



Image Filtering

Computer Vision

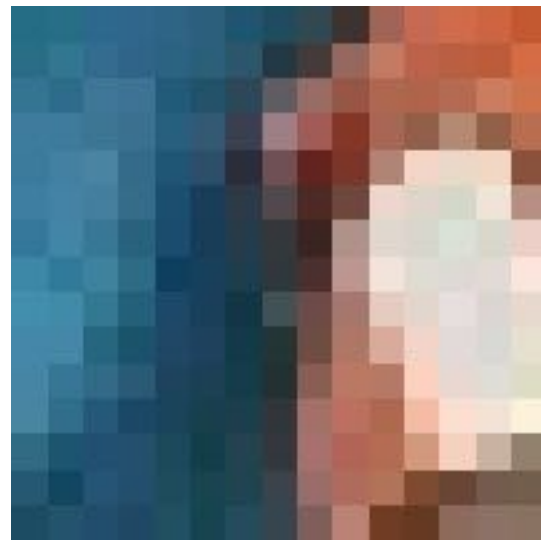
Carnegie Mellon University (Kris Kitani)



What is an image?

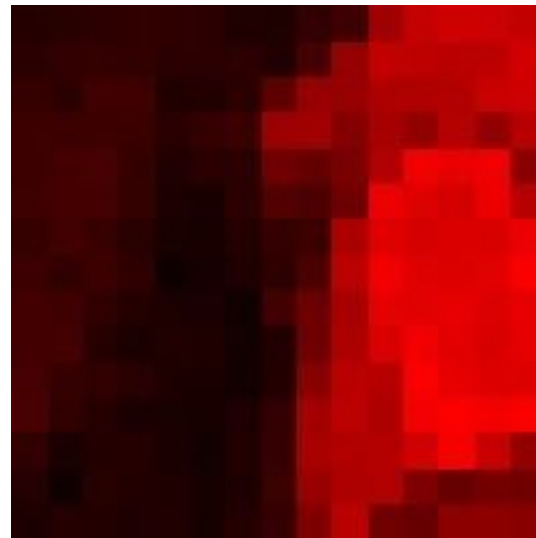


An image is an array of numbers

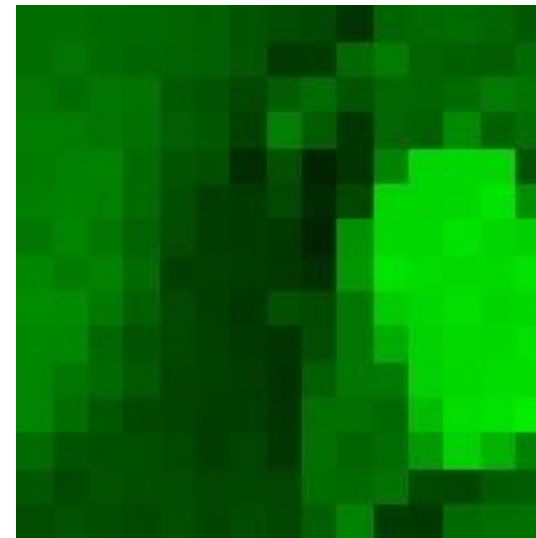


color image patch

