Image Data Augmentation (Week 8)

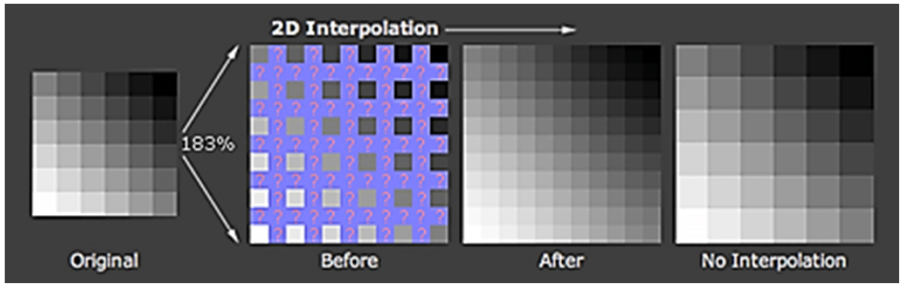
Image Data Augmentation

- Data augmentation
  - It is a set of techniques that enhance the size and quality of machine learning training datasets so that better learning models can be trained with them.
- Image augmentation
  - It is the procedure of improving the quality and information content of original data before processing. Examples include:
  - Filtering with morphological operators
  - Noise removal using filters
  - Gamma transformations
  - Contrast adjustment
  - Histogram equalisation, etc.

Interpolation

Interpolation

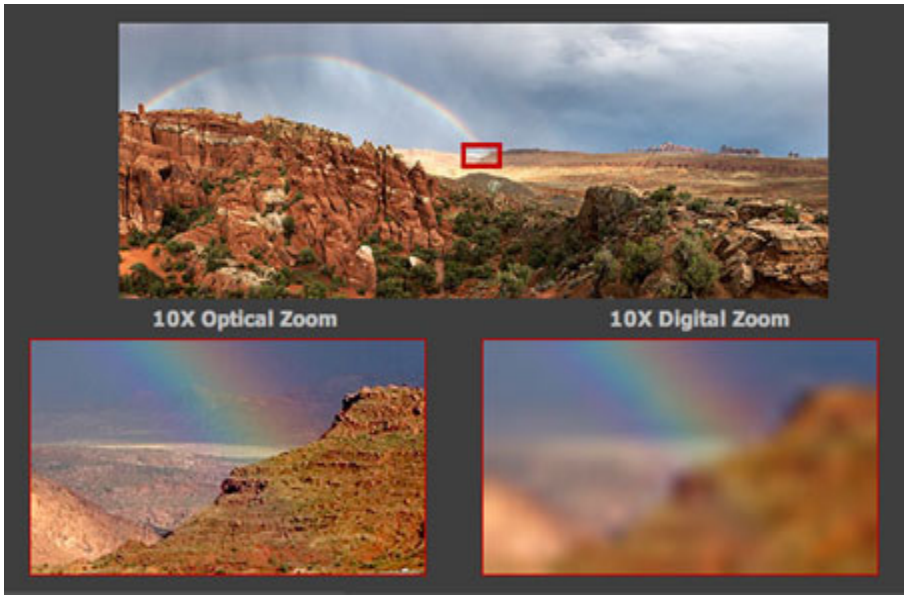
- What happens when the template size slightly mismatches with the frame information?
- Interpolation is a method of creating new data points within the range of known data points.



- Resizing an image (or a feature map) to a desired spatial dimension is a common operation when building AI applications.
- Helpful in case of template matching, when the size of the template mismatches with the frame information.
- Can create possible templates of different sizes to match the frame information.

