Image Basics

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- Brief introduction of `OpenCV`
- Pixels, colors, and image formats

OpenCV

- `OpenCV` is an open source computer vision library written in C/C++ language
- `OpenCV` contains more than 500 functions derived from various fields of computer vision
    - Image segmentation
    - Face recognition
    - Action recognition
    - Motion tracking
    - Motion analysis
- The image is treated as a matrix in the computer

```
import pandas as pd
import numpy as np

data_file = ".\data\cat.csv"
cat = pd.read_csv(data_file)
cat
```

```
.dataframe tbody tr th {
    vertical-align: top;
}

.dataframe thead th {
    text-align: right;
}
```

	R	G	B
0	213	218	222
1	213	218	222
2	213	218	222
3	213	218	222
4	213	218	222
...	...	...	...
243044	216	219	226
243045	216	219	226
243046	215	218	225
243047	215	218	225
243048	215	218	225

243049 rows × 3 columns

```
print(cat.shape)
print(type(cat))
# define matrix
width = height = 493
cat_rgb = []
for i in range(height):
    row = []
    for j in range(width):
        index = i * height + j
        rgb_element = [cat.at[index, 'R'], cat.at[index, 'G'], cat.at[index, 'B']]
        row.append(rgb_element)
    cat_rgb.append(row)
# data type transfermation
cat_rgb = np.array(cat_rgb)
print(cat_rgb.shape)
print(type(cat_rgb))
```

```
(243049, 3)
<class 'pandas.core.frame.DataFrame'>
(493, 493, 3)
<class 'numpy.ndarray'>
```

```
print(cat_rgb)
# 493 rows
# 493 rgb elements in each row
```

```
[[[213 218 222]
  [213 218 222]
  [213 218 222]
  ...
  [151 155 158]
  [150 154 157]
  [149 153 156]]

 [[213 218 222]
  [213 218 222]
  [213 218 222]
  ...
  [145 149 152]
  [144 148 151]
  [143 147 150]]

 [[213 218 222]
  [213 218 222]
  [213 218 222]
  ...
  [141 145 148]
  [140 144 147]
  [139 143 146]]

 ...

 [[ 19  18  14]
  [ 19  18  14]
  [ 19  18  14]
  ...
  [215 218 225]
  [215 218 225]
  [215 218 225]]

 [[ 19  18  14]
  [ 19  18  14]
  [ 18  17  13]
  ...
  [215 218 225]
  [215 218 225]
  [215 218 225]]

 [[ 19  18  14]
  [ 18  17  13]
  [ 18  17  13]
  ...
  [215 218 225]
  [215 218 225]
  [215 218 225]]]
```

```
from matplotlib import pyplot as plt
import matplotlib.colors as mat_color

no_norm = mat_color.Normalize(vmin=0, vmax=255, clip=False)
plt.imshow(cat_rgb, norm=no_norm)
```

```
<matplotlib.image.AxesImage at 0x1de53cd10a0>
```

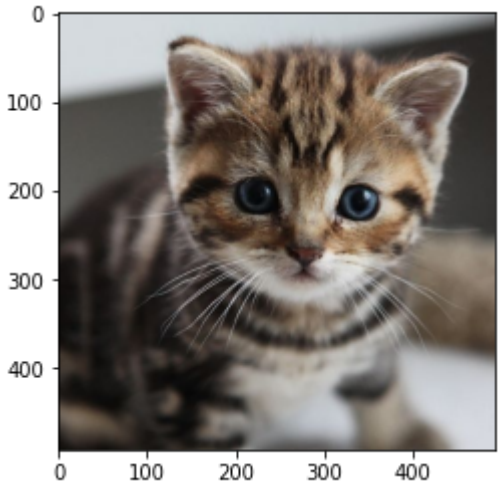


Image formats

- Just shown is the `RGB` image type, which is in line with human vision
- In addition to the `RGB` series, common color spaces include `HSV`, `HSL`, `XYZ`, etc.
    - `Hue`
    - `Saturation`
    - `Value/Lightness`
- In image recognition, `RGB` is easily affected by light
    - Manual compensation through programming
    - Convert it into `HSV` mode
- `RGB -> HSV`

