

ANN - Demo

- **Optical character recognition (OCR) problem:** the process of converting scanned images of handwritten, typed or printed text into machine-encoded text.*
- **Digit Recognizer:** How to recognize handwritten numbers?

label = 3



label = 5



label = 3



label = 6



label = 1



label = 7



label = 2



label = 8



label = 6



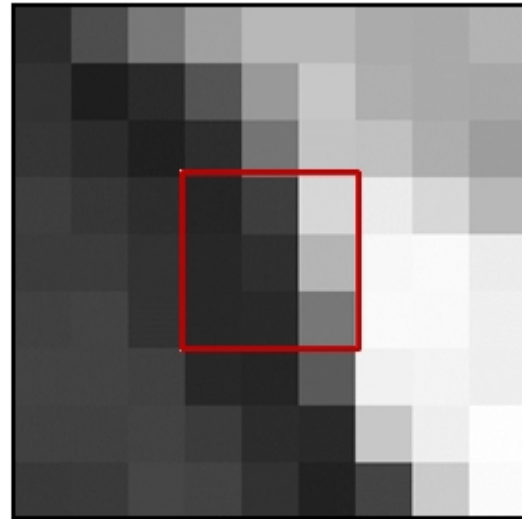
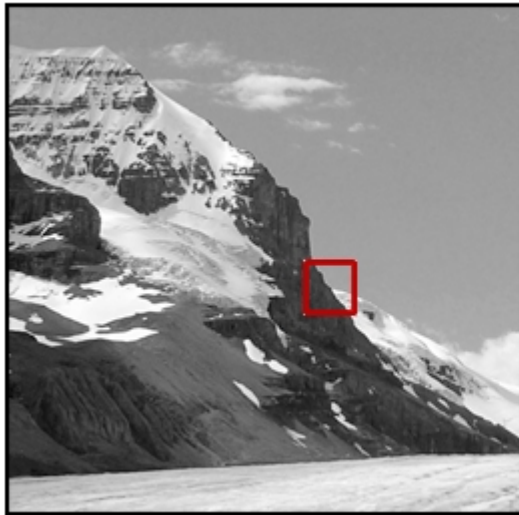
label = 9



Images extracted from the Internet.

What is a digital image?

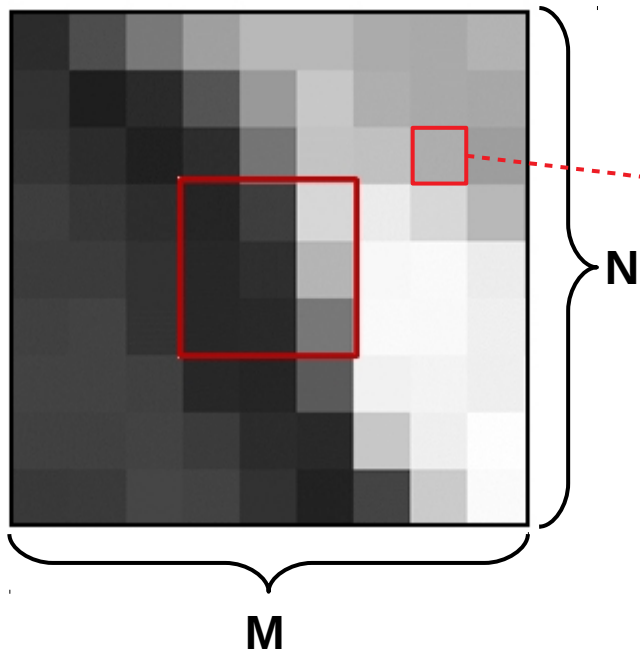
- The computer stores the information in binary representation.
- The basic unit is the bite {0,1}, and one byte is 8 bits: 10111101
- An image is a matrix of $N \times M$ pixels. The pixel is the smallest unit of information in a digital image, and each pixel is a point of the image.



Images extracted from Internet.

Image representation

- The image resolution is the amount of $M \times N$ pixels, it is the image size.
- While more resolution then better image quality.

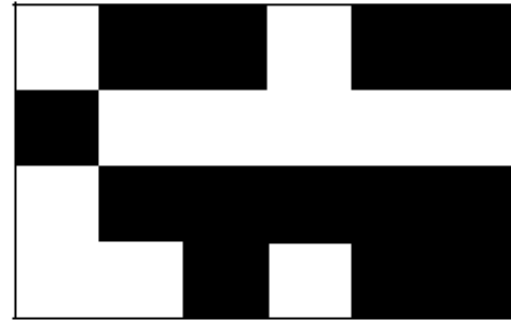


- A pixel indicates the amount of light in the image at that position, in the point of the matrix.
- The pixel value is represented by a discrete value.

B/W Images

- Black and white images are represented only by binary values.
- A pixel with value 1 indicates the white color.
- A pixel value 0 represents the black color.