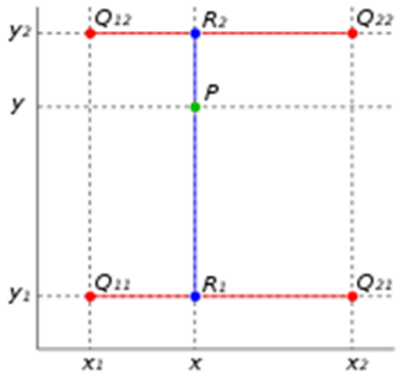
Interpolation: Digital zoom

- Many compact digital cameras can perform both an optical and a digital zoom.
- A camera performs an optical zoom by moving the zoom lens so that it increases the magnification of light before it even reaches the digital sensor.
- In contrast, a digital zoom degrades quality by simply interpolating the image — after it has been acquired at the sensor.



Bilinear Interpolation

- Bilinear interpolation is a method for interpolating functions of two variables (e.g., x and y) using repeated linear interpolation.
- We first do linear interpolation in the x-direction:



$$R_1 = f(x, y_1) = \frac{x_2 - x}{x_2 - x_1} f(Q_{11}) + \frac{x - x_1}{x_2 - x_1} f(Q_{21}),$$

$$R_2 = f(x, y_2) = \frac{x_2 - x}{x_2 - x_1} f(Q_{12}) + \frac{x - x_1}{x_2 - x_1} f(Q_{22}).$$

- Interpolating in the y-direction:

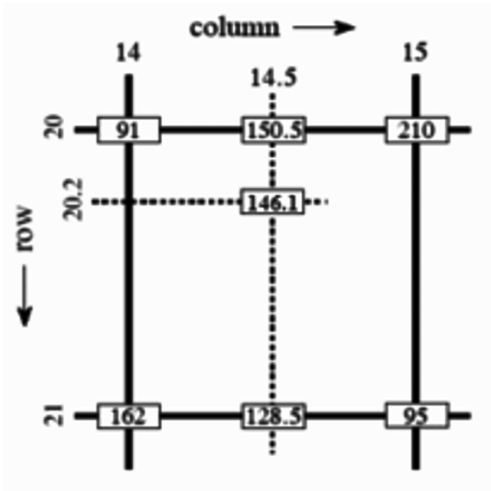
$$P = f(x, y) = \frac{y_2 - y}{y_2 - y_1} f(x, y_1) + \frac{y - y_1}{y_2 - y_1} f(x, y_2)$$

$$= \frac{y_2 - y}{y_2 - y_1} \left(\frac{x_2 - x}{x_2 - x_1} f(Q_{11}) + \frac{x - x_1}{x_2 - x_1} f(Q_{21}) \right) + \frac{y - y_1}{y_2 - y_1} \left(\frac{x_2 - x}{x_2 - x_1} f(Q_{12}) + \frac{x - x_1}{x_2 - x_1} f(Q_{22}) \right)$$

Bilinear Interpolation: Gray scale image: DIY

- Suppose you want to magnify image by adding 4 rows and 1 column in the image.
- The intensity value at the pixel computed at (row 20.2, column 14.5) can be calculated by first linearly interpolating between the values at columns 14 and 15 on each row 20 and 21 i.e. x-direction:

$$I_{20,14.5} = \frac{15-14.5}{15-14} \cdot 91 + \frac{14.5-14}{15-14} \cdot 210 = 150.5,$$
$$I_{21,14.5} = \frac{15-14.5}{15-14} \cdot 162 + \frac{14.5-14}{15-14} \cdot 95 = 128.5,$$