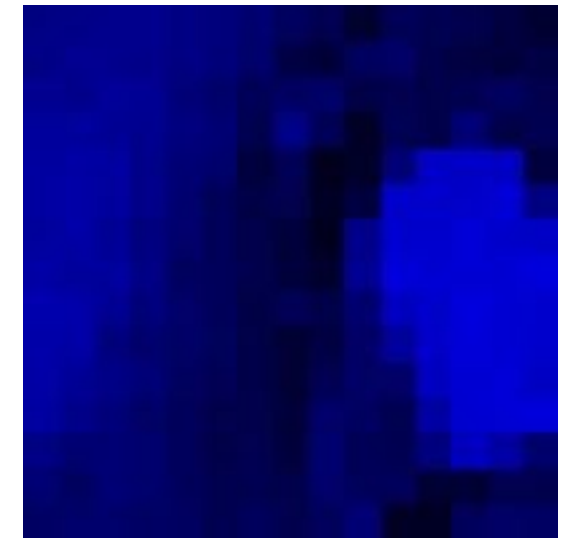
Red



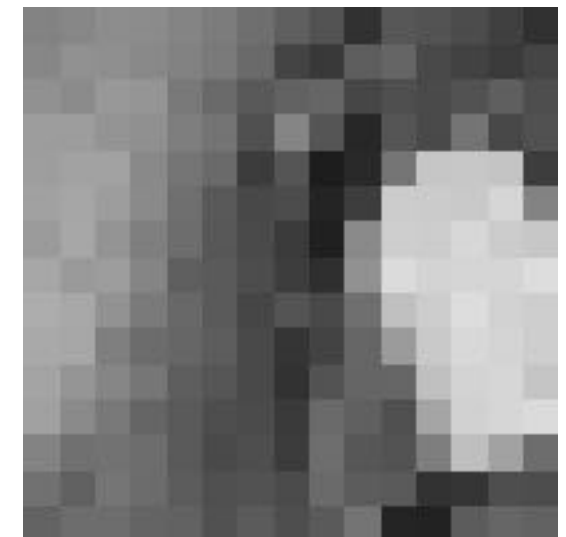
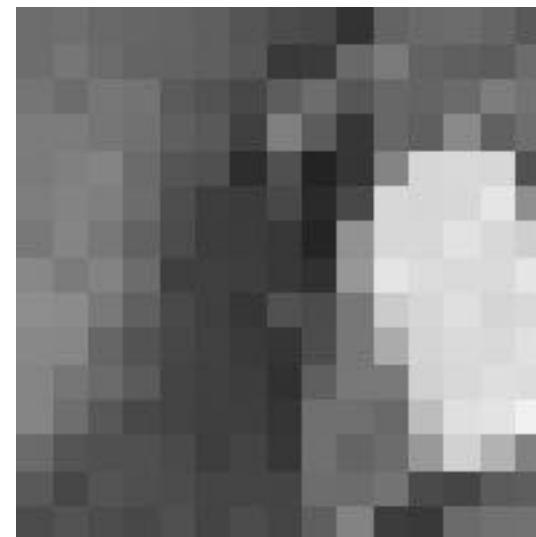
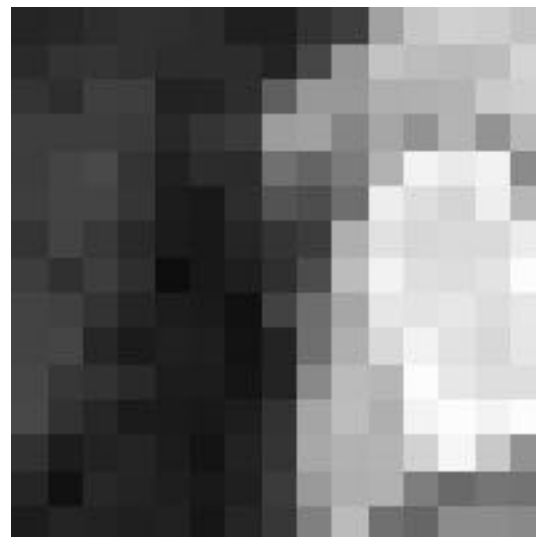
Green



Blue



colorized for visualization



actual intensity values per channel (quantized to 256 values)

