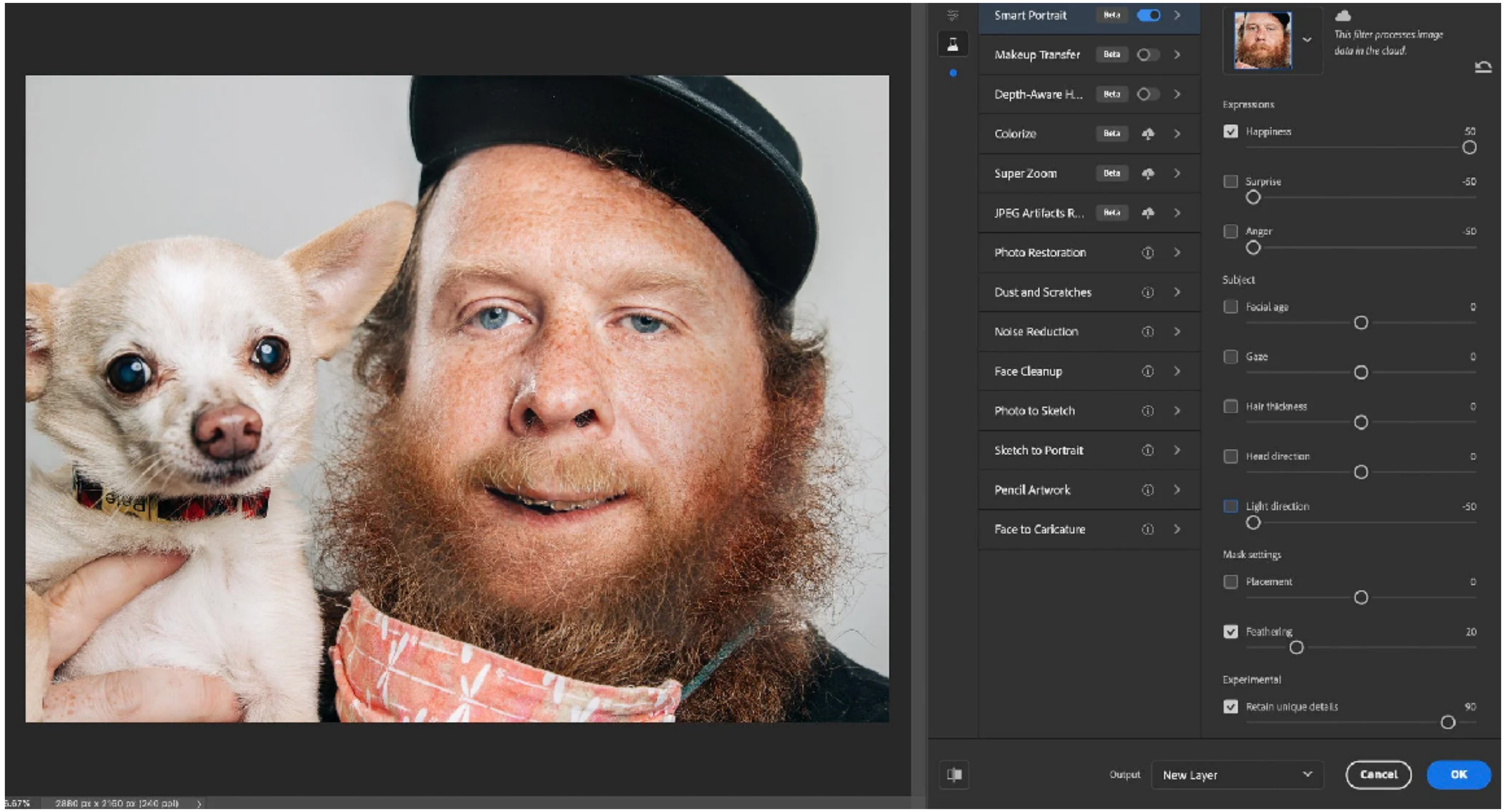
COMP0026: Image Processing

Image Transformations



[Popular Science]

Lectures will be Recorded

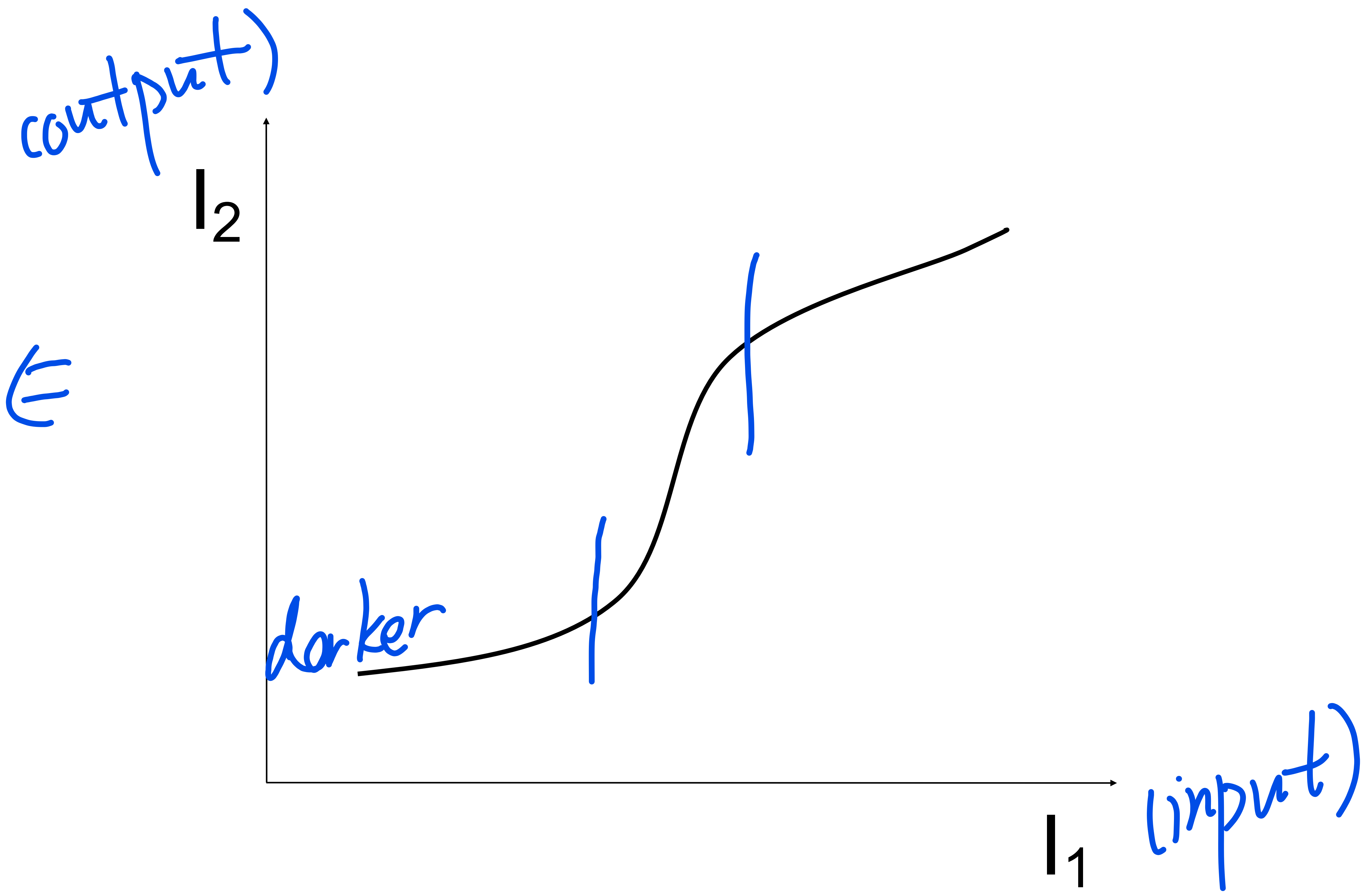
Outline

- Grey-level transformations
  - Histogram equalization
- Geometric transformations
  - Affine transformations
  - Interpolation
  - Warping and morphing

Grey-level Transformations

- Start with I_1
- Change the image grey level in each pixel by a fixed mapping f

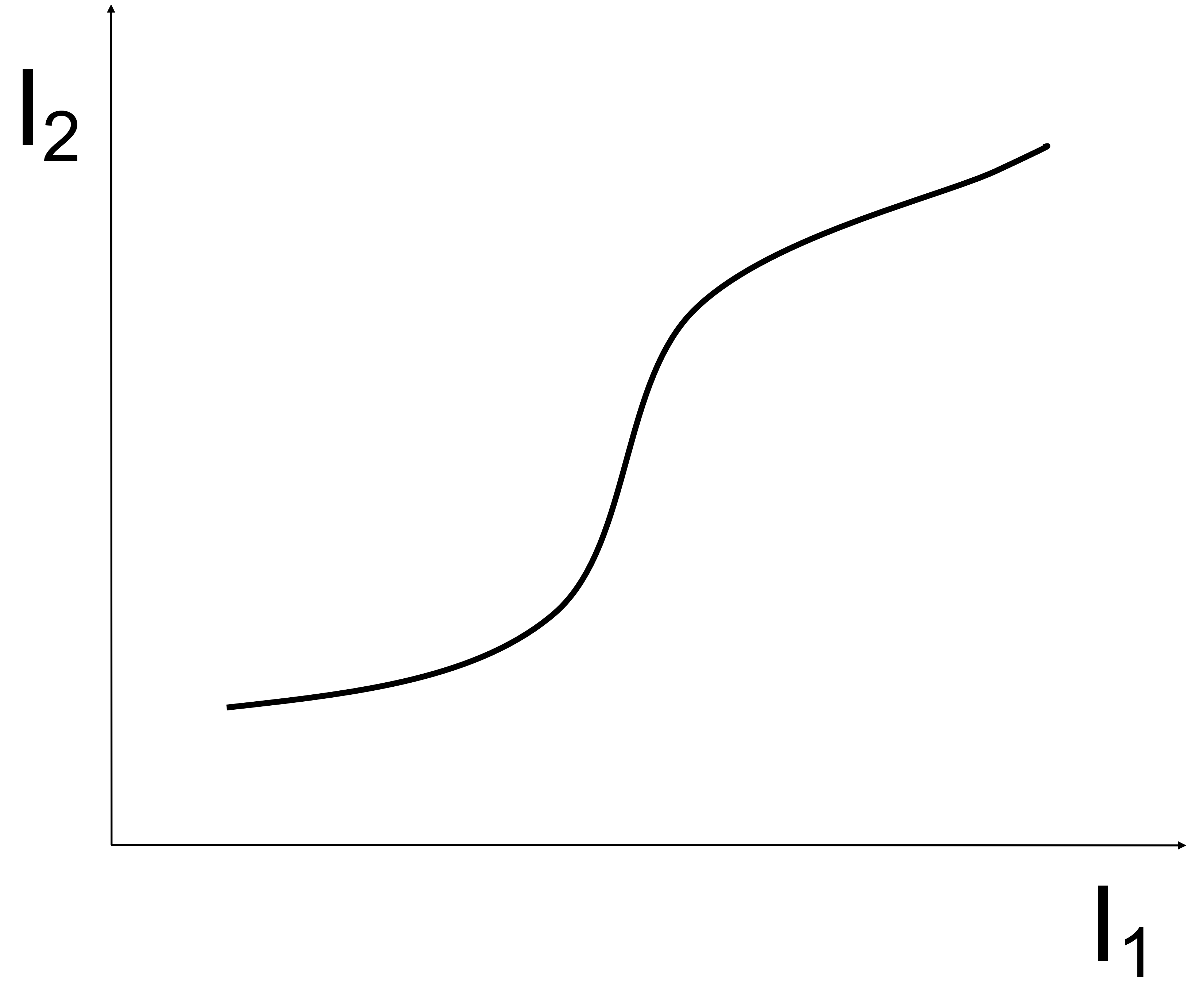
只是为了中间一段有更多的值表示



Grey-level Transformations

- **Start with** I_1
- **Change the image grey level in each pixel by a fixed mapping** f