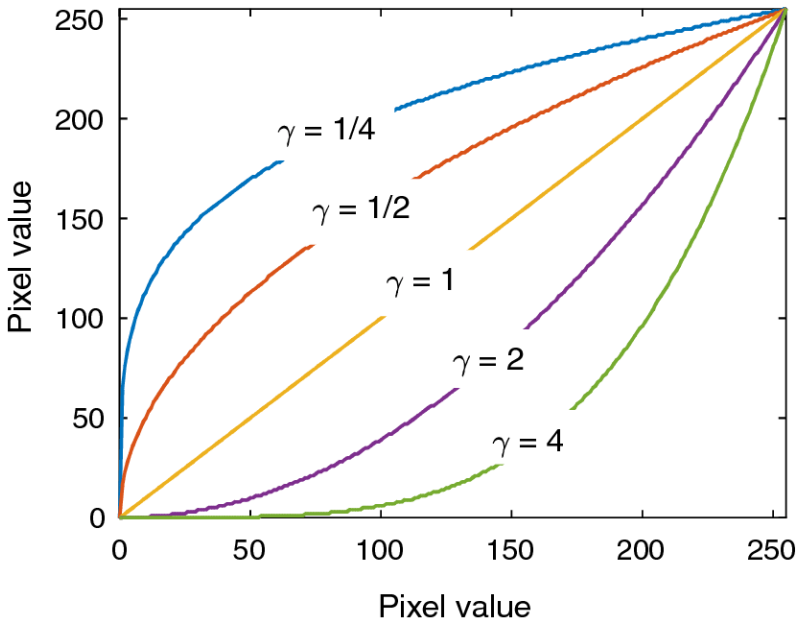
- Then interpolating linearly in y-direction:

$$I_{20.2,14.5} = \frac{21-20.2}{21-20} \cdot 150.5 + \frac{20.2-20}{21-20} \cdot 128.5 = 146.1$$

Image Data Adjustment

Gamma Adjustments

- Gamma correction is a nonlinear operation for encoding and decoding luminance in video or digital images.
- When a camera records video or a digital image, it's more sensitive to the light coming in than humans are.
  - If twice as many photons hit the camera sensor as usual, the camera registers twice as many photons. It has a linear relationship to the brightness coming in.
  - However, humans do not. When we see, if our eyes received twice as many photons, we'd perceive a much smaller increase in brightness.



Gamma Adjustments

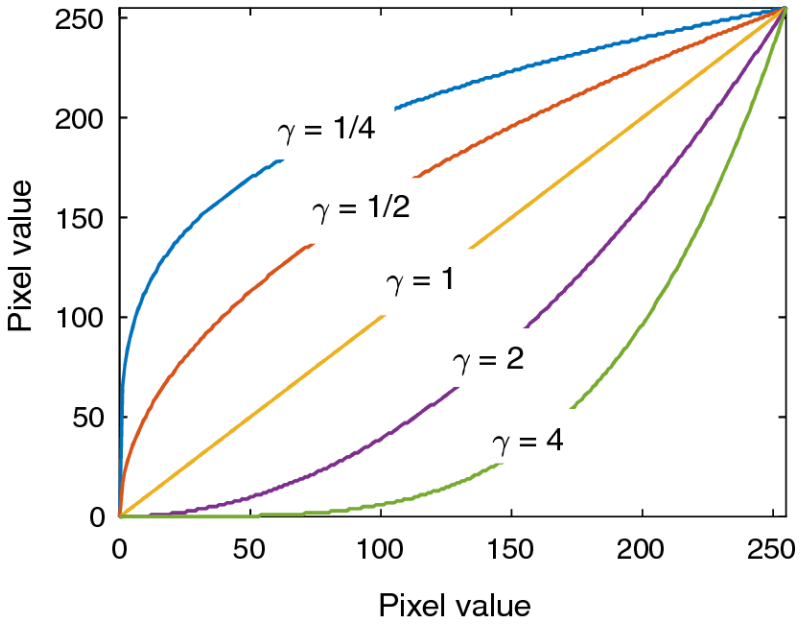
- The general form of gamma transformation function is:

$$s = c \times r^{1/\gamma}$$

where, 's' and 'r' are the output and input pixel values, respectively and 'c' and 'γ' are the positive constants.

- Gamma law curves with $\gamma < 1$ map a narrow range of dark input values into a wider range of output values.
- Similarly, for $\gamma > 1$, map a wide range of dark input values into a narrow range of output values.

If the image is captured at night, which gamma value should be employed?