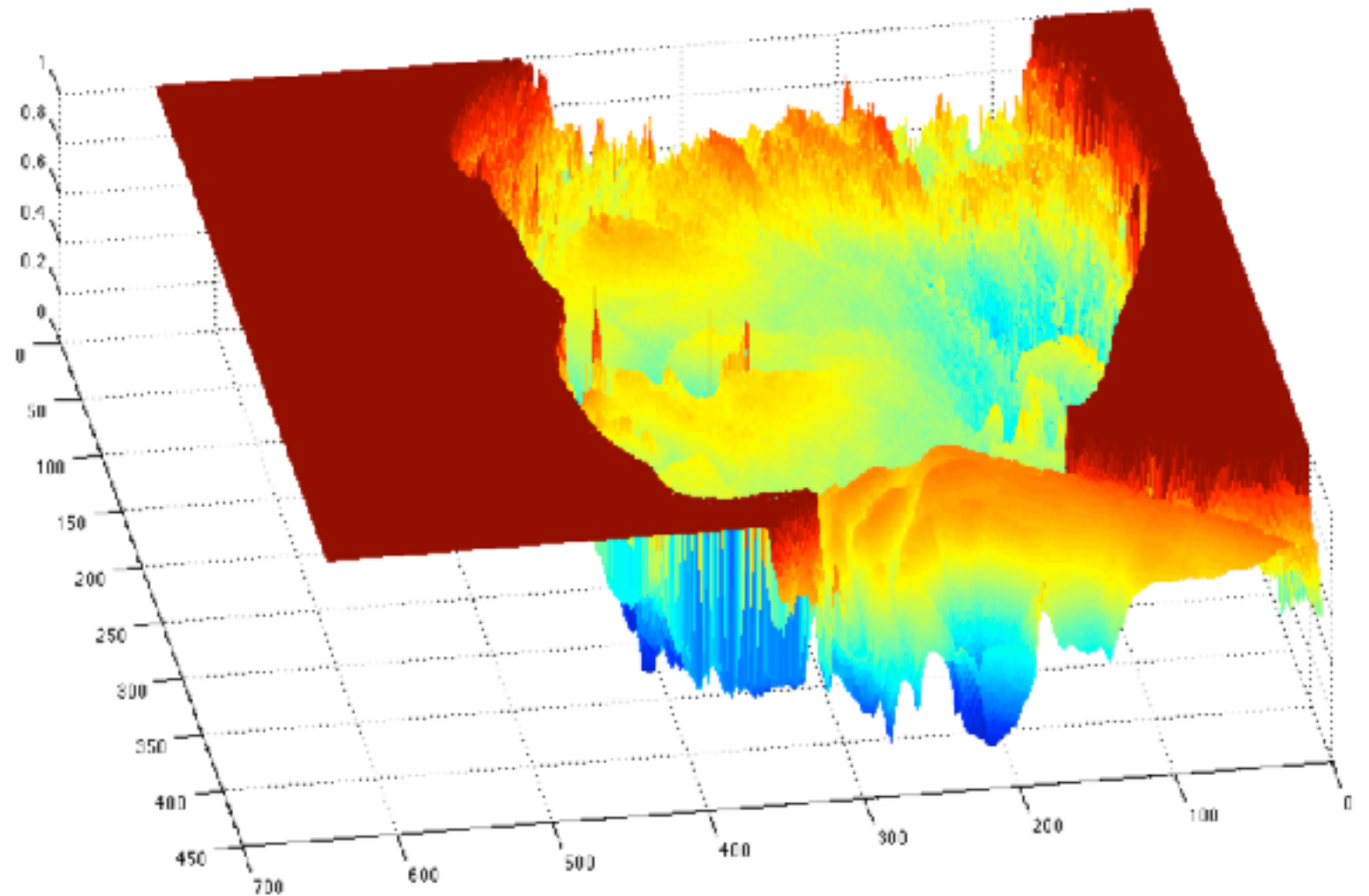
how many bits needed per pixel?

Helpful to think of an image as a ...