$$f : \mathbb{R} \rightarrow \mathbb{R}$$

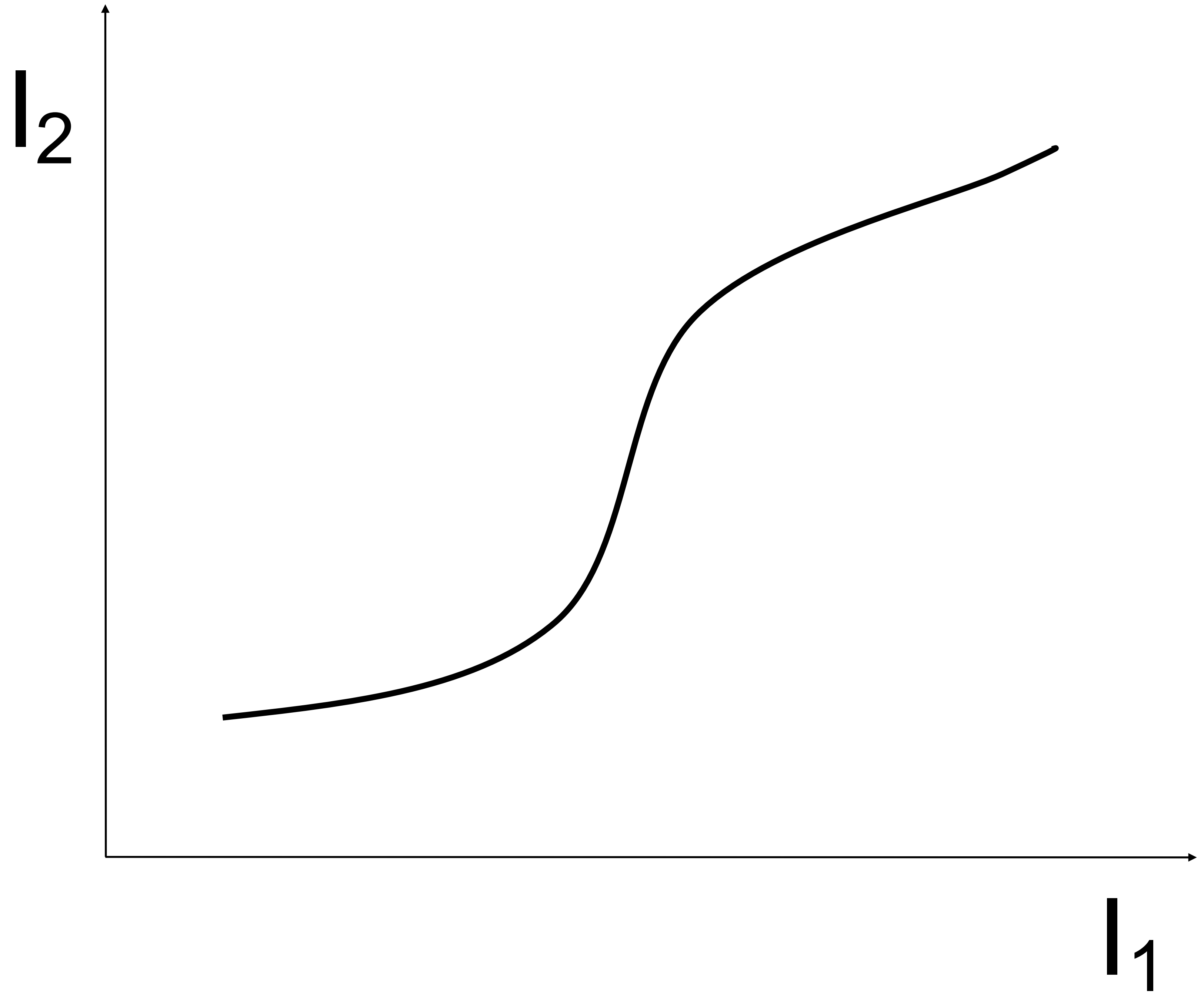


Grey-level Transformations

- **Start with I_1**
- **Change the image grey level in each pixel by a fixed mapping f**

$$f : \mathbb{R} \rightarrow \mathbb{R}$$

$$I_2(x, y) = f(I_1(x, y))$$



Linear: Contrast Stretch

仿射

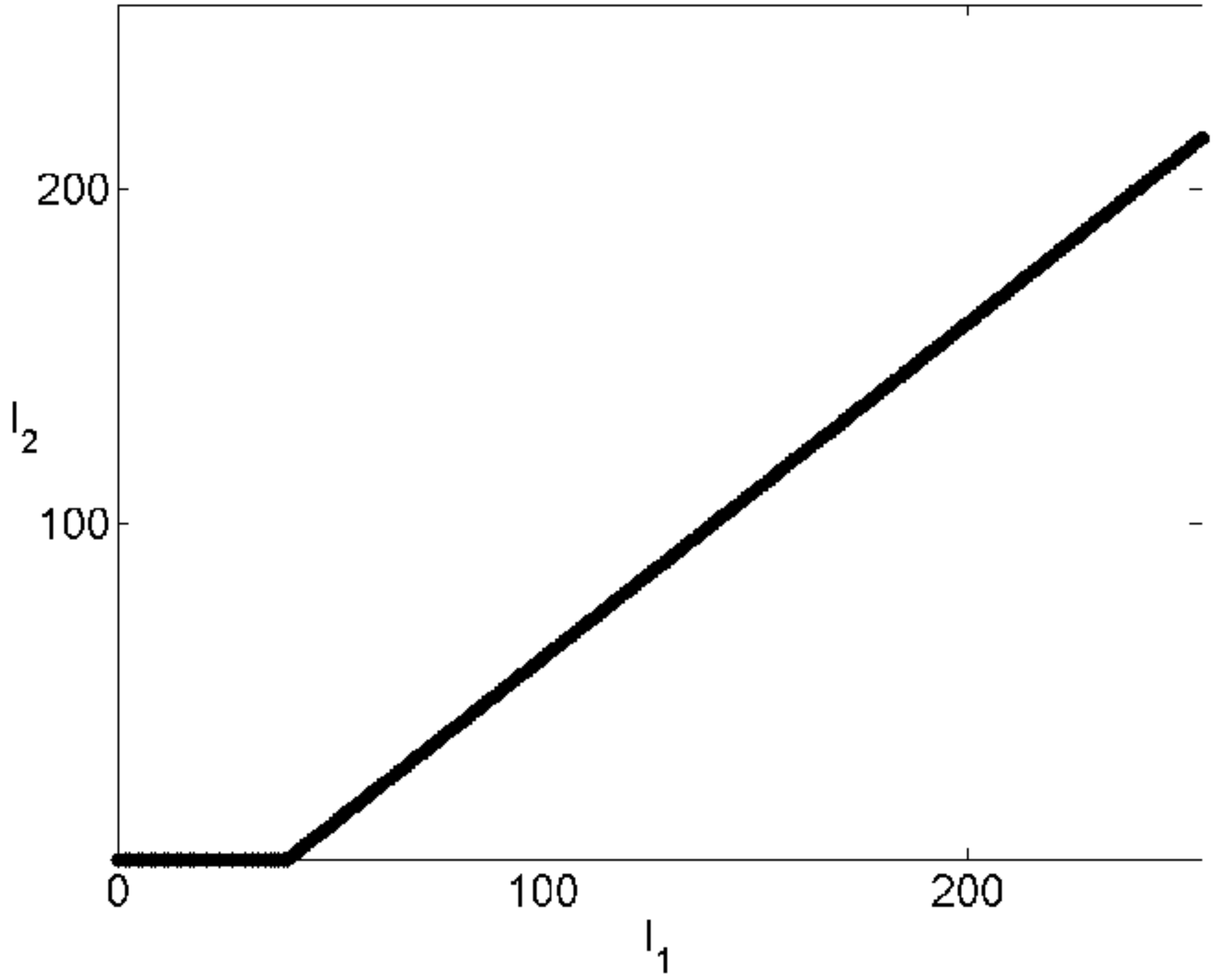
- f is an affine/linear function:

$$f(x) = \alpha x + \beta$$

- We must preserve the range of grey level values as [0,255]