$\gamma < 1$

Gamma Adjustments ($\gamma = 0.5$)

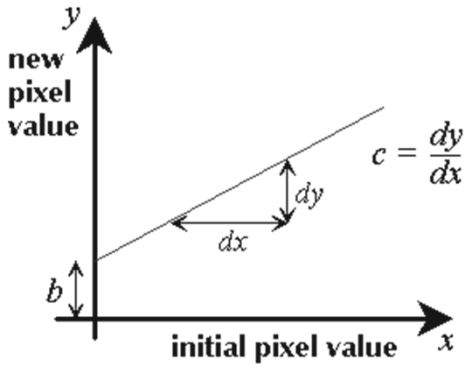
Gamma Adjustments

Linear Contrast Adjustment

- There are a number of models which can be used to adjust image contrast.
- The most popular is the linear contrast stretch.
- In this model, if an image pixel has initial value x. Its new updated value can be estimated using:

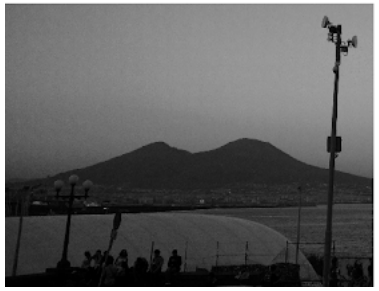
$$y = cx + b$$

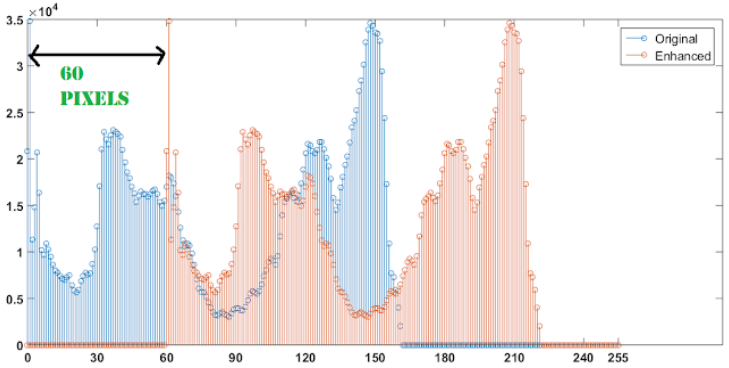
- Assume $c = 1$ and $b = 0$. How pixel values will change?
  - It remain unchanged.
- Increase c
  - Differences between initial pixel values will be greater.
  - Hence contrast increases, or stretching happens.
- Decreasing c
  - Squeezes the contrast.



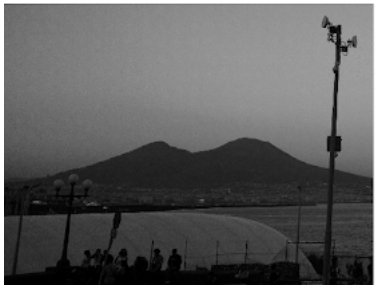
Linear Contrast Adjustment

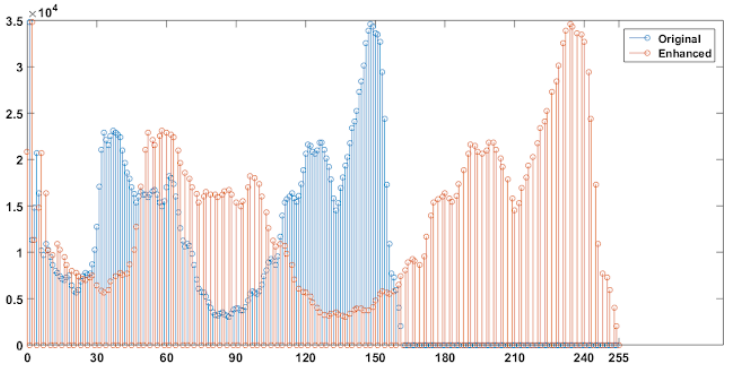
- $c = 1$
- $b = 60$





- $c > 1$
- $b = 0$





Linear Contrast Adjustment: RGB Image Data