$$s_{\mathrm{HSV}} = \frac{\max\{r,g,b\} - \min\{r,g,b\}}{\max\{r,g,b\}}$$

- `HSV -> RGB`

$$
\begin{aligned}
c_1 &= \lfloor h' \rfloor \\
c_2 &= h' - c_1 \\
w_1 &= (1 - s_{\mathrm{HSV}}) \cdot v \\
w_2 &= (1 - s_{\mathrm{HSV}} \cdot c_2) \cdot v \\
w_3 &= (1 - s_{\mathrm{HSV}} \cdot (1 - c_2)) \cdot v \\
\begin{pmatrix} r \\ g \\ b \end{pmatrix} &= \begin{cases}
(v, w_3, w_1)^{\mathrm{T}} & \text{if } c_1 = 0 \\
(w_2, v, w_1)^{\mathrm{T}} & \text{if } c_1 = 1 \\
(w_1, v, w_3)^{\mathrm{T}} & \text{if } c_1 = 2 \\
(w_1, w_2, v)^{\mathrm{T}} & \text{if } c_1 = 3 \\
(w_3, w_1, v)^{\mathrm{T}} & \text{if } c_1 = 4 \\
(v, w_1, w_2)^{\mathrm{T}} & \text{if } c_1 = 5
\end{cases}
\end{aligned}
$$

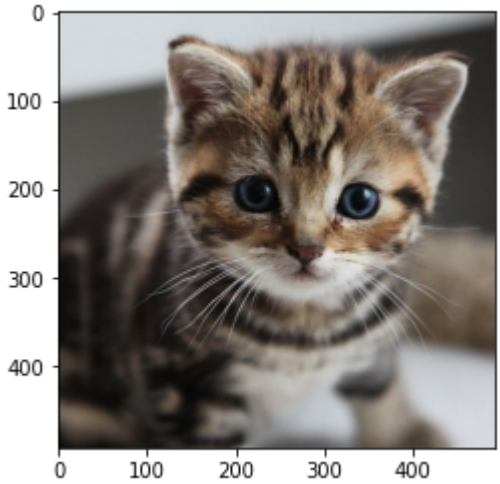
```
import cv2
import numpy as np
from matplotlib import pyplot as plt

path = "./images/cat.jpg"
# read original BGR image
img_bgr = cv2.imread(path)
print("image loaded")
```

```
image loaded
```

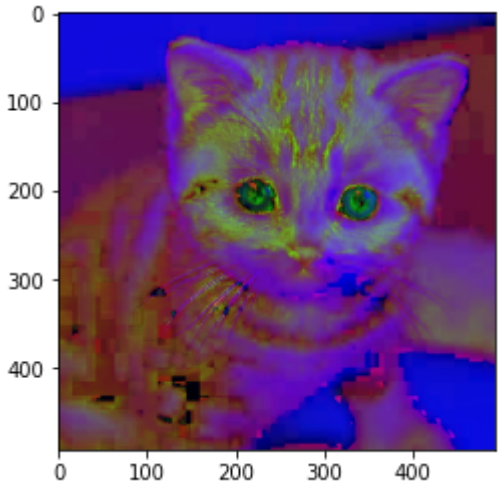
```
img_rgb = cv2.cvtColor(img_bgr, cv2.COLOR_BGR2RGB)
plt.imshow(img_rgb, norm=no_norm)
```

```
<matplotlib.image.AxesImage at 0x1de5406d9d0>
```