Contrast Stretch α=1.0, β=-40

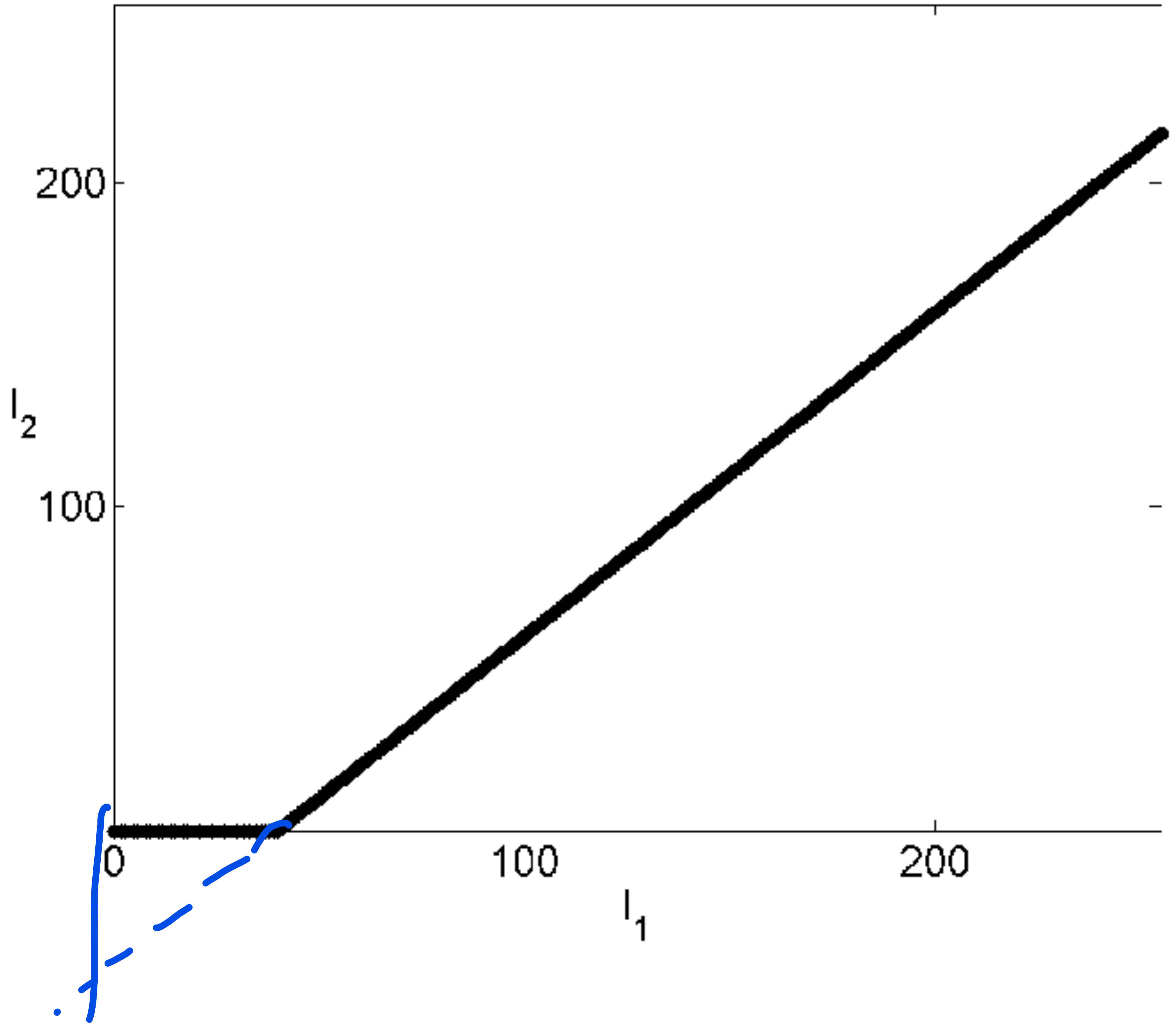
$$f(x) = \alpha x + \beta$$



Contrast Stretch α=1.0, β=-40

darker

$$f(x) = \alpha x + \beta$$



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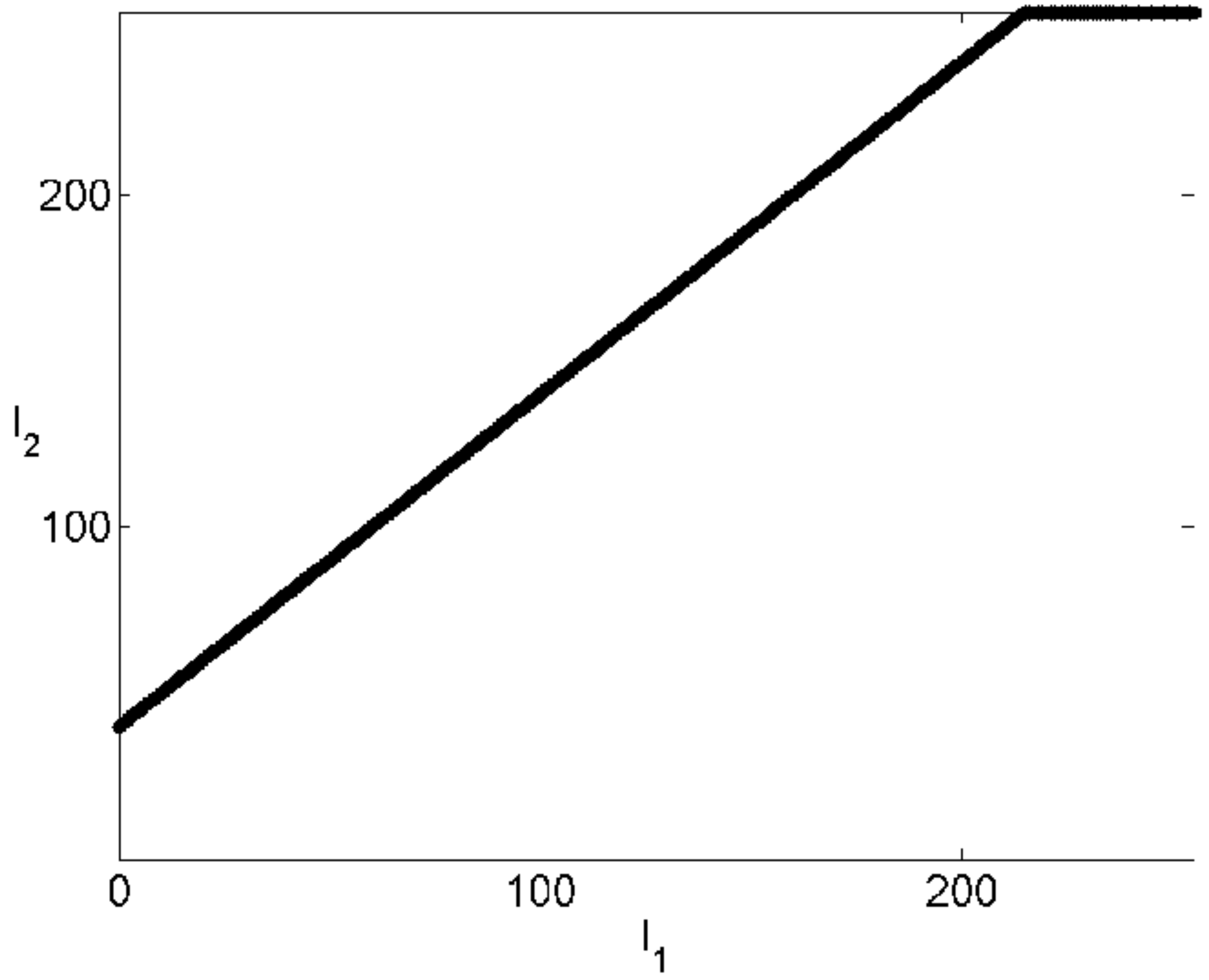
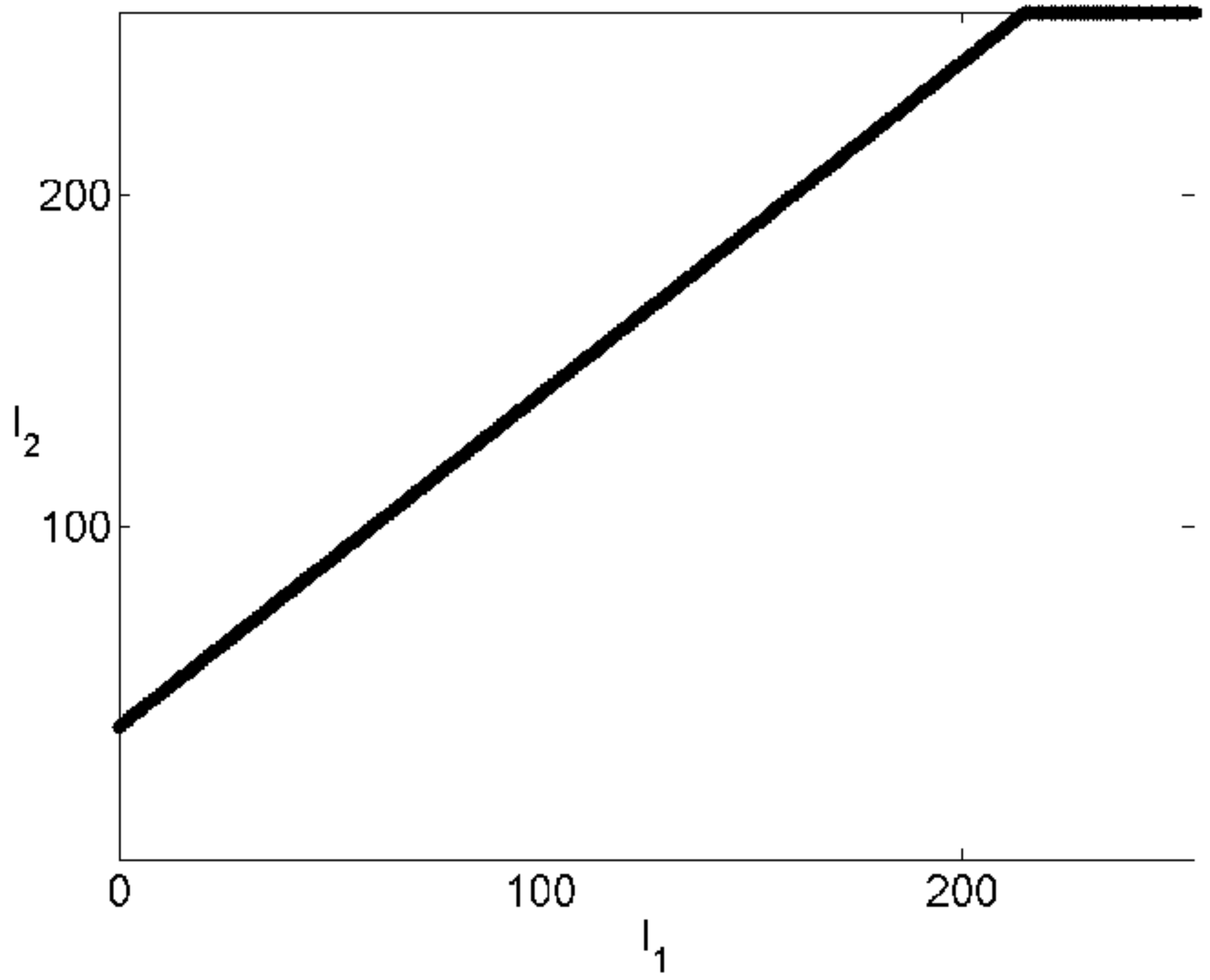


Contrast Stretch α=1.0, β=40

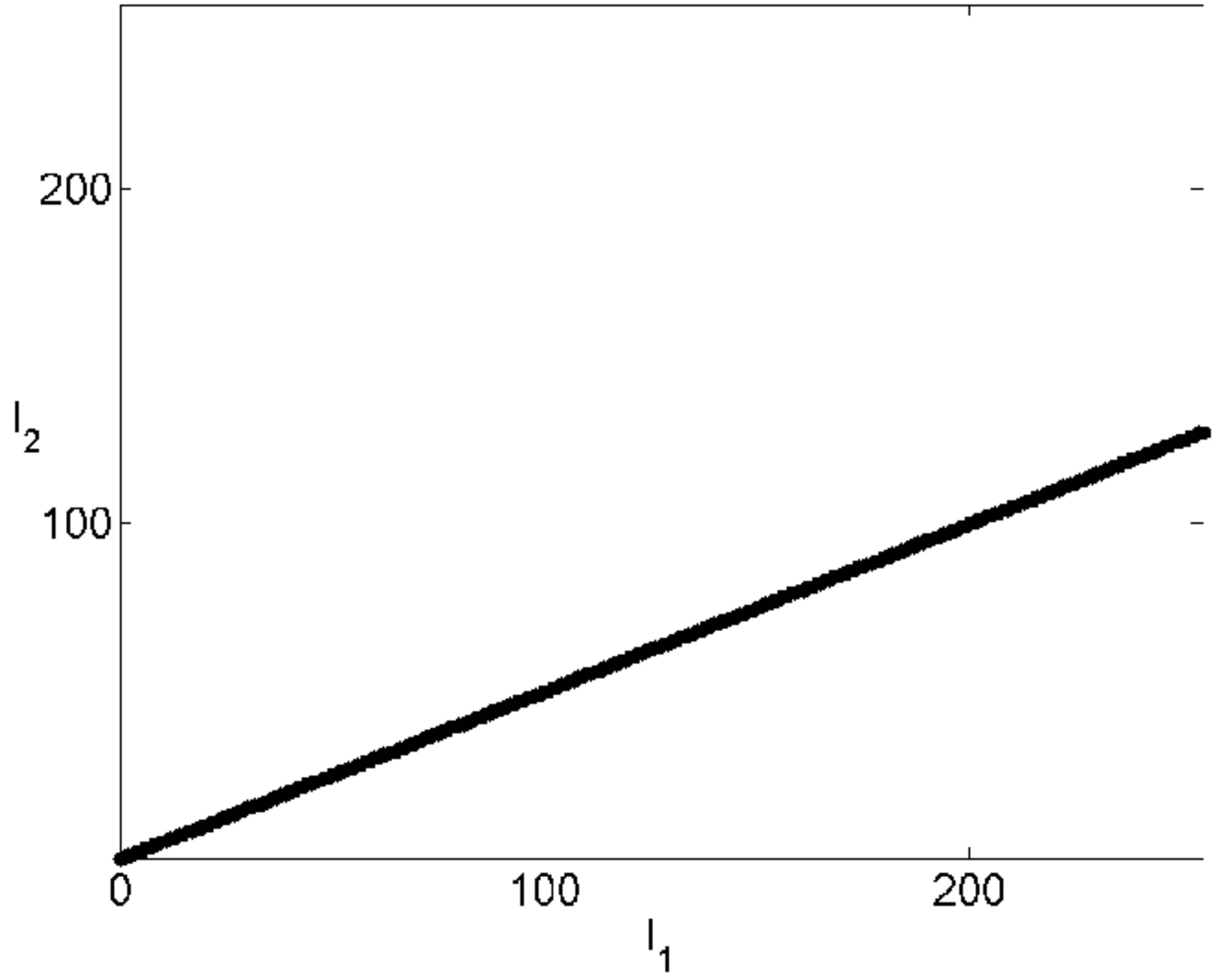
brighter

$$f(x) = \alpha x + \beta$$



Contrast Stretch α=0.4, β=0

$$f(x) = \alpha x + \beta$$



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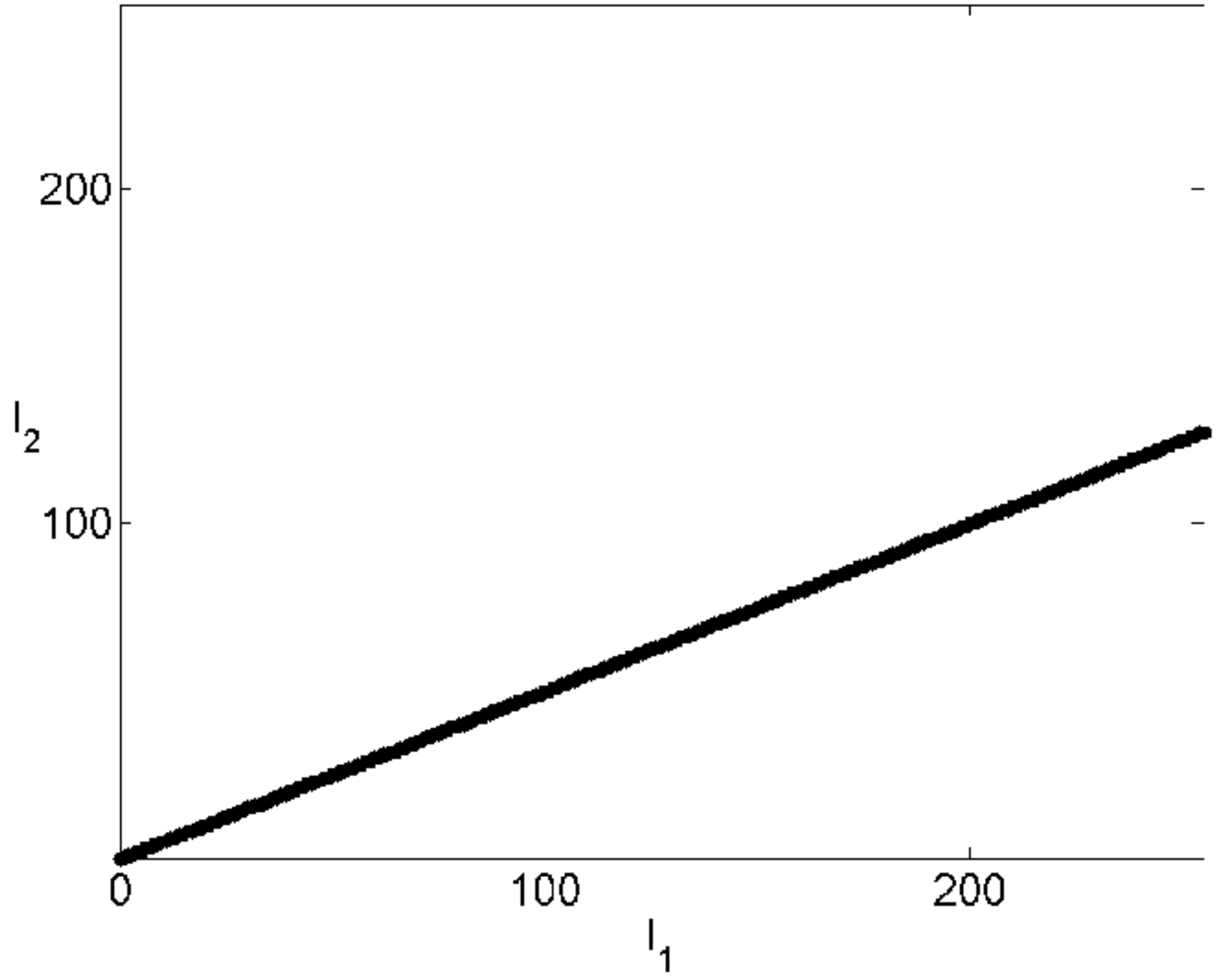
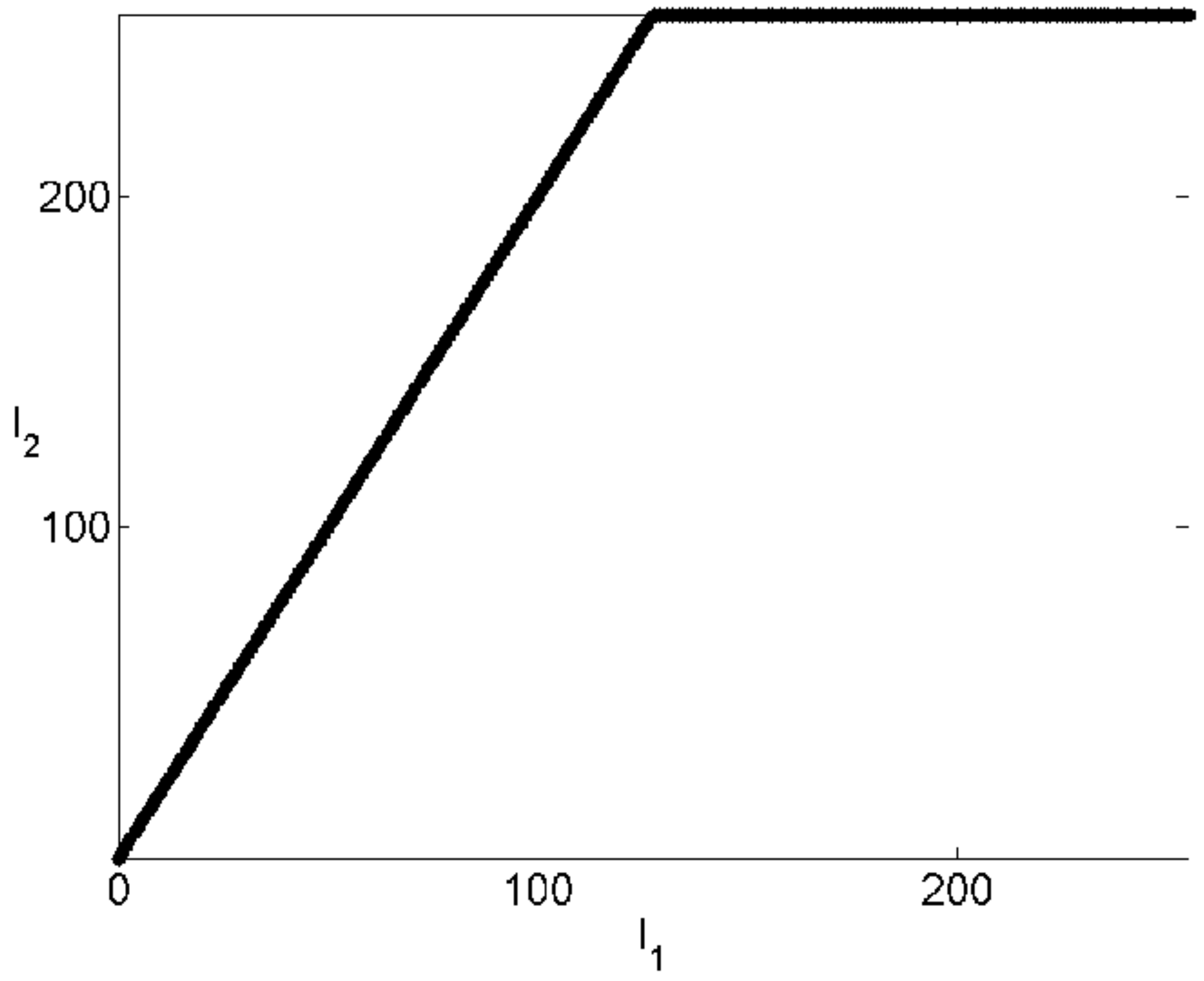