2D function



$$f(\mathbf{x}) \quad \mathbf{x} = \begin{bmatrix} x \\ y \end{bmatrix}$$



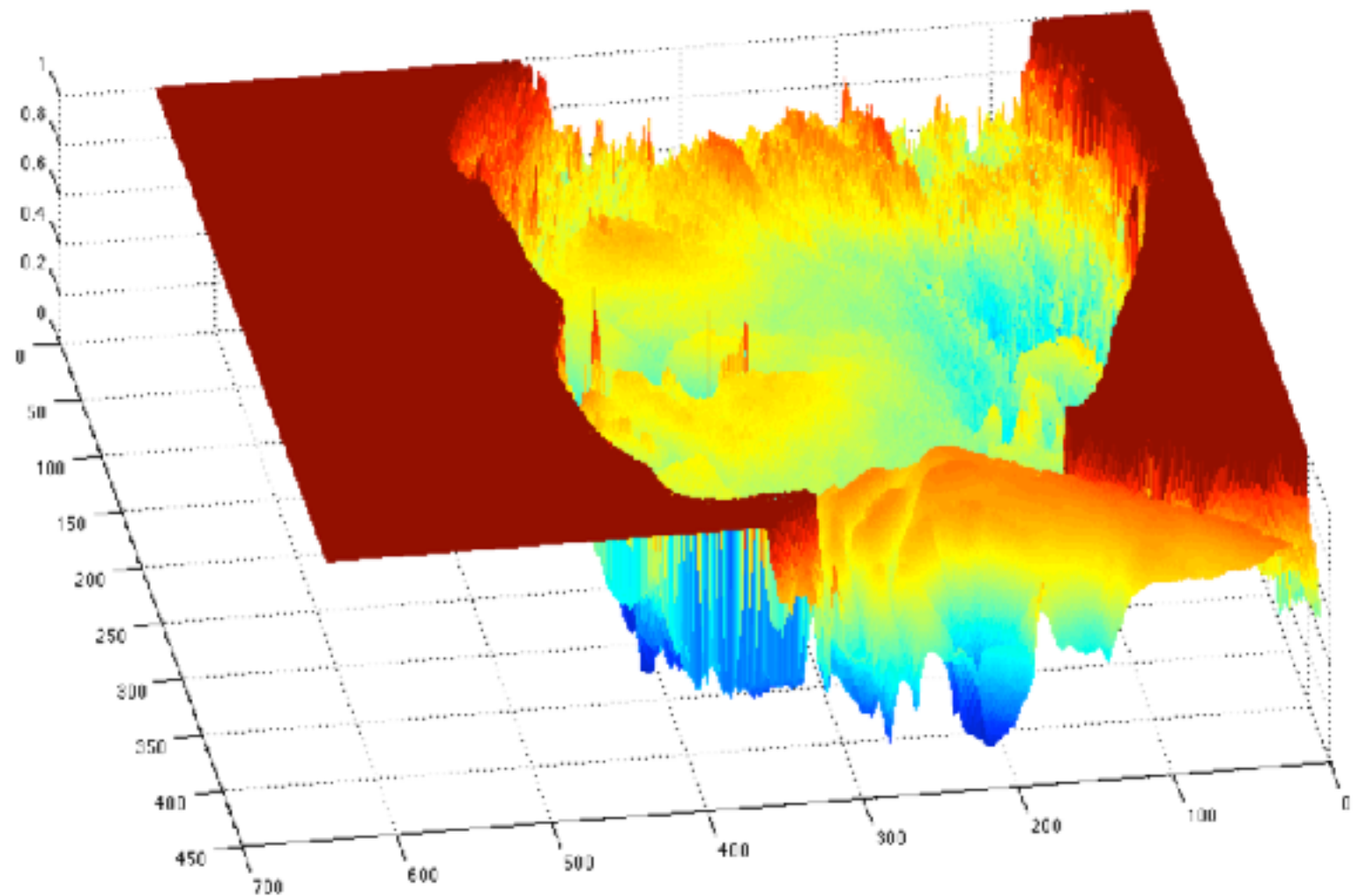
Helpful to think of an image as a ...

2D function



$$f(\boldsymbol{x}) \quad \boldsymbol{x} = \begin{bmatrix} x \\ y \end{bmatrix}$$

What is the range of $f(\boldsymbol{x})$?