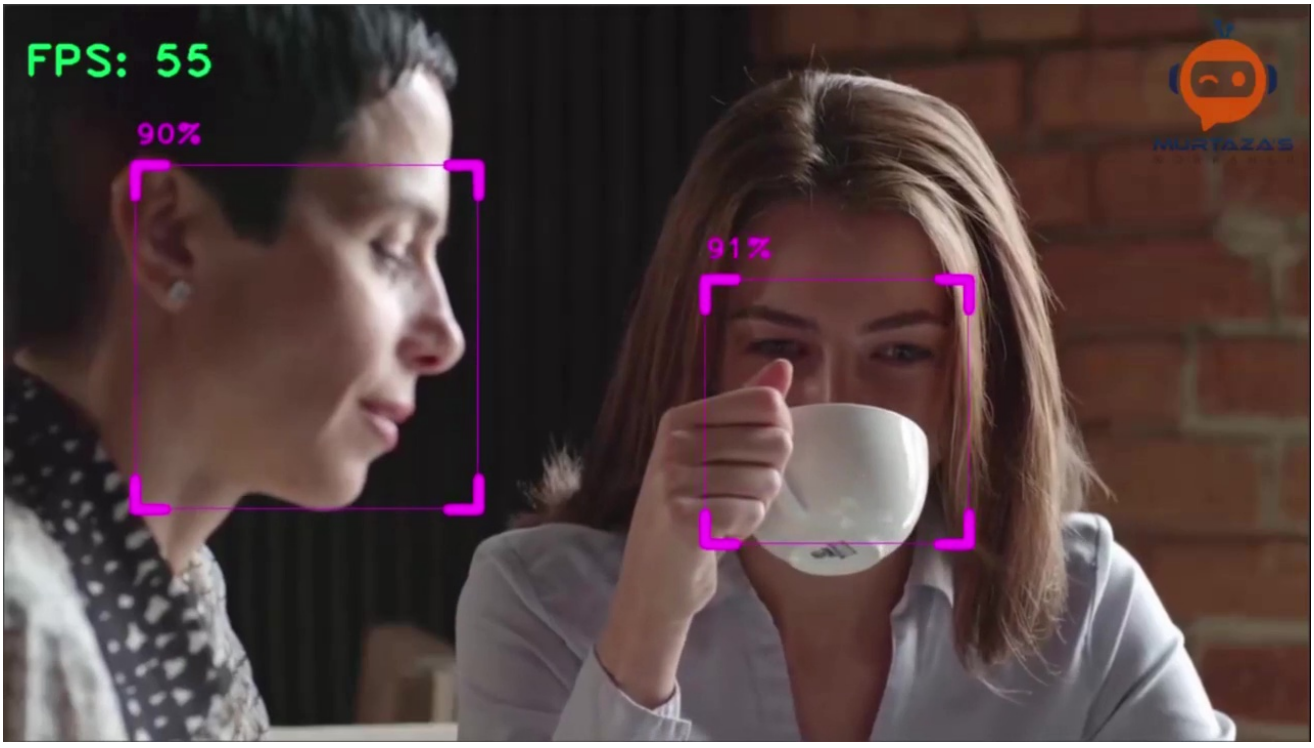

```
img_hsv = cv2.cvtColor(img_bgr, cv2.COLOR_RGB2HSV)
plt.imshow(img_hsv, norm=no_norm)
```

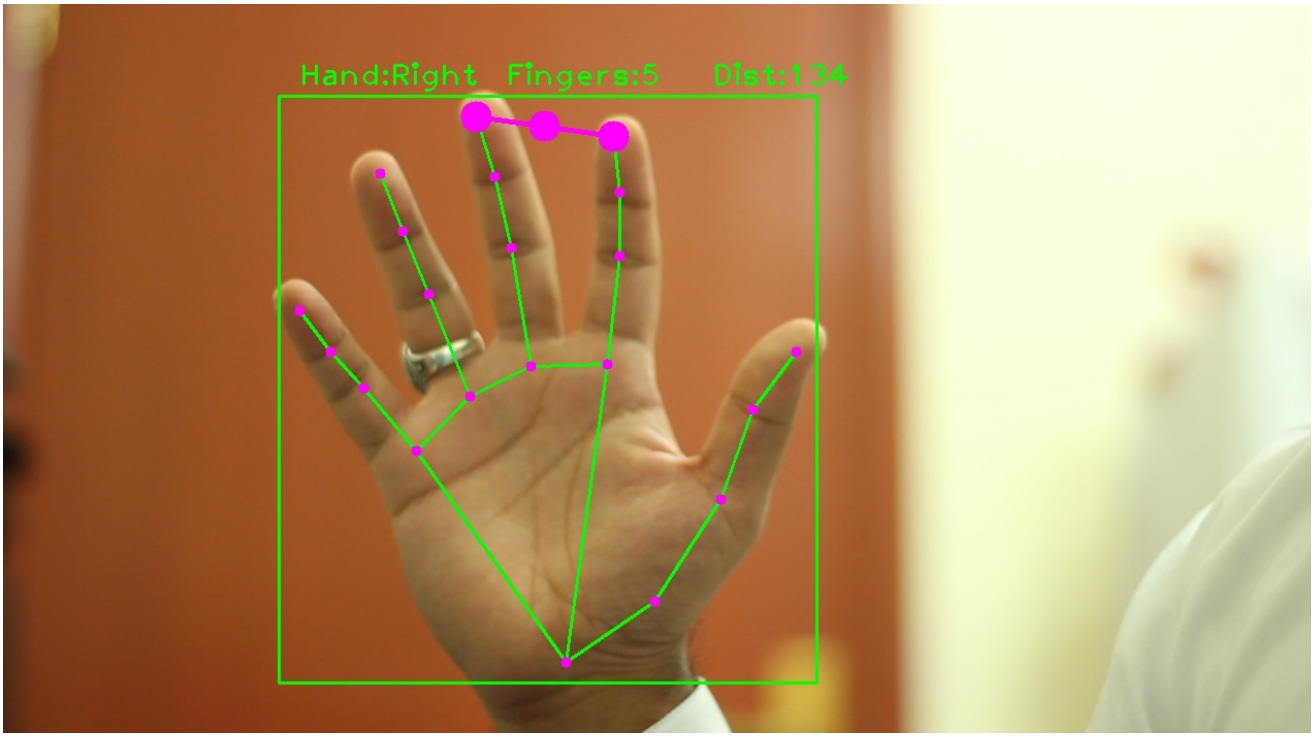
```
<matplotlib.image.AxesImage at 0x1de540d55b0>
```