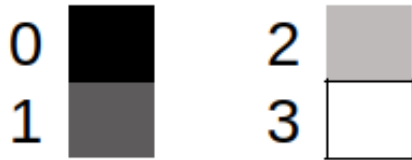
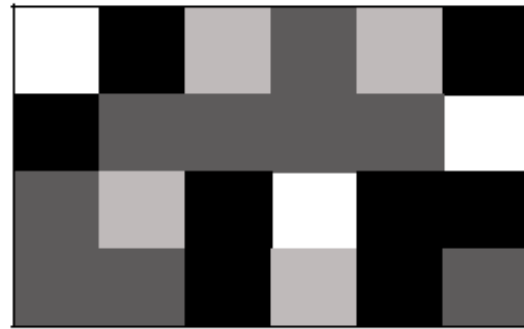
| | | | | | |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 0 | 0 |



Gray scale Images

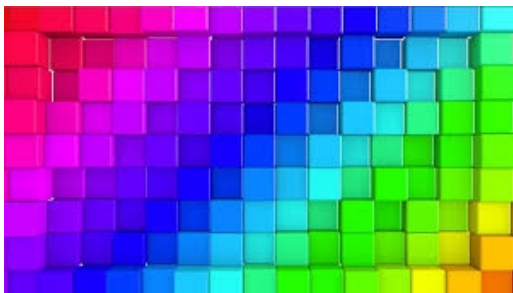
- Each pixel has a value equivalent to a level (intensity) of gray.
- For example, a pixel could represent 4 different colors:

| | | | | | |
|---|---|---|---|---|---|
| 3 | 0 | 2 | 1 | 2 | 0 |
| 0 | 1 | 1 | 1 | 1 | 3 |
| 1 | 2 | 0 | 3 | 0 | 0 |
| 1 | 1 | 0 | 2 | 0 | 1 |



Color Images

- Color depth refers to the diversity of colors to be represented.
- Colors variety, color depth, is the bits per pixel, that is, the number of bits necessary to represent the color of one pixel.



1 bit: {0, 1}, 2 different colors, black and white

2 bits: {00, 10, 01, 11}, 4 different colors.

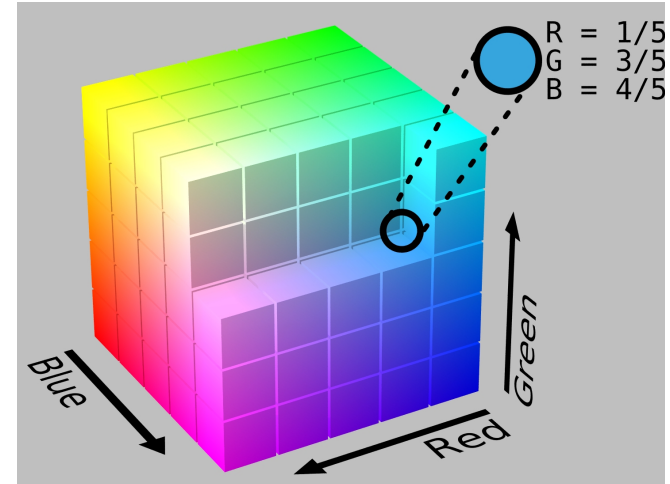
3 bits: {000, 001, 010, 100, 110, 101, 011, 111}, 8 different colors

4 bits: {0000, 0001,}, 16 colors

8 bits: {00000000, 00000001,}, 256 colors

Color Images

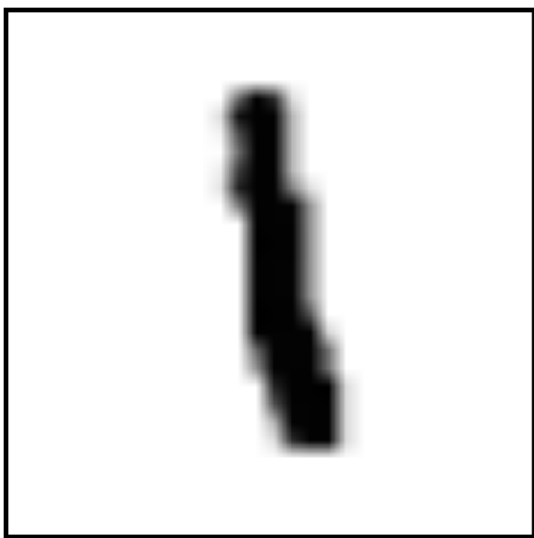
- Assuming an image with a color depth of 24 bits.
- There are 8 bits to store 3 primary colors: 8 bits for Red, 8 bits for Green, and 8 bits for Blue.
- A 24-bit image can have 256 tones of Red, 256 tones of Green, and 256 tones of Blue.
- The image can contain 16.777.216 (256 x 256 x 256) colors



| R | G | B | Color Name |
|-----|-----|-----|------------|
| 0 | 0 | 0 | Black |
| 255 | 255 | 255 | White |
| 224 | 224 | 224 | Light Gray |
| 128 | 128 | 128 | Gray |
| 64 | 64 | 64 | Dark Gray |
| 255 | 0 | 0 | Red |
| 255 | 96 | 208 | Pink |
| 160 | 32 | 255 | Purple |

Digit Recognizer

- A digit represented in an image corresponds to a numerical matrix.
- Assume that the following image is composed of 28 x 28 pixels.
- It is a numerical matrix that contains 784 numbers.