Contrast Stretch α=2.0, β=0

$$f(x) = \alpha x + \beta$$



Contrast Stretch α=2.0, β=0

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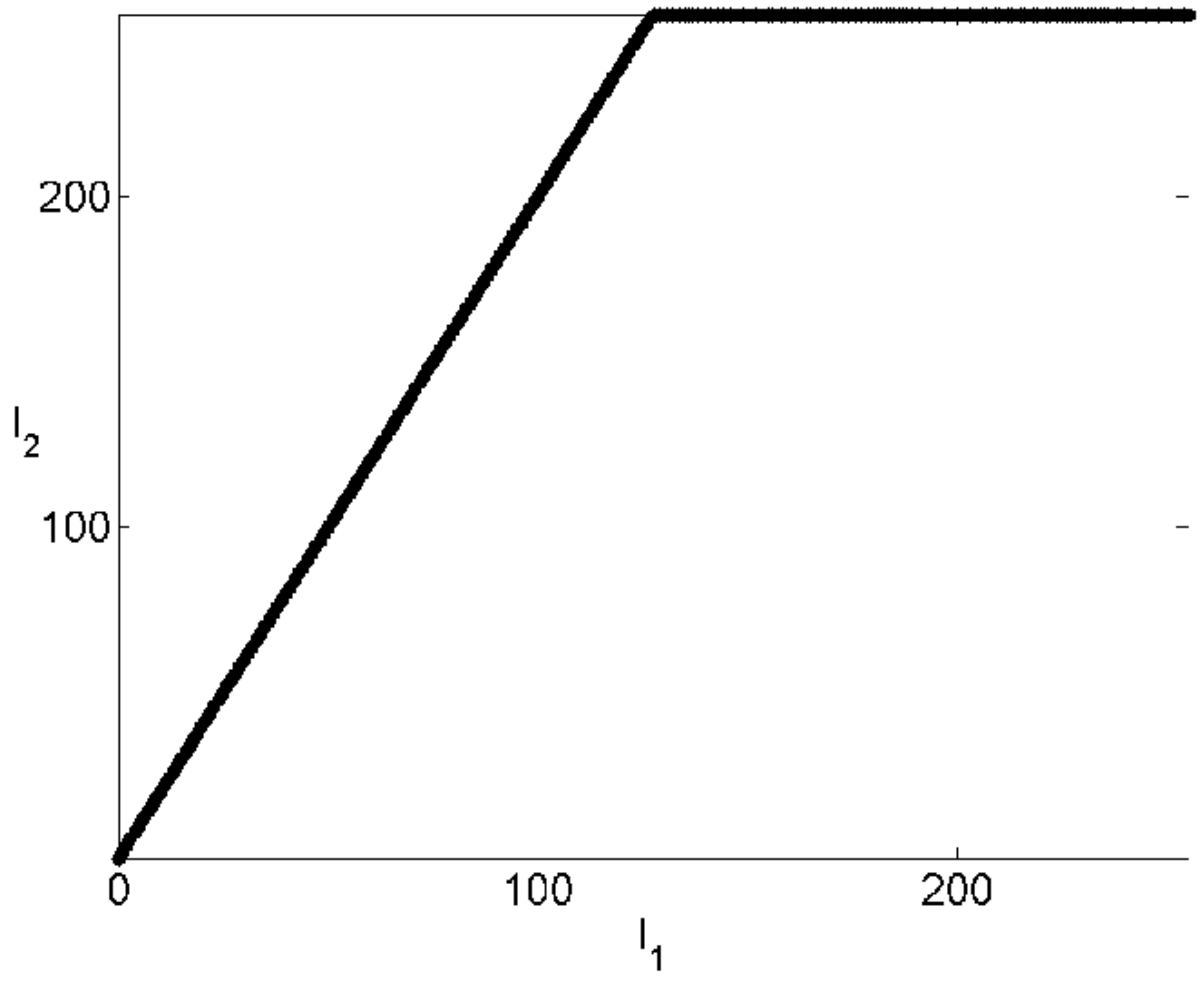

Non-linear: Gamma Correction

Gamma 矫正?

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- Non-linear grey-level transformations are useful too

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- Gamma correction adjusts for differences between camera sensitivity and the human eye

$$f(x) = Ax^{\gamma}$$

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- Non-linear grey-level transformations are useful too
- Gamma correction adjusts for differences between camera sensitivity and the human eye

$$f(x) = Ax^{\gamma}$$

- $A = 255^{1-\gamma}$ ensures that the grey scale range is unchanged

Non-linear: Gamma Correction

$$Ax^{1-\gamma}$$

$$\gamma = 0.25$$

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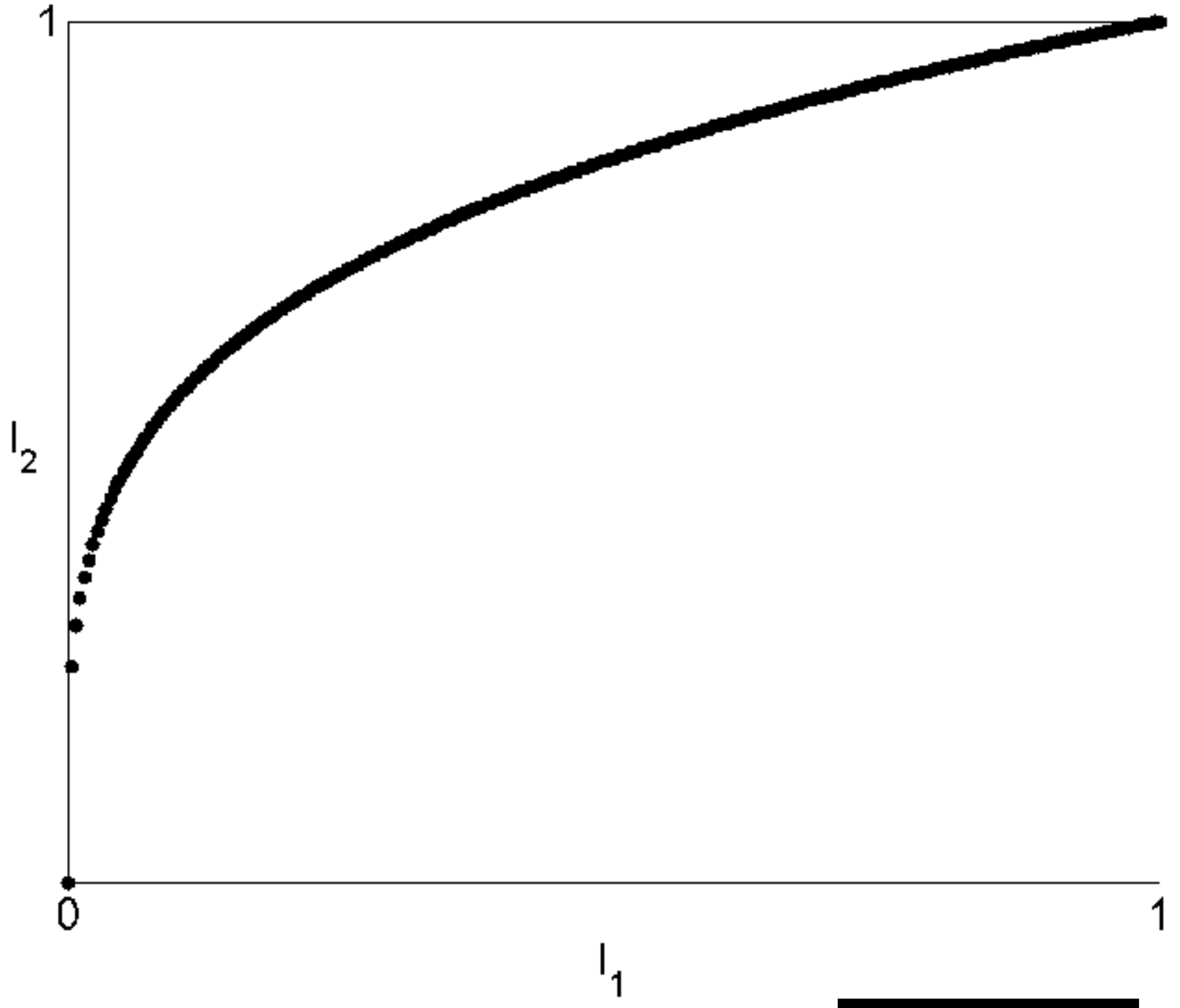
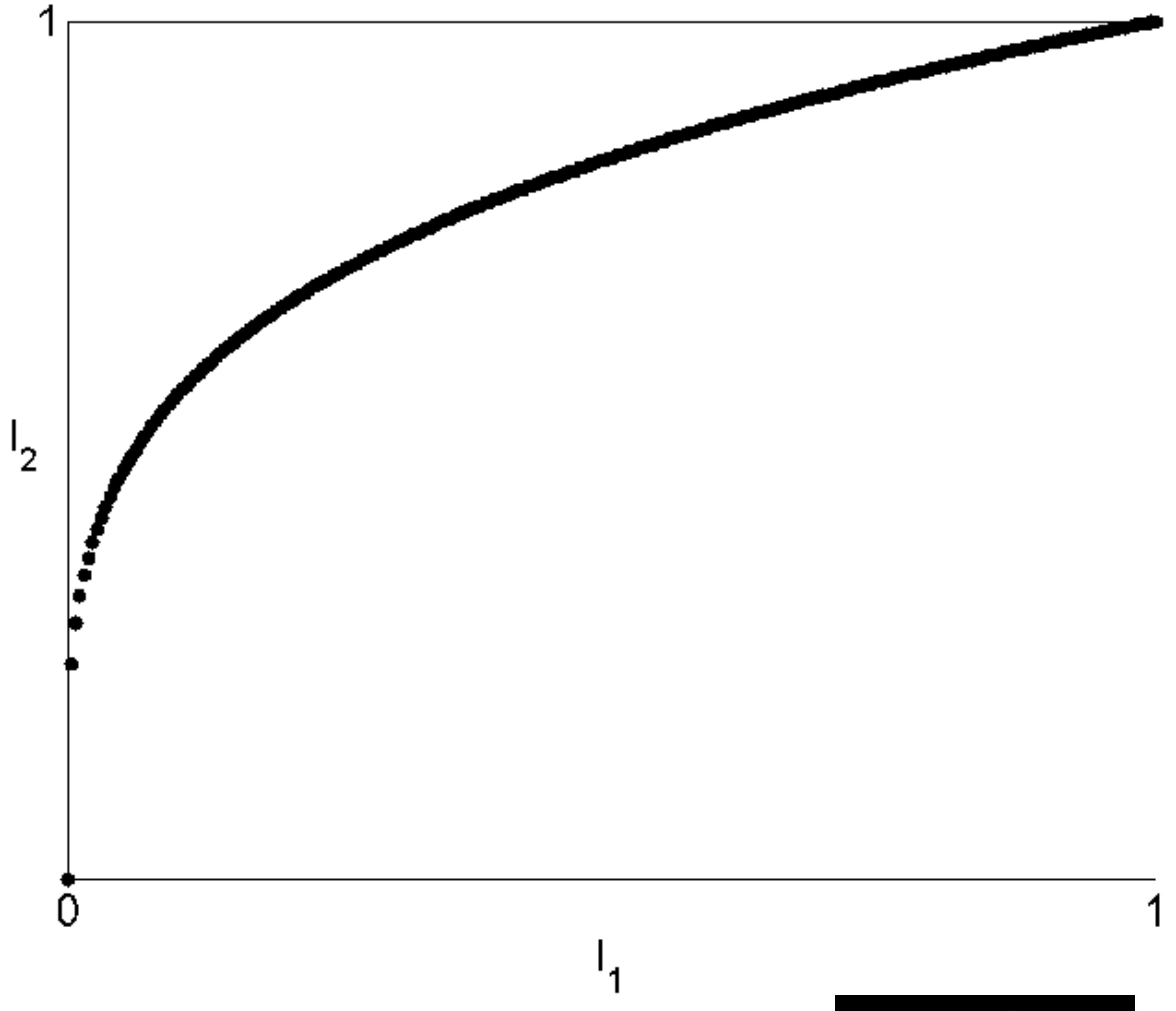


