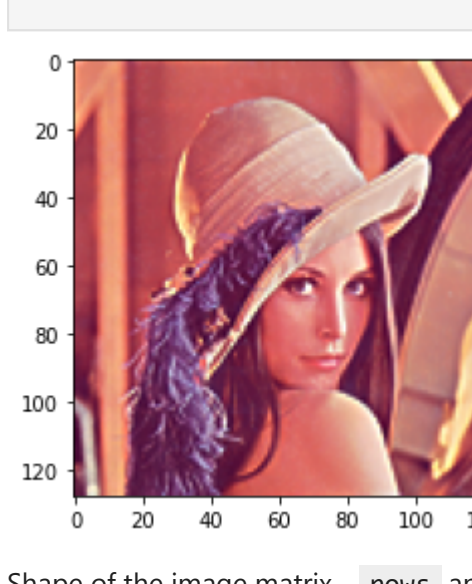
`BGR` → to → `RGB` format

In [32]:
```
image_mat = cv2.cvtColor(image_mat, cv2.COLOR_BGR2RGB)
```

The image matrix would be like -

```
[[[255 183 159] ... [255 202 142]]
 [[255 169 140] ... [159  74  87]]
 [[255 164 118] ... [ 81  14  62]]
 ...
 [[ 96  30  64] ... [119  33  61]]
 [[ 92  27  61] ... [178  65  74]]
 [[ 89  25  60] ... [202  72  80]]]
```

In [33]:
```
plt.imshow(image_mat)
plt.show()
```



Shape of the image matrix - `rows` and `columns`

In [34]:
```
image_mat.shape
```
Out[34]:
```
(128, 128, 3)
```

In [35]:
```
rows, cols, p = image_mat.shape
print(rows)
print(cols)
print(p)
```
```
128
128
3
```

How many `pixels` are there in the above `image`?

In [36]:
```
pixels = rows * cols
```

In [37]:
```
pixels
```
Out[37]:
```
16384
```

How many `pixel values` are there including `R`, `G`, and `B` values?