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| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|----|----|----|----|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | .6 | .8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | .7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | .7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | .5 | 1 | .4 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | .4 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | .4 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | .7 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .9 | 1 | .1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .3 | 1 | .1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

DR Problem

- Predict the digit label [0,1,2,3,4,5,6,7,8,9] based on the intensity level value (color) of 784 pixels:

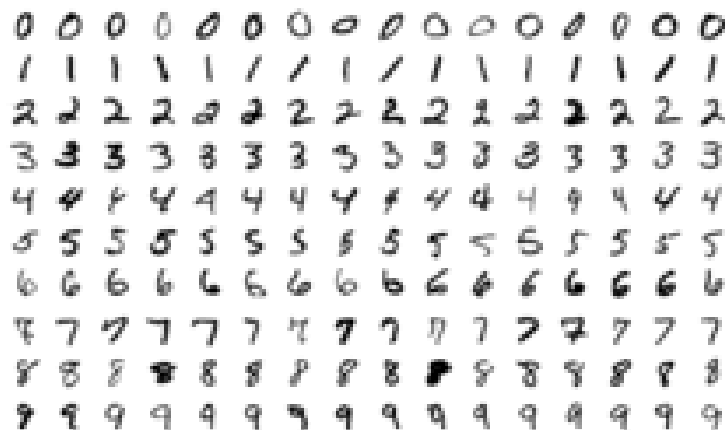
| label | pixel0 | pixel1 | pixel2 | pixel3 | pixel4 | pixel5 | | pixel775 | pixel776 | pixel777 | pixel783 |
|-------|--------|--------|--------|--------|--------|--------|-----|----------|----------|----------|----------|
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | ... | 0 | 250 | 0 | 0 |
| 1 | 0 | 0 | 0 | 234 | 0 | 0 | ... | 0 | 0 | 0 | 0 |
| 2 | 1 | 123 | 0 | 0 | 0 | 231 | ... | 21 | 0 | 0 | 67 |
| 3 | 4 | 0 | 245 | 0 | 0 | 0 | ... | 0 | 0 | 0 | 0 |

- Digit Recognizer

Data Set: 42.000 x 785

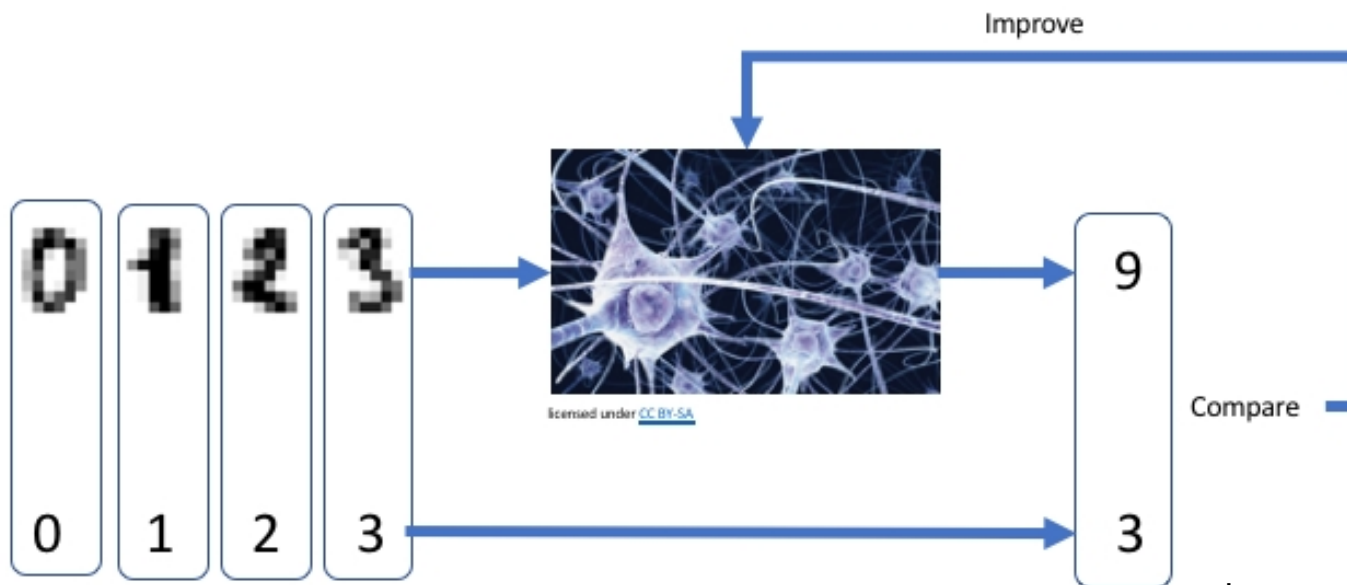
- Small DS: (1797, 64), each data point is a 8x8 image of a digit.

Link: [Recognizing hand-written digits](#)



ANN Process

- Build a neural network that allows the correct classification of labels based on pixels.
- From the miss classification, the label is corrected and through back propagation, the ANN model learns.



Images extracted from Internet.

Jupyter Demo...