Non-linear: Gamma Correction

$$Ax^{1-\gamma}$$

$$\gamma = 0.25$$



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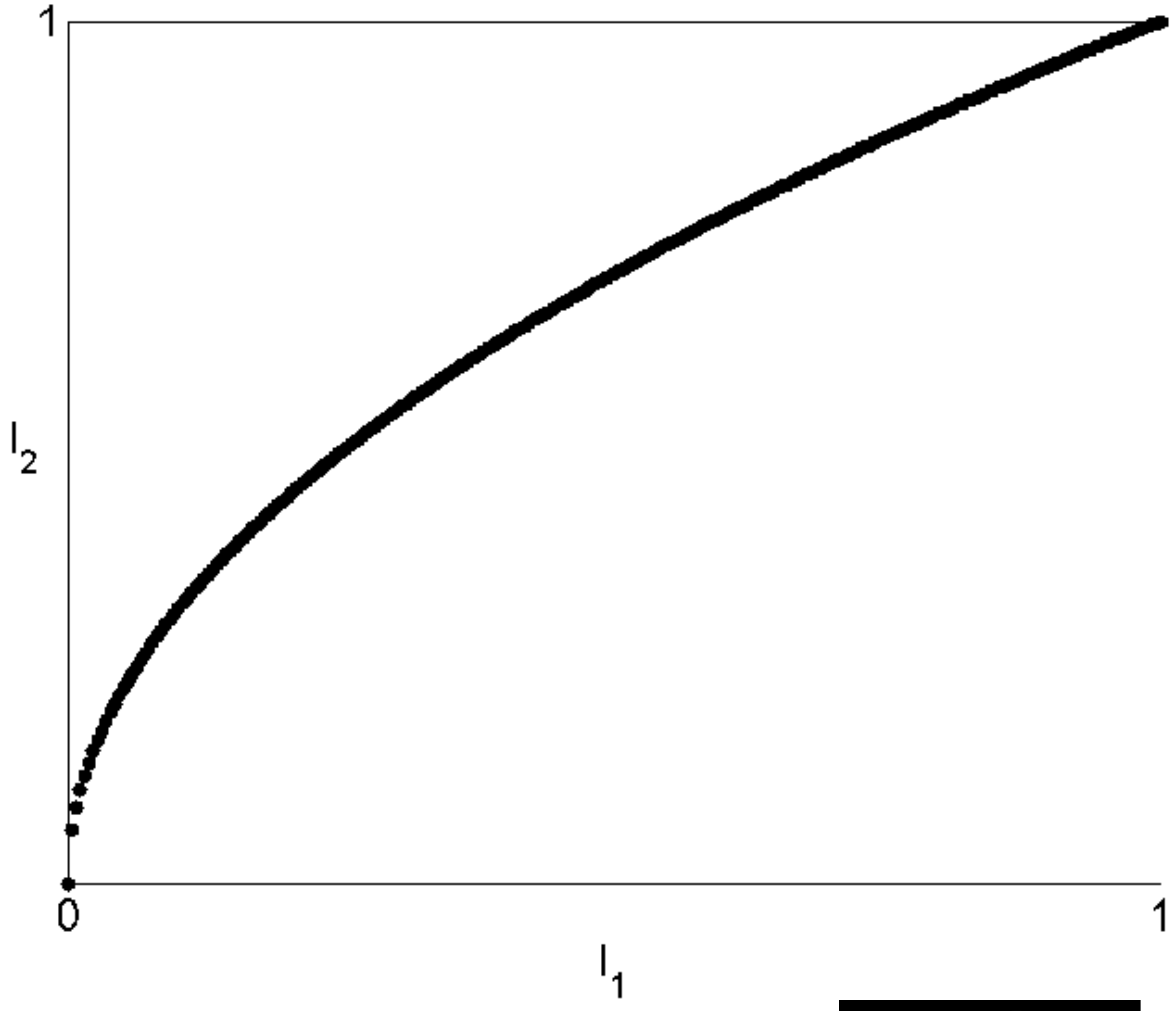

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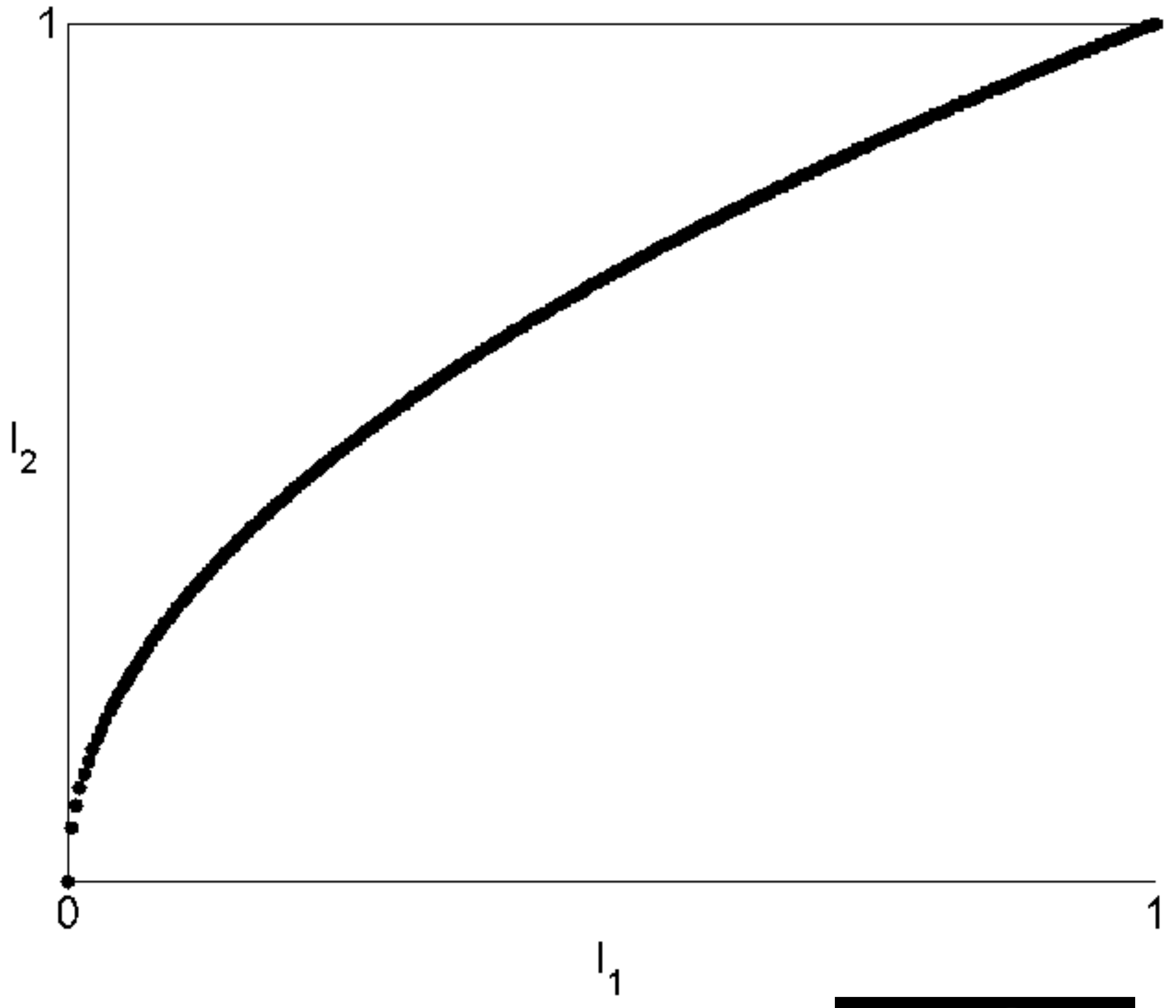