In [38]:
```
pixel_values = rows * cols * p
```

In [39]:
```
pixel_values
```
Out[39]:
```
49152
```

Separate `R`, `G`, and `B` from the image

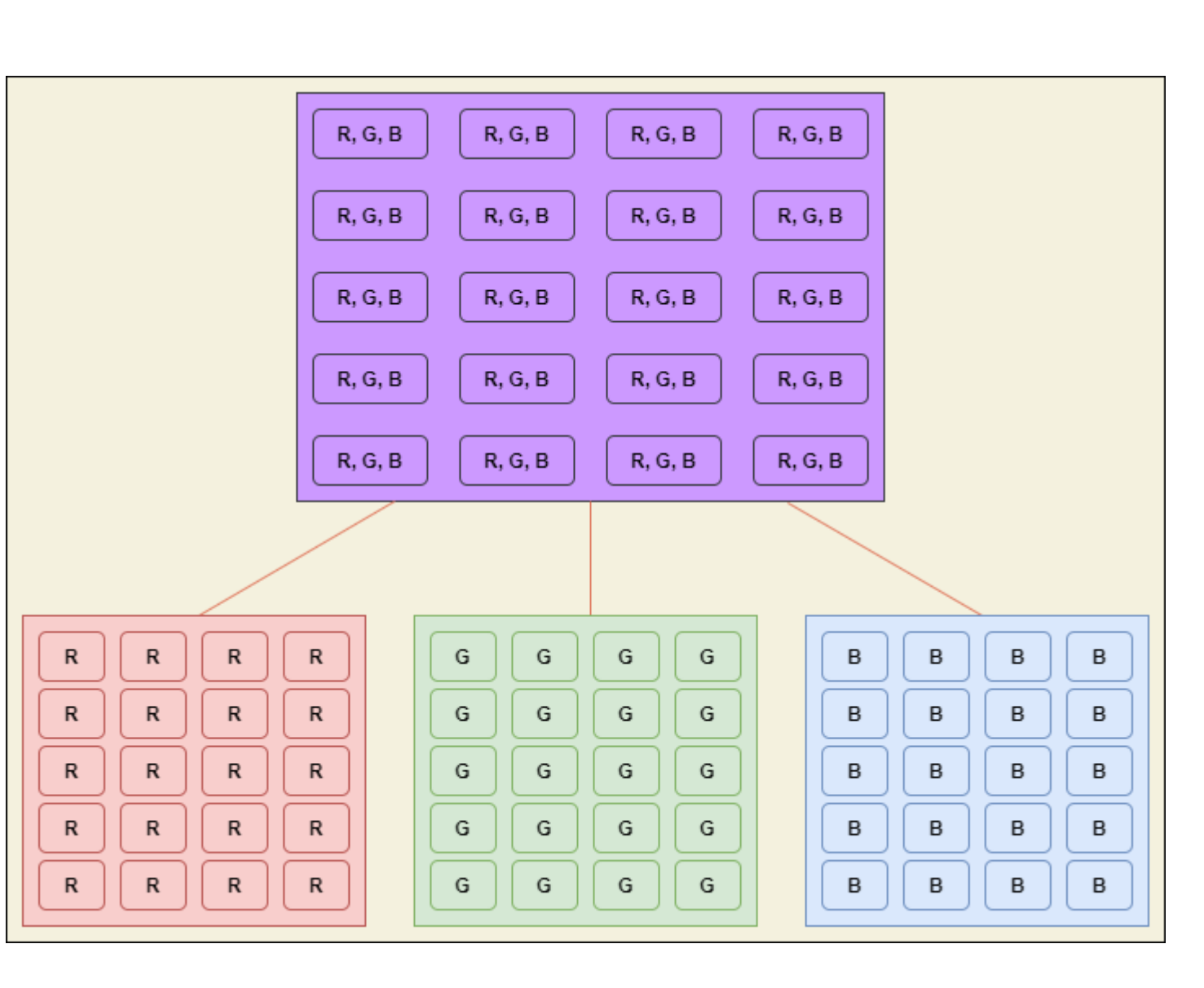


Image by Author

We make use of `cv2.split()` method to separate the `RGB` pixels from the image.

In [40]:
```
rimage_mat, gimage_mat, bimage_mat = cv2.split(image_mat)
```

In [41]:
```
print("R → \n\n", rimage_mat)
```
```
R →

 [[255 255 255 ... 212 255 255]
 [255 255 247 ... 227 227 159]
 [255 246 232 ... 190 103  81]
 ...
 [ 96 100 100 ... 105 100 119]
 [ 92  97  95 ... 105 124 178]
 [ 89  96  91 ... 115 156 202]]
```

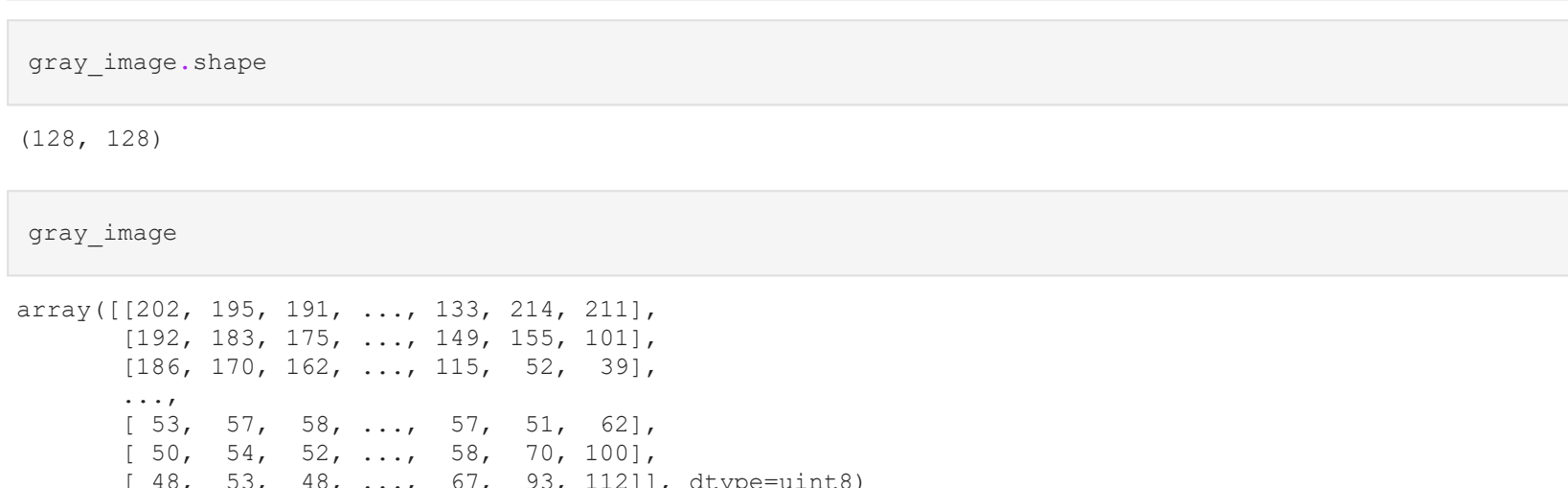
In [42]:
```
print("G → \n\n", gimage_mat)
```
```
G →

 [[183 174 167 ...  99 203 202]
 [169 156 149 ... 117 126  74]
 [164 142 136 ...  82  25  14]
 ...
 [ 30  33  34 ...  32  26  33]
 [ 27  30  28 ...  33  43  65]
 [ 25  29  24 ...  42  64  72]]
```

