Intensity (Gray-Level) Transformations

- Intensity (or Gray-Level) Transformations
  - \( s = T(r) \)
Types of Intensity Transformations

- Basic Transformations
  - Linear
    - Original
    - Negative
    - Piece-wise linear
  - Bit-plane slicing
  - Log
  - Power-Law (Gamma)

- Histogram equalization
Basic Transformation Functions
Linear Transforms

- Original $\rightarrow s = r$

- Negative $\rightarrow s = L - 1 - r$
Linear Transforms

- Piece-wise linear
  - **Contrast stretching** = increase range of intensity levels
  - **Intensity-level slicing** = brighten/darken certain intensity range
  - **Zig-zag** = when input range >> output range
Bit-Plane Slicing

- Can decompose 8-bit image into “bit planes”

http://hwshow-ipc.blogspot.com/2009/12/hw5-8-bit-plane-slicing.html
Log Transformations

- $s = c \log(1 + r)$
  - When input range $>>$ display range
Power-Law (Gamma)

- $s = cr^\gamma$
  - $\gamma = \text{Greek letter gamma}$
  - More flexible than log transform
  - Used in \textit{gamma correction}
    - Transforms image to display correctly on given device
    - Needed because of non-linear voltage-to-intensity response
Histograms

- Histogram – discrete probability function
  - Bin for each possible value
  - Bin contains either:
    - Number of pixels with given gray value
    - OR
    - Probability value from 0.0 to 1.0

\[ P_r (r) = \frac{n_r}{N} \]

- where \( N \) = total # of pixels and \( n_r \) = # of pixels with \( r \) intensity
Histogram Equalization

- Histogram Equalization
  - Transform grayscale values so that histogram is more evenly distributed
  - Use CDF (Cumulative Distribution Function) as transformation function $T(r)$

$$s = T(r) = (L-1) \sum_{j=0}^{r} P_r(j) = \frac{(L-1)}{N} \sum_{j=0}^{r} n_j$$