Transformation II

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Transformation: Enhancement

Goal: make the image look better:

- View and process the visual information with greater clarity.

Image enhancement: subjective:

- Depends upon the information required.
- Also physical characteristics of the image.
- The prior knowledge.
- User's experience, intuition and judgement.

Evaluation: perceived quality of results.

Poor image characterstics: poor lighting and noise.

Transformation: Dynamic Range

“Dynamic range of a sensor = largest possible signal divided by the smallest possible signal it can generate.”

Dynamic range = range of possible pixel values of a given image or sensor.

A good image should utilise the full (or most of the) range of the sensor or image.

Increasing the dynamic range improves contrast.

Transformation: Logarithmic

Operation: compresses dynamic range of image:

- (i.e. smaller range of pixel values).
- Replaces each pixel value with its logarithm:

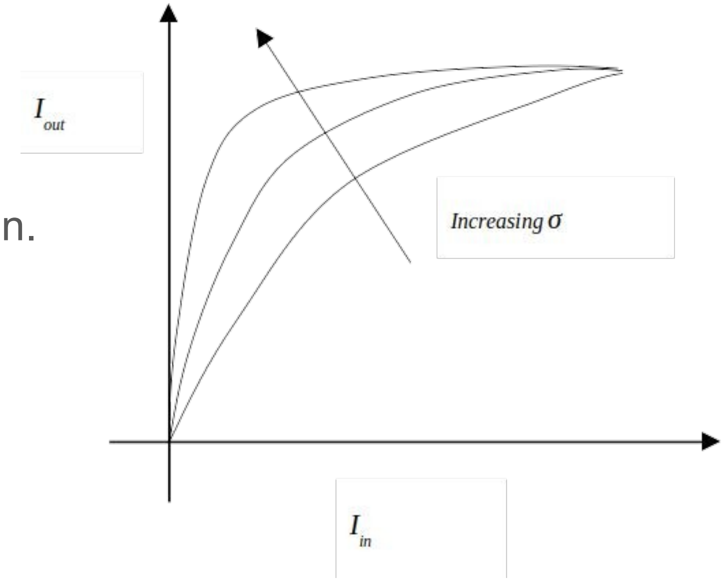
$$I_{output}(i, j) = ln\ I_{input}(i, j)$$

In practice (as logarithm undefined for zero):

$$I_{output}(i, j) = c\ ln\left[1 + (e^{\sigma} - 1)\ I_{input}(i, j)\right]$$

with additional scaling factors σ and c.

Transformation: Logarithmic



Scaling factors *σ* and *c*

- *σ* controls the input range to the logarithmic function.
- *c* scales the output to the range 0->255.
- *R* is the maximum value in I_{input}.

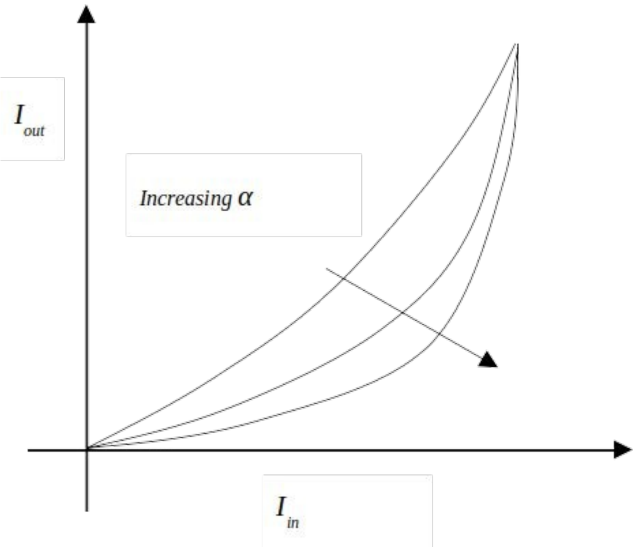
$$I_{output}(i,j) = c\,ln\left[1 + \left(e^{\sigma} - 1\right) I_{input}(i,j)\right]$$

$$c = \frac{255}{log(1 + |R|)}$$

Transformation: Logarithmic

Logarithmic transform: increases the dynamic range of dark regions in an image and decreases the dynamic range in light regions.

Transformation: Exponential



Operation: inverse of logarithmic transform.

- Compresses dynamic range differently
- Replaces each pixel value with its exponent:

$$I_{output}(i, j) = \exp I_{input}(i, j)$$

In practice (expand for variable basis and scaling):

$$I_{output}(i,j) = c\left[(1+\alpha)^{I_{input}(i,j)} - 1\right]$$

with additional scaling factors c and α.

Transformation: Exponential

- enhances detail in high value regions (bright).
- decreases the dynamic range in low value regions (dark).

Transformation: Power

Operation: raise each pixel value to fixed power:

$$I_{output}(i, j) = c(I_{input}(i, j))^r$$

For $r > 1$:

- enhances (spreads) high value portions of the image at the expense of low value regions.

For $r < 1$:

- enhances (spread) low pixel values whilst compressing high intensity values.

`Raise to Power' transform = similar logarithmic (r < 1) and exponential (r>1).

Transformation: Power

r > 1: enhances high value pixels at the expense of low value pixels.

r = 2

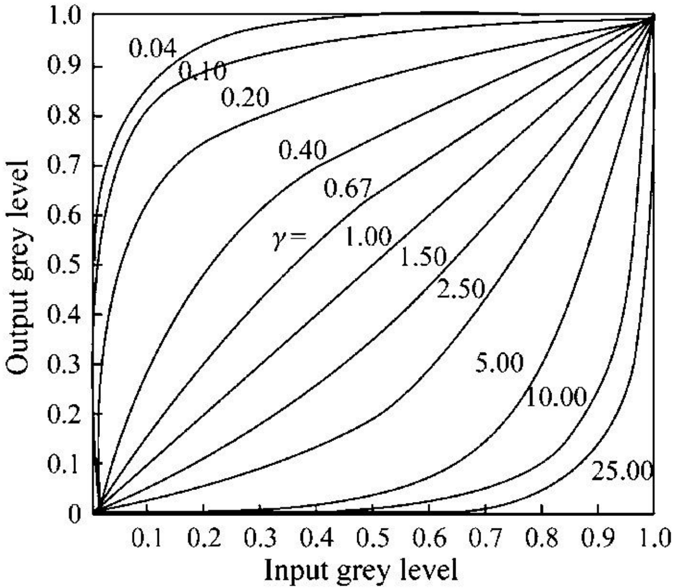
r = 0.5

Transformation: Gamma

Problem: computer monitor output is not linear function of input:

- Relationship is in fact exponential.
- E.g. request monitor output of value 0.5: result output 0.5^r
    - r ~= 2.5 (varies per model / manufacturer).
    - r = gamma value.

$$I_{output} = (I_{input})^{gamma}$$



Solution: preprocess using an inverse 'raise to power' to cancel this out:

$$(I_{input})^{1 / gamma}$$

Applications

An enhancement method using local Gamma correction with three-level thresholding. First, three-level thresholding is used to segment the image based on maximum fuzzy entropy. It can make it possible to segment the image into three gray levels (dark, medium tone, and bright). Then, local Gamma correction is applied to the three levels respectively. Finally, the image by Gamma correction is linear stretched with saturation.

J. Shi and Y. Cai, "A novel image enhancement method using local Gamma correction with three-level thresholding," 2011 6th IEEE Joint International Information Technology and Artificial Intelligence Conference, 2011, 374-378.