In [43]:
```
print("B → \n\n", bimage_mat)
```
```
B →

 [[159 148 142 ... 101 163 142]
 [140 130 124 ... 107 113  87]
 [118 115 113 ...  83  64  62]
 ...
 [ 64  66  71 ...  63  58  61]
 [ 61  63  67 ...  62  68  74]
 [ 60  62  64 ...  72  82  80]]
```

Plot `R`, `G`, and `B` separately

In [44]:
```
l = [1, 2, 3, 4]
g = [5, 6, 7, 8]

# [(1, 5), (2, 6), (3, 7), (4, 8)]
f = list(zip(l, g))
print(f)
```
```
[(1, 5), (2, 6), (3, 7), (4, 8)]
```

In [45]:
```
cmap_values = [None, 'Reds', 'Greens', 'Blues']
titles = ['Original', 'Red Lenna', 'Green Lenna', 'Blue Lenna']
image_matrices = [image_mat, rimage_mat, gimage_mat, bimage_mat]

fig, axes = plt.subplots(nrows=1, ncols=4, figsize=(15, 10))

for i, ax in zip(range(4), axes):
    ax.axis("off")
    ax.set_title(titles[i])
    ax.imshow(image_matrices[i], cmap=cmap_values[i])

plt.show()
```



Some matrix operations

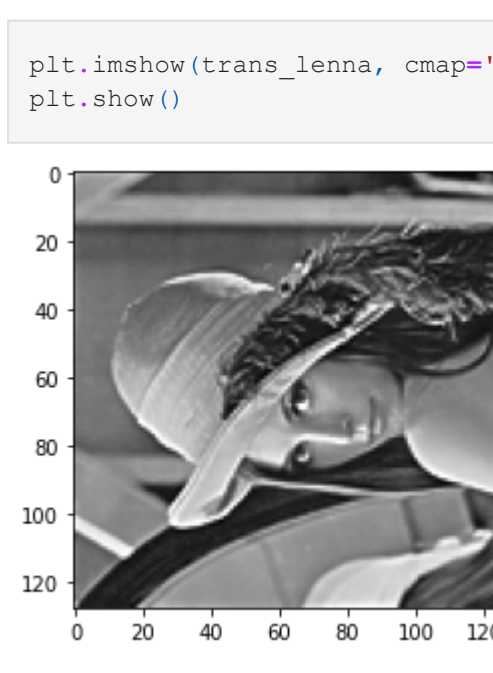
- Let's take grayscale matrix of original image

In [46]:
```
gray_image = cv2.imread('lena_image.png', 0)
```

In [47]:
```
gray_image.shape
```
Out[47]:
```
(128, 128)
```

In [48]:
```
gray_image
```
Out[48]:
```
array([[202, 195, 191, ..., 133, 214, 211],
       [192, 183, 175, ..., 149, 155, 101],
       [186, 170, 162, ..., 115,  52,  39],
       ...,
       [ 53,  57,  58, ...,  57,  51,  62],
       [ 50,  54,  52, ...,  58,  70, 100],
       [ 48,  53,  48, ...,  67,  93, 112]], dtype=uint8)
```

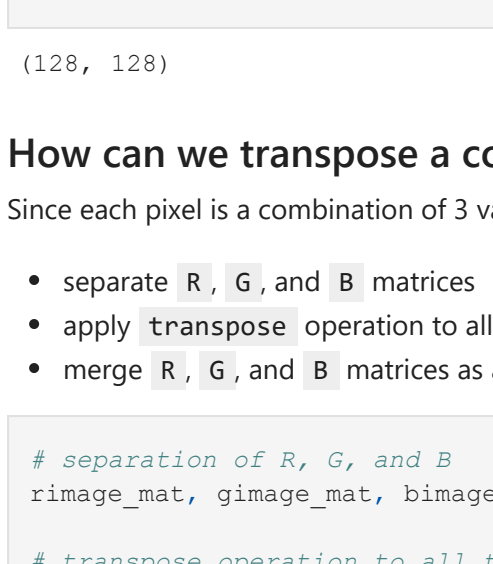
In [49]:
```
plt.imshow(gray_image, cmap='gray')
plt.show()
```