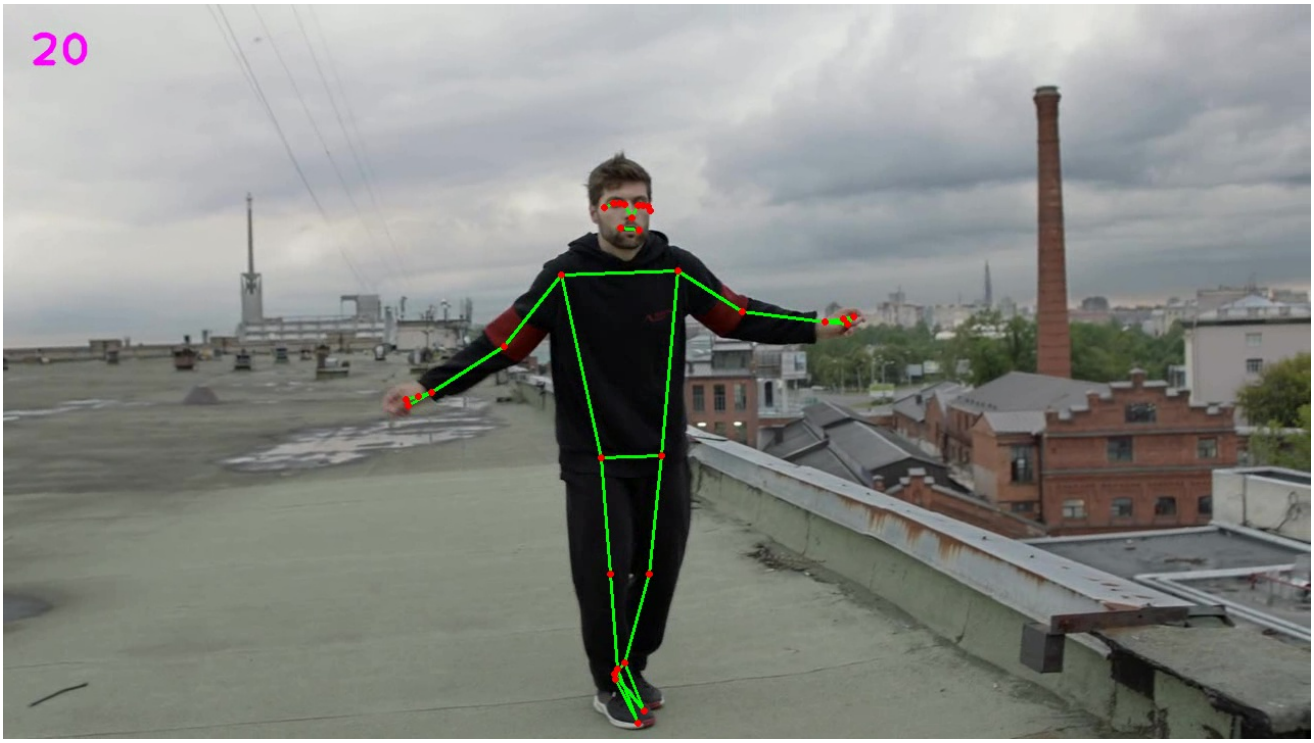


Application of OpcnCV

- Filtering, binarization, cutting, scale and rotation transformations, image gradients
- Line and circle detection, feature point detection, edge detection, blob detection, feature point detection, pattern recognition
    - QR code identification
    - Face detection
    - Gesture recognition
    - Human gesture recognition




Hand:Right Fingers:5 Dist:134


20