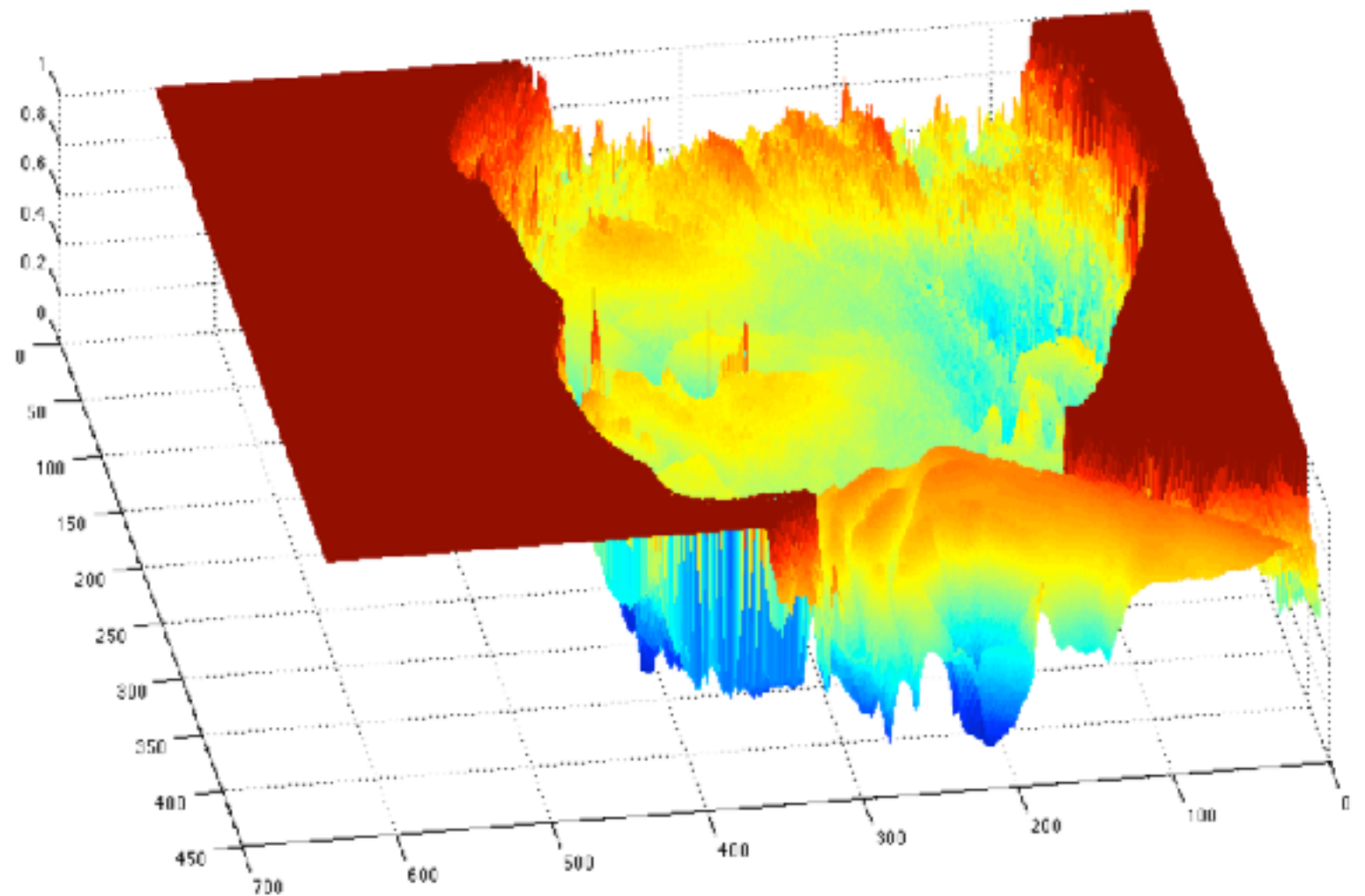


Helpful to think of an image as a ...

2D function



$$f(\mathbf{x}) \quad \mathbf{x} = \begin{bmatrix} x \\ y \end{bmatrix}$$

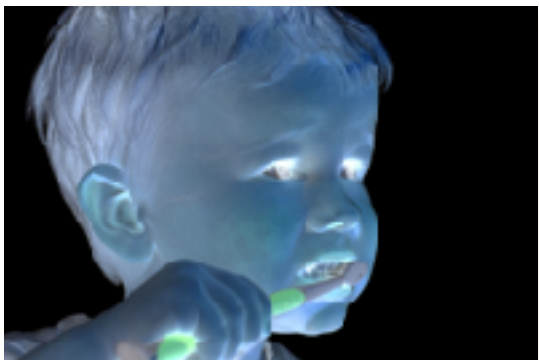


What is the range of $f(\mathbf{x})$?

8-bit image: 256 values

What kind of image transformations can we perform?

Filtering



changes the pixel values

Warping



changes the pixel location

What kind of image transformations can we perform?

Filtering

F



$$G(\boldsymbol{x}) \Downarrow h\{F(\boldsymbol{x})\}$$

G



changes the **range** of image

Warping



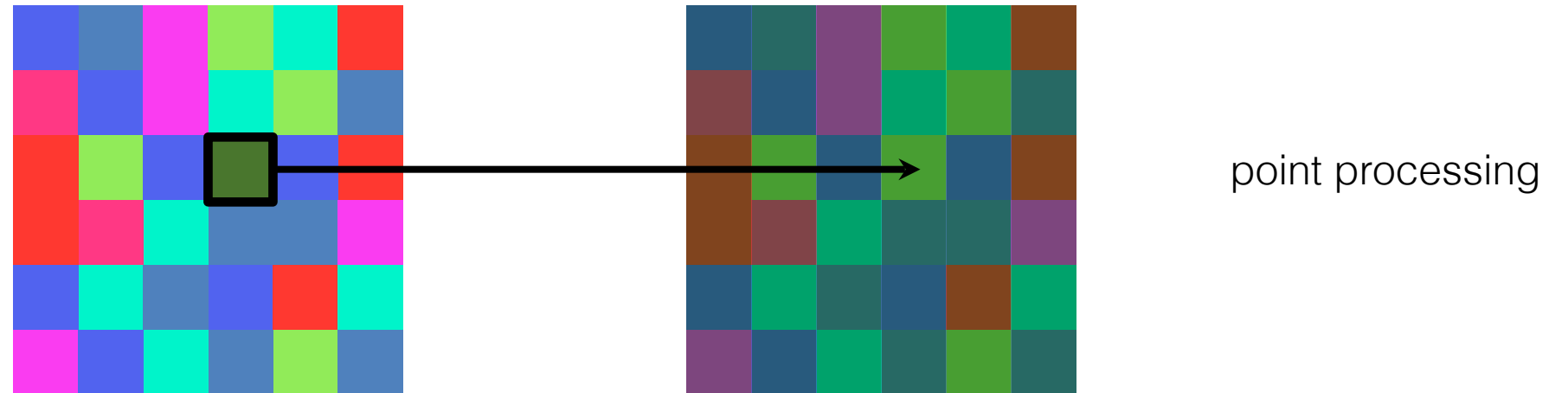
$$G(\boldsymbol{x}) \Downarrow F(h\{\boldsymbol{x}\})$$