$\gamma < 1$
brighter

Non-linear: Gamma Correction

$\gamma > 1$

darker

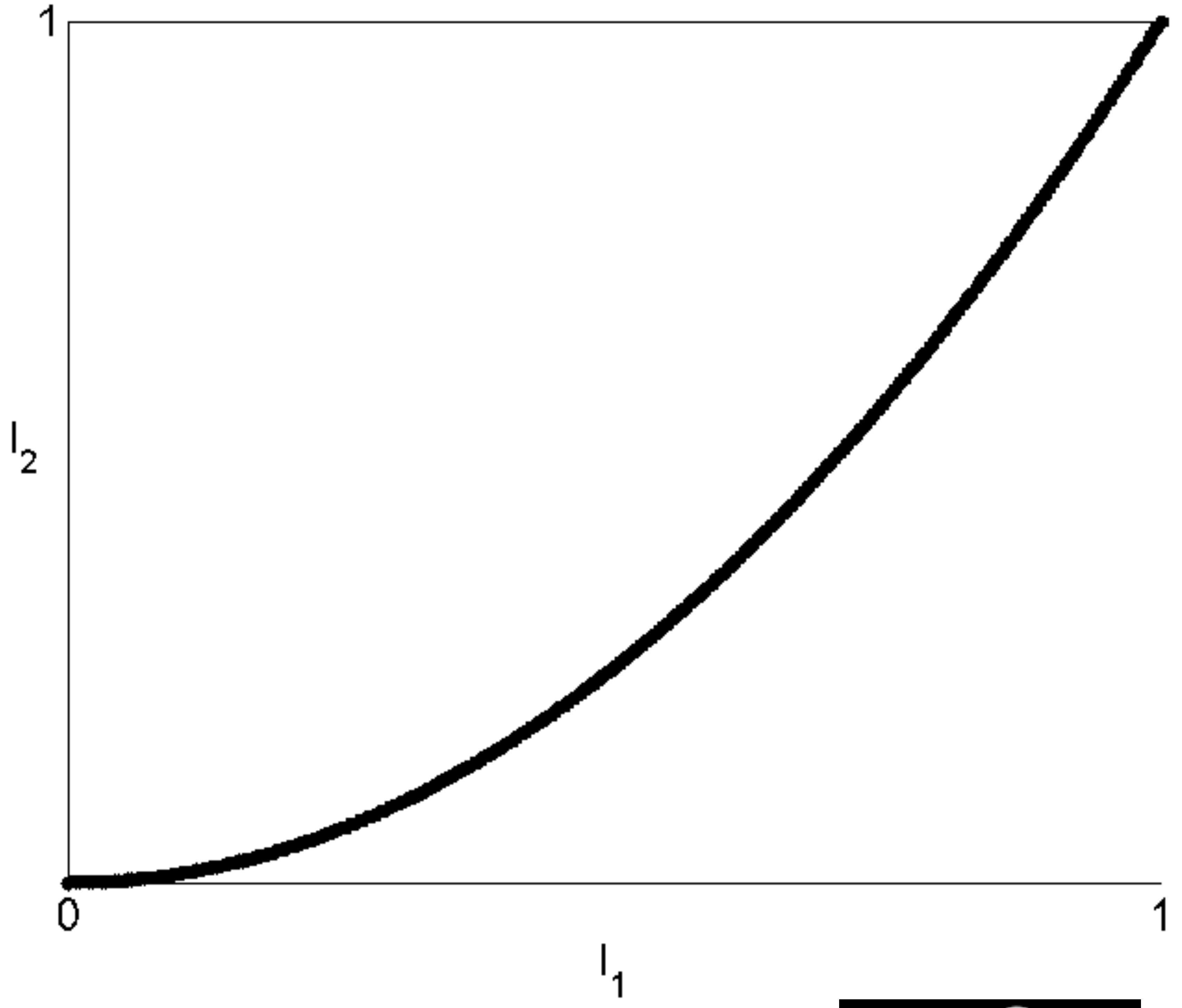
$$Ax^{1-\gamma}$$

$$\gamma = 2$$

Non-linear: Gamma Correction

$$Ax^{1-\gamma}$$

$$\gamma = 2$$



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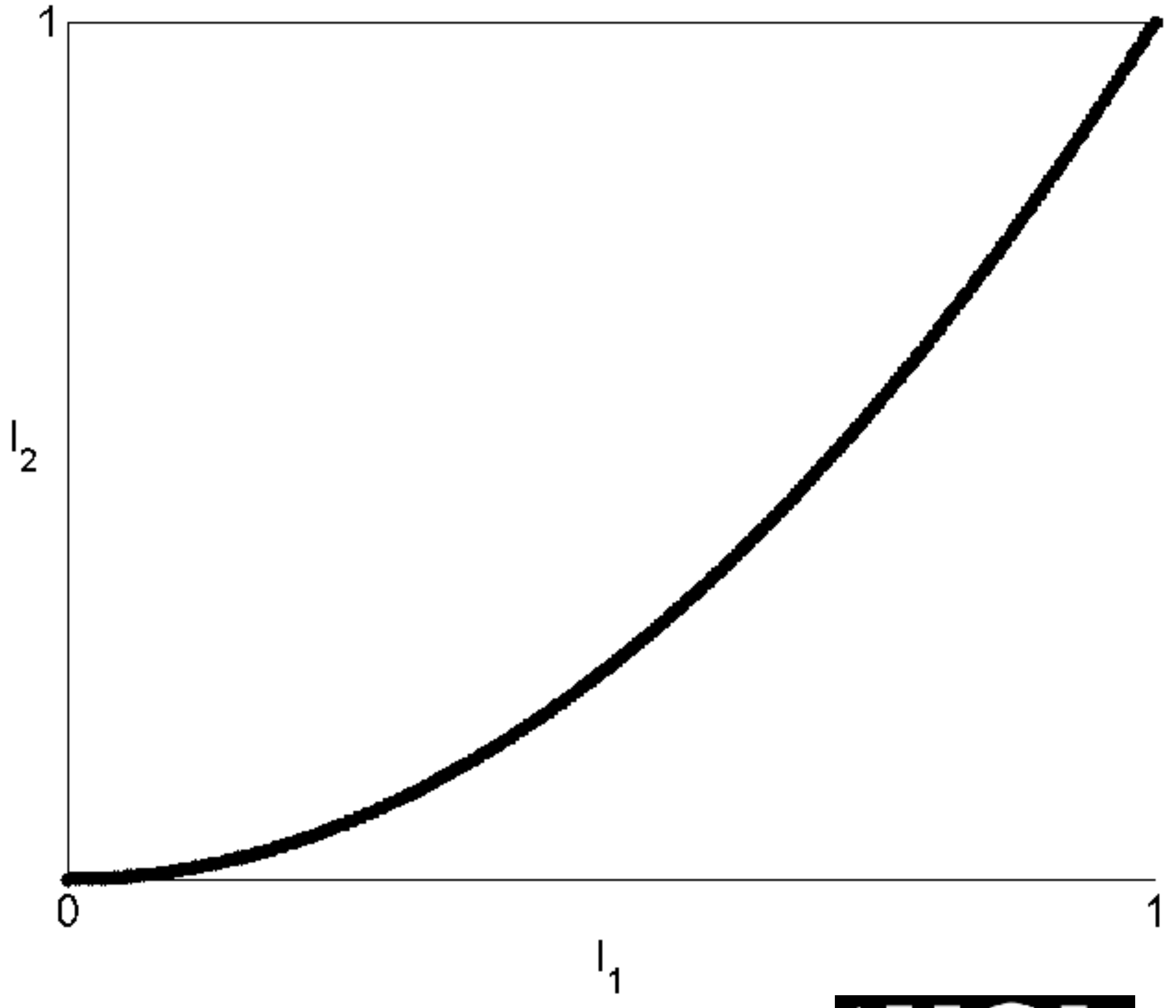
$$Ax^{1-\gamma}$$

$$\gamma = 2$$



Non-linear: Gamma Correction

$$Ax^{1-\gamma}$$

$$\gamma = 4$$

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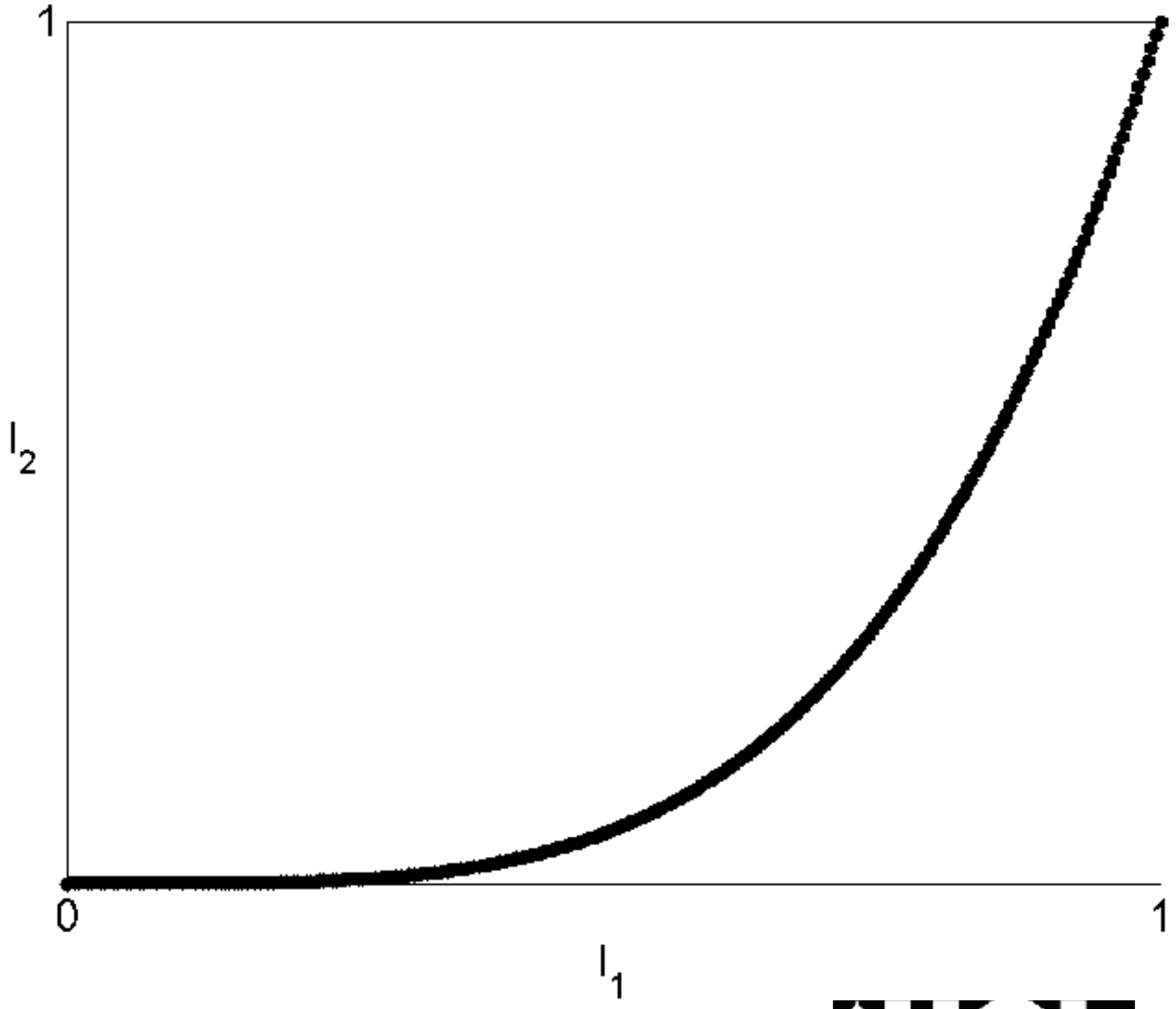
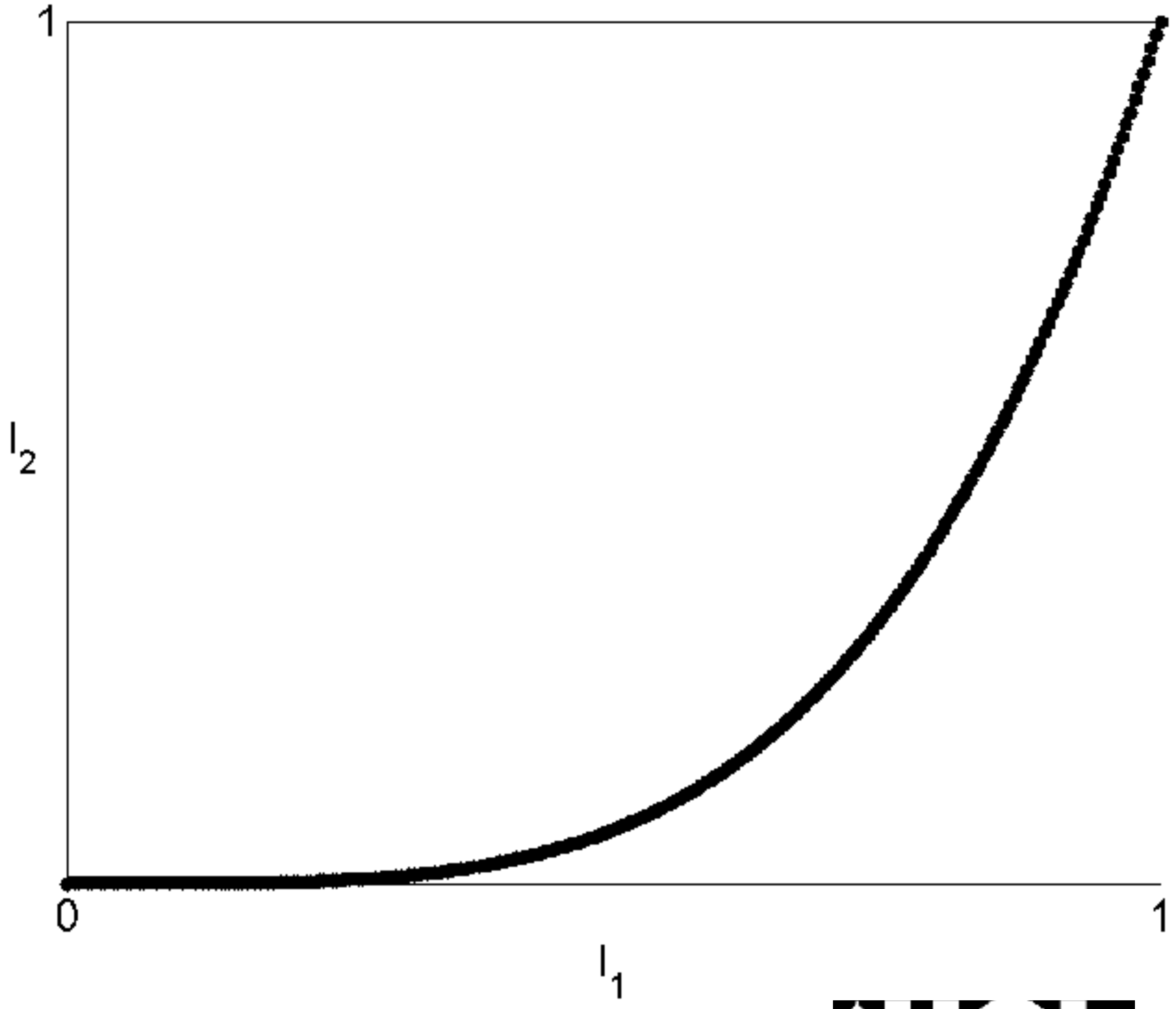