Tranpose gray lenna

In [50]:
```
trans_lenna = gray_image.T
```

In [51]:
```
plt.imshow(trans_lenna, cmap='gray')
plt.show()
```



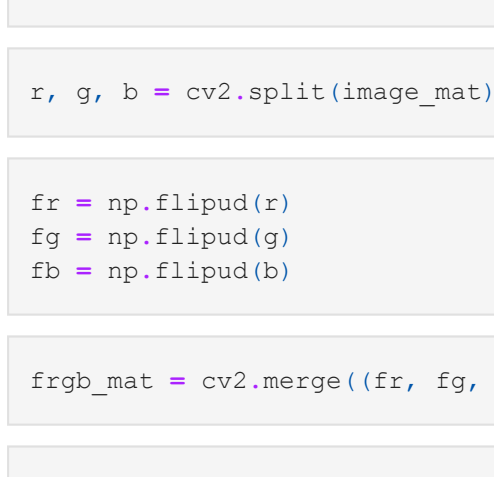
In [52]:
```
trans_lenna.shape
```
Out[52]:
```
(128, 128)
```

How can we transpose a colored image?

Since each pixel is a combination of 3 values, we have to -

- separate `R`, `G`, and `B` matrices
- apply `transpose` operation to all the 3 matrices
- merge `R`, `G`, and `B` matrices as a one single matrix

In [53]:
```
# separation of R, G, and B
rimage_mat, gimage_mat, bimage_mat = cv2.split(image_mat)

# transpose operation to all the 3 matrices
trans_r = rimage_mat.T
trans_g = gimage_mat.T
trans_b = bimage_mat.T

# merging R, G, and B matrices into one single matrix
trans_color_lenna = cv2.merge((trans_r, trans_g, trans_b))

# plotting the transposed colored image
plt.imshow(trans_color_lenna)
plt.show()
```



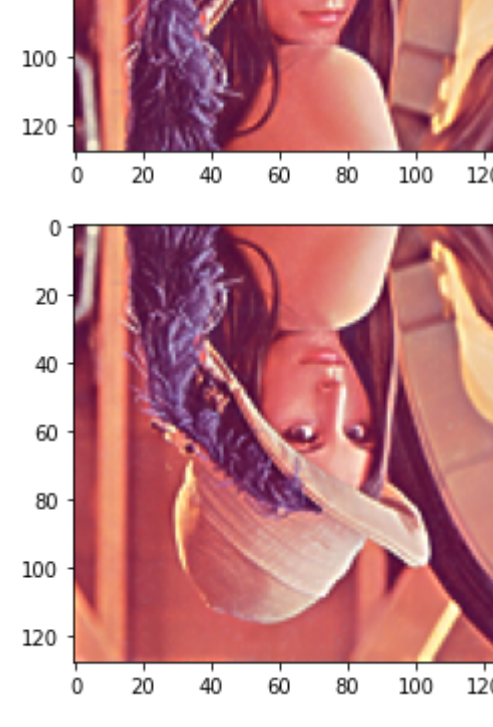
In [54]:
```
image_mat = cv2.imread('lena_image.png')
image_mat = cv2.cvtColor(image_mat, cv2.COLOR_BGR2RGB)
```

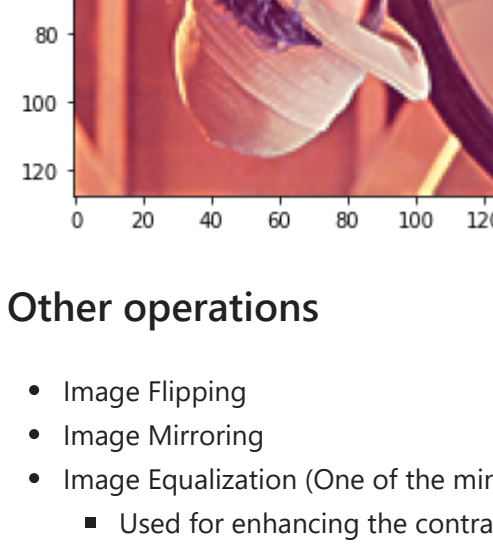
In [55]:
```
r, g, b = cv2.split(image_mat)
```

In [56]:
```
fr = np.flipud(r)
fg = np.flipud(g)
fb = np.flipud(b)
```

In [57]:
```
frgb_mat = cv2.merge((fr, fg, fb))
```

In [58]:
```
plt.imshow(image_mat)
plt.show()
plt.imshow(frgb_mat)
plt.show()
```





Other operations

- Image Flipping
- Image Mirroring
- Image Equalization (One of the mind blowing operations)
  - Used for enhancing the contrast of an image
- Image Binarization
- Image Inversion
- Image Cropping
- Image Bordering
- Image Convolution with kernels (One of the mind blowing operations)
  - Used for Smoothening, Blurring, Edge detection etc

PS: All you can find in my blog websites.

- GitHub → https://github.com/msameeruddin/image-app
- Hashnode → https://msameeruddin.hashnode.dev/
- edium.com/