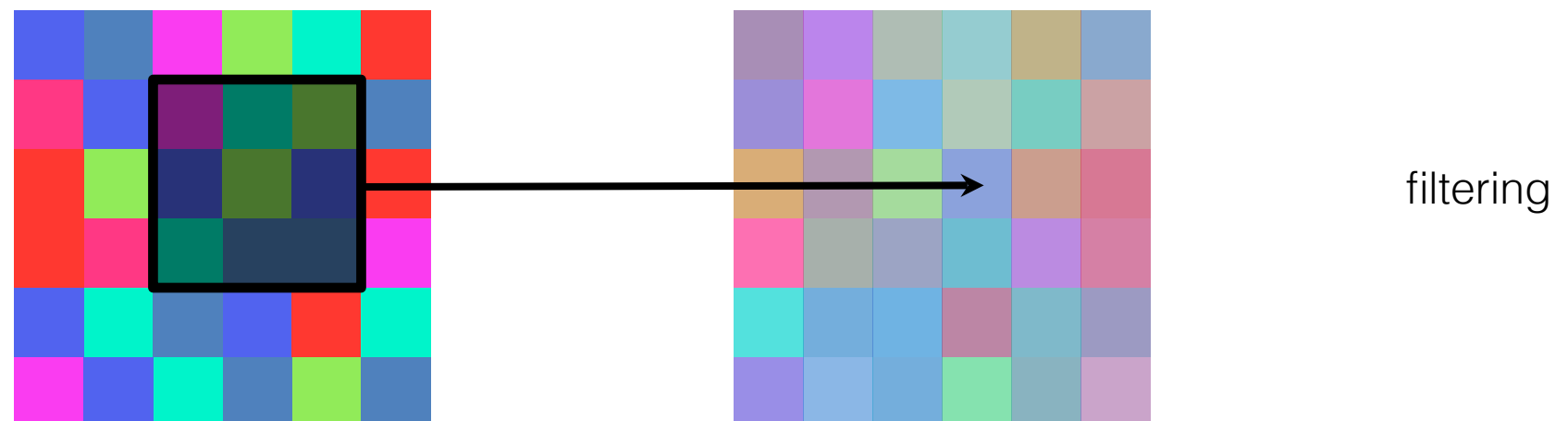
changes the **domain** of image

What kind of image filtering can we perform?

Point Operation



Neighborhood Operation



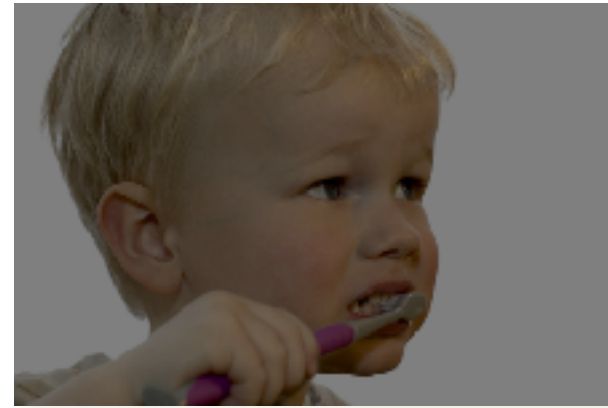
Examples of Point Processing



Original



Darken



Lower Contrast



Nonlinear Lower Contrast



Invert



Lighten



Raise Contrast



Nonlinear Raise Contrast

Examples of filtering



Original



Gradient Magnitude



Gaussian Blur



Median



Adaptive Thresholding



Bilateral