Non-linear: Gamma Correction

$$Ax^{1-\gamma}$$

$$\gamma = 4$$



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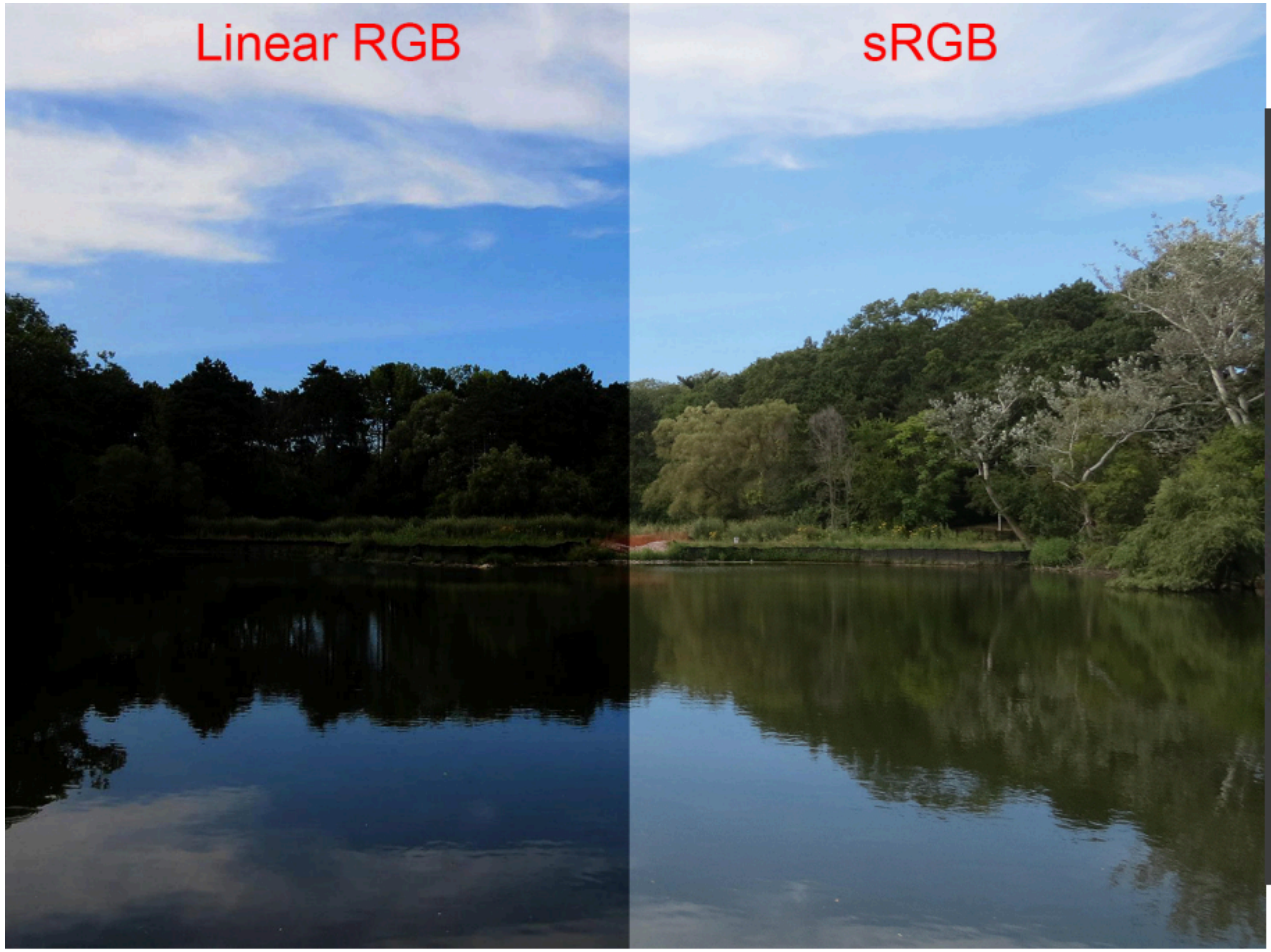
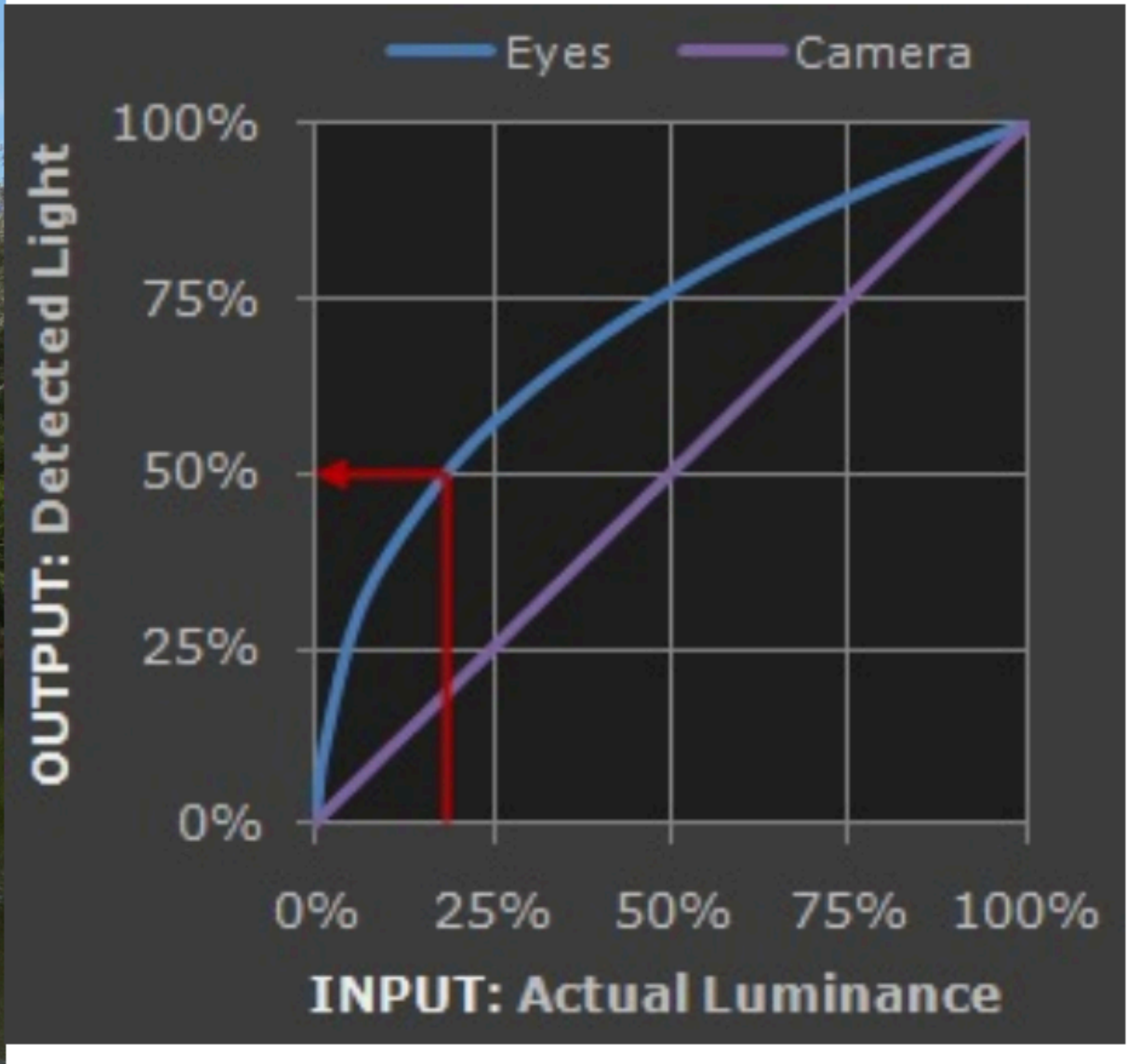
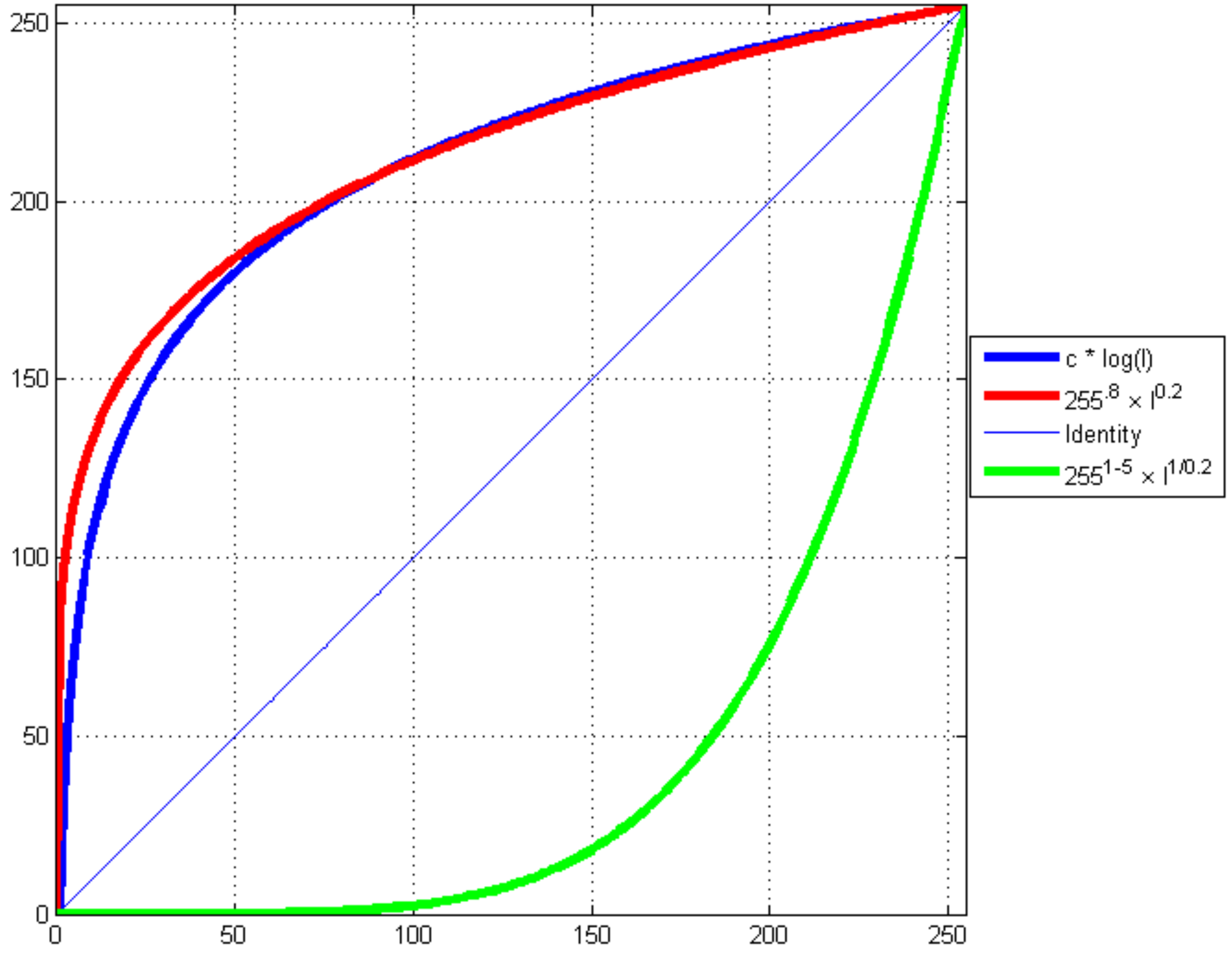




Gamma Correction



For example, CRT’s would have γ = 2.5, so pre-apply a γ = 1/2.5.

Histogram Equalization

- Tries to use all the grey levels equally often
- The resultant grey level histogram should then flat

- Use the cumulative histogram for f

Cumulative Histogram

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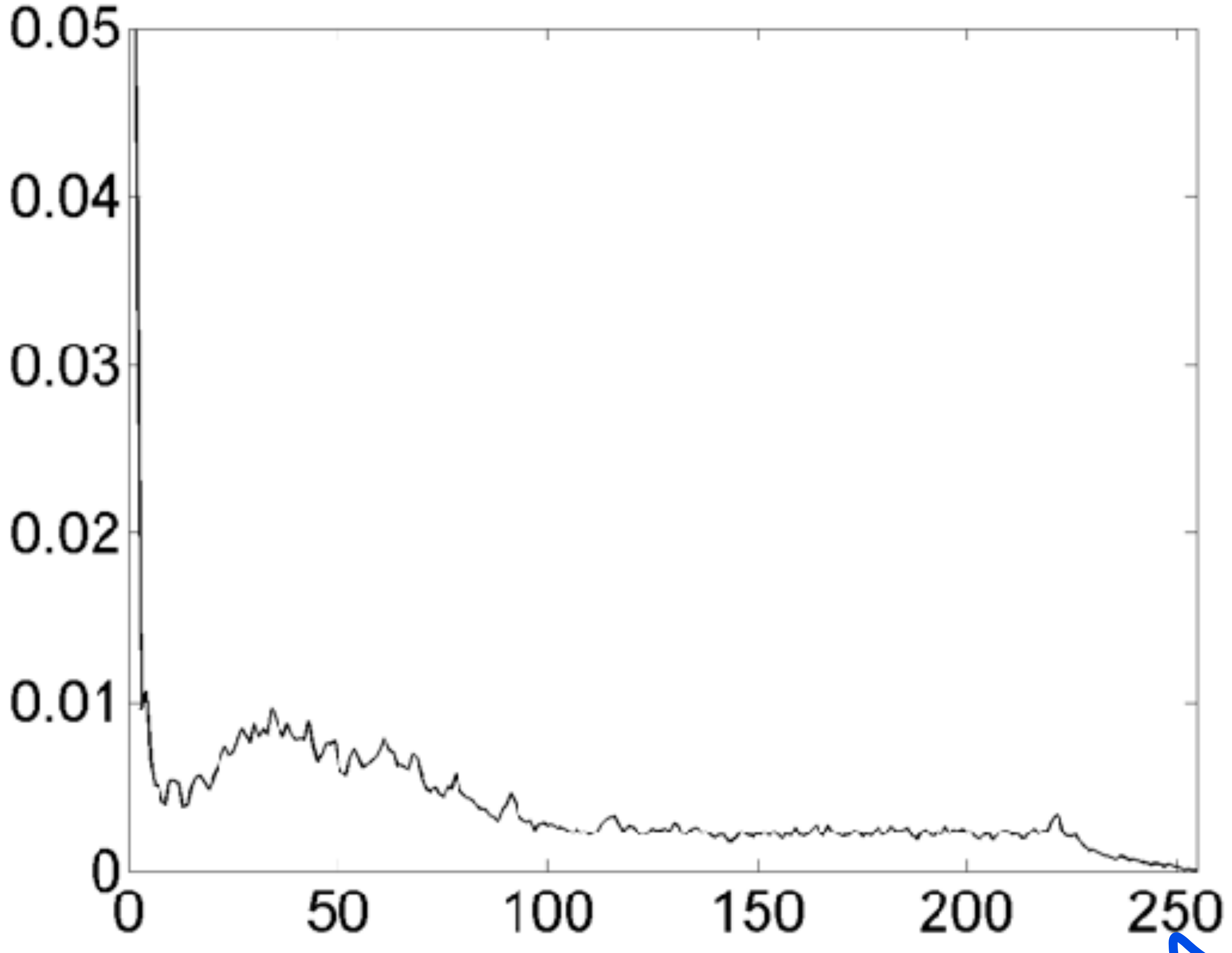
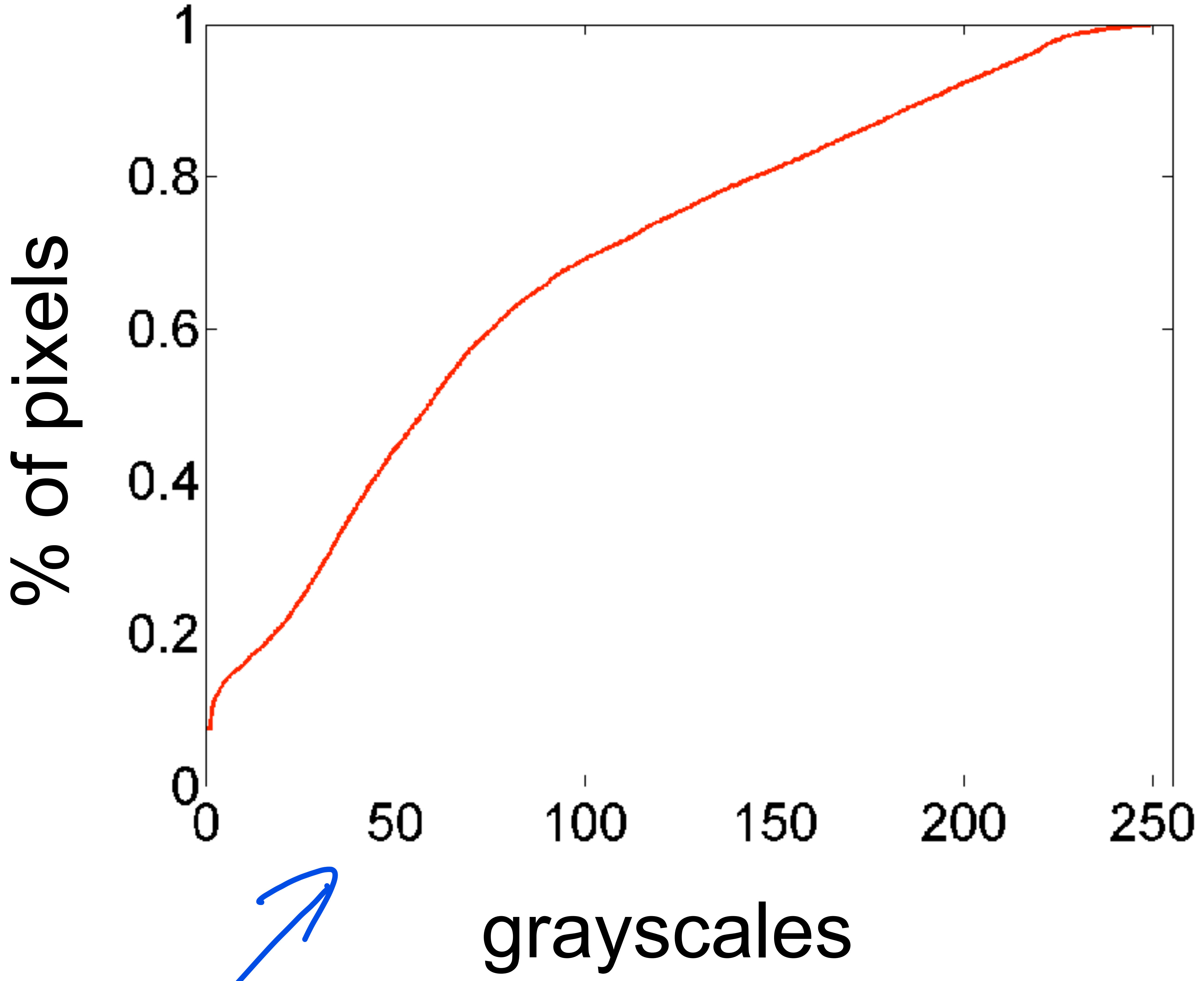


cumulative



Histogram Equalization

new value

cumulative

$$h(v) = \mathrm{round}\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L-1)\right)$$

where cdf_{min} is the minimum non-zero value of the cumulative distribution function (in this case 1), M × N gives the image's number of pixels (for the example above 64, where M is width and N the height) and L is the number of grey levels used (in most cases, like this one, 256).

Histogram Equalization

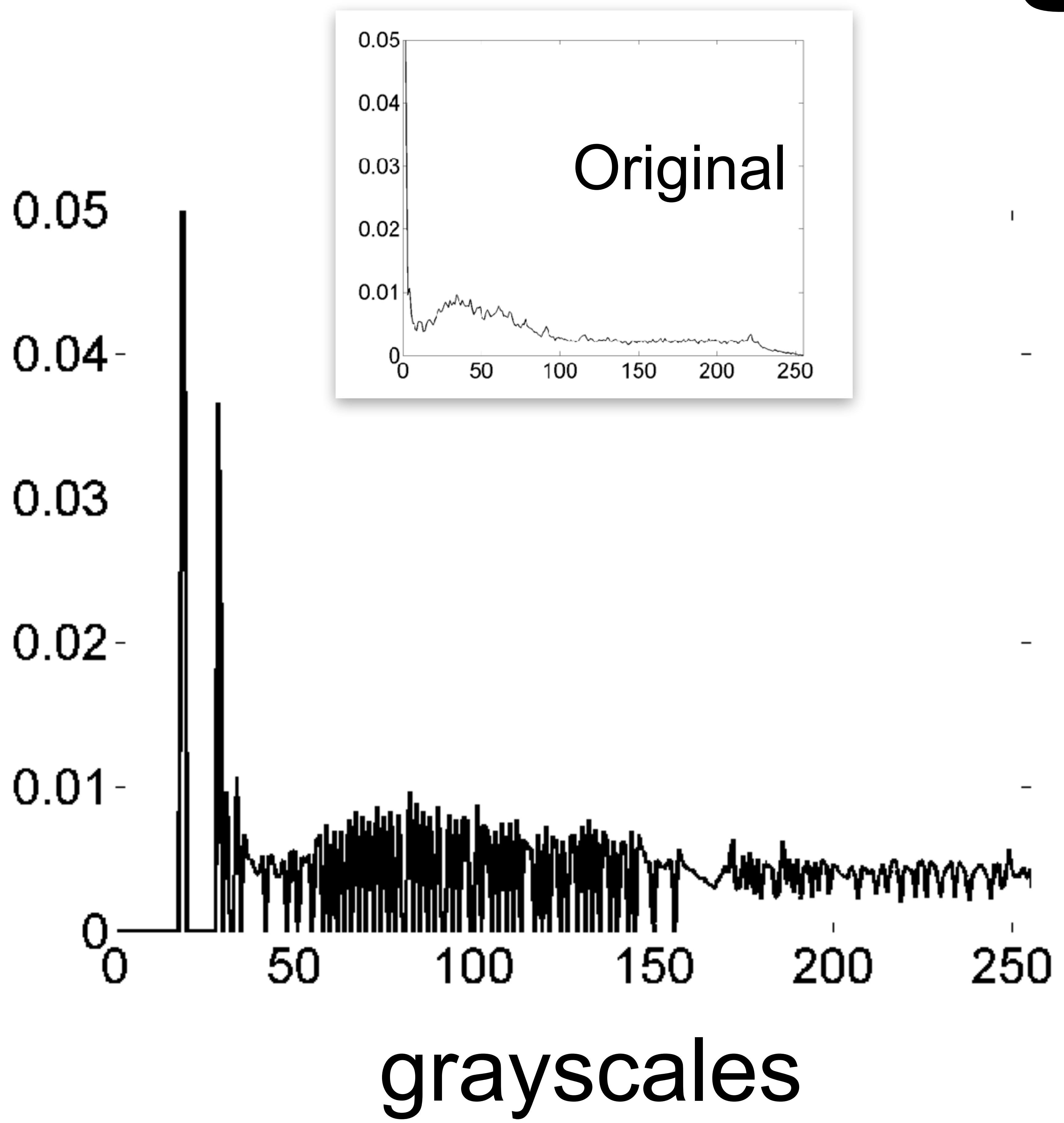
```
function eqIm = histEq(image)
[X,Y] = size(image);
% Construct the cumulative histogram
for i=0:255
cumHist(i) = sum(sum(image <= i))/(X*Y);
end
% Use it to transform the grey level in each pixel.
eqIm = fix(255*cumHist(image));
```

Equalized Image

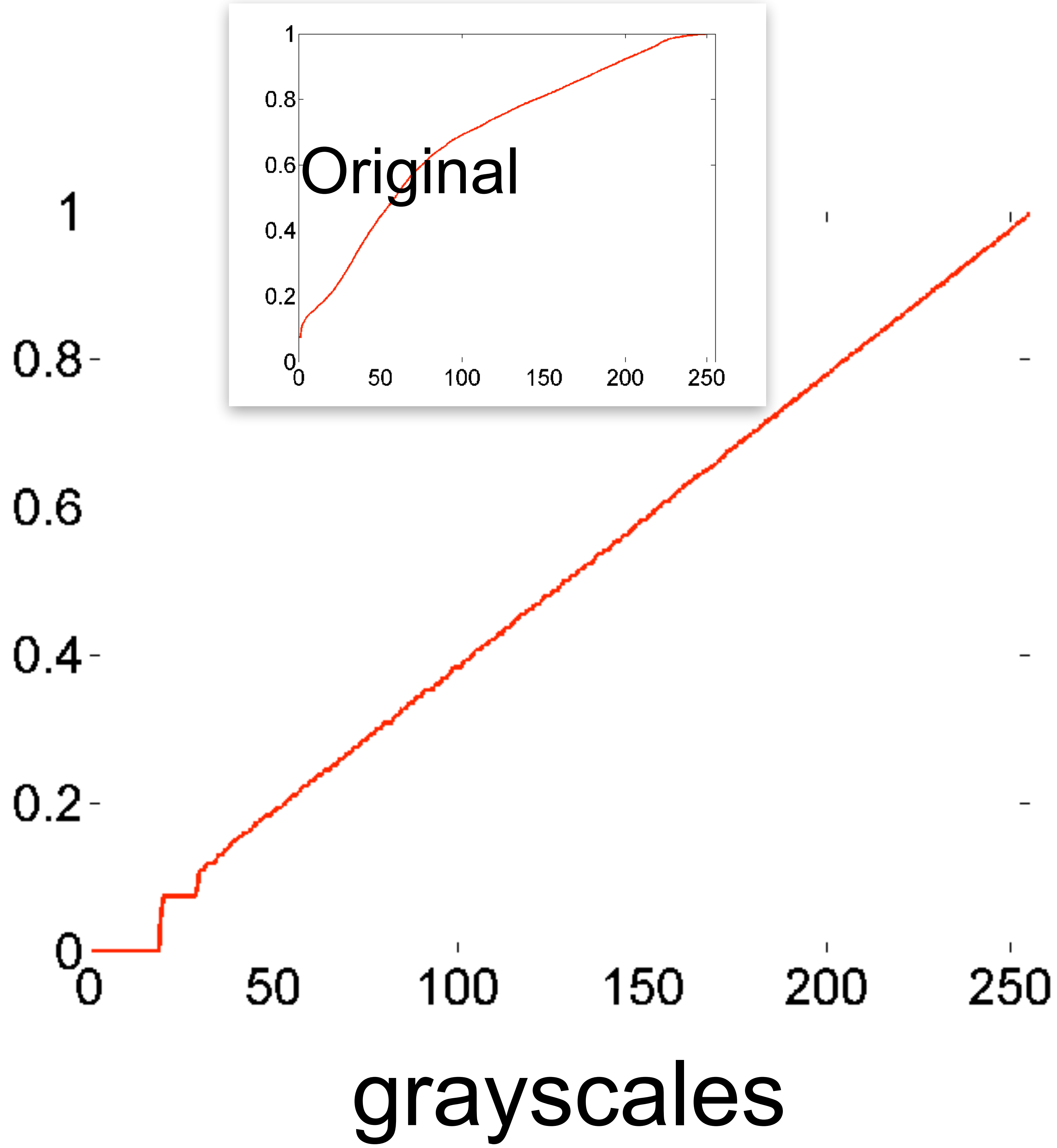
original

equalized

Equalized Histograms



Histogram



Cumulative histogram

Exercises (not assessed)

- Write functions for linear grey-level transformations and gamma correction.

- Try moderate and extreme settings on an image and observe the effects they have.

- Plot the grey-level histograms before and after the grey-level transformations.