A GLOSSARY OF IMAGE PROCESSING TERMS

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This article provides a glossary of terms used in image processing, the field of computer science that develops techniques for enhancing digital images to make them more enjoyable to look at, and easier to analyse by computers as well as humans.

A

Addition
A point process that blends the values of corresponding pixels in two input images. A single parameter controls which input image dominates the output image.

Area Processes
A category of image-processing techniques that calculate the value of each output-image pixel from the corresponding input-image pixel and its neighbours. Examples include halftoning, sharpening and median filtering.

Aspect Ratio
The ratio of the width of an image to its height. Examples include 4:3, the aspect ratio of a standard TV, and 16:9, the aspect ratio of a widescreen TV.

Average Greyscale
The shade of grey produced by adding the brightnesses of the RGB components of a colour pixel and dividing by three.

B

Backward Mapping
The technique geometric processes use to calculate output-image pixel values from input-image pixel values. Backward-mapping processes start with a pixel in the output image, find the corresponding pixel in the input image, calculate a new pixel value, and assign the new value to the output-image pixel.

Bayer Filter
Enables a CCD to capture colour by covering 2×2 blocks of CCD-sensor elements with one red, one blue and two green filters, which makes colour CCDs more sensitive to the green wavelengths of light, just like our eyes.

Bi-linear Interpolation
A method of calculating the value of a pixel with fractional co-ordinates that lies in between a 2×2 neighbourhood of pixels.

Bitmap Image
An image composed of black and white pixels.

Blurring
An area process that produces an effect similar to an out-of-focus photograph. Blurring removes the detail in an image by making each pixel more like its neighbours.

Bounding Box
The smallest rectangle that encloses a shape so that each of the four sides touches an extremity of the shape.

Brightness
Determines the intensity of the colour presented by a pixel in a colour image, or the shade of grey presented by a pixel in a greyscale image.

Brightness Transformation
A point process that maps input brightnesses onto output brightnesses with a linear or non-linear mathematical function.

C

Capture

The process of measuring and visualising physical phenomena such as visible and non-visible electromagnetic radiation. Examples include taking a photograph and scanning a document.

CCD

A charge-couple device is an imaging sensor that contains a rectangular grid of light-sensitive capacitors. Each capacitor accumulates a charge proportional to the brightness of the light it detects; the brighter the light, the higher the charge.

Closing

A morphological operation produced by following a dilation by an erosion. Often used for filling holes in bitmap images.

Colour Model

Determines how the colour in a digital image is represented numerically. Examples include the RGB and HSB colour models.

Composition

A point process that overlays the pixels of a foreground input image onto the pixels of a background input image.

Contrast

The difference between the lightest and darkest regions of an image.

Contrast Expansion

An image-processing technique that re-distributes the brightness in an image to eliminate regions that are either too dark or too light. Examples include basic and ends-in contrast expansion.

Convolution

A method of calculating the new value of a central pixel in a neighbourhood by multiplying each pixel in the neighbourhood by a corresponding weight; the new value of the central pixel is the sum of the multiplications.

Corrupted Pixel

A pixel value altered by noise.

Cropping

A geometric process that reduces the size of an image by discarding the pixels outside a specified region called the crop selection.

D

Diagonal Axis

The line that runs from the top-left corner of an image to the bottom-right corner, or from the top-right corner to the bottom-left corner.

Digital Camera

An imaging device that focuses visible light onto a CCD.

Digital Image

An image captured by an imaging device and represented in a computer as a rectangular grid of pixels.

Dilation

A morphological operation that increases the size of objects in an image by adding a layer of foreground pixels around each object.

E

Edge

Edges mark the boundaries between the objects in a scene. A large change in pixel brightness over a small number of pixels often indicates the presence of an edge.

Edge Detector

An image-processing routine that flags the large changes in pixel brightness that indicate potential edges. Edge detectors often visualise their results in edge maps. Examples include the Sobel, Prewitt, Kirsch and Laplacian edge detectors.

Edge Direction

The angle that specifies the direction of an edge. The angle is perpendicular to the direction of the large change in brightness that indicates the edge.

Edge Magnitude

A number that represents how confident an edge detector is that it has found an edge in an image.

Edge Map

A greyscale output image that visualises the magnitude of the edge found at each pixel in an input image; the greater the magnitude, the brighter the corresponding edge-map pixel. Thresholding an edge map highlights the strongest edges.

Edge Mask

A set of convolution weights that highlight the size and direction of the edges in an image.

Electromagnetic Spectrum

The complete range of electromagnetic radiation from short wavelength gamma radiation to long wavelength radio waves.

Erosion

A morphological operation that decreases the size of objects in an image by removing a layer of foreground pixels around each object. Often used for removing projections and blobs in bitmap images.

F

Flipping

A geometric process that swaps the pixels in an image across the horizontal, vertical and diagonal axes.

Forward Mapping

The technique point and area processes use to calculate output-image pixel values from input-image pixel values. Forward-mapping processes start with a pixel in the input image, calculate a new pixel value, and assign the new value to the corresponding pixel in the output image.

Frame Averaging

A point process that removes noise from a series of input images taken of the same subject. Each output-image pixel value is the average of the corresponding input-image pixel values.

G

Gaussian Noise

A form of image noise that adds small positive and negative deviations to the pixels in an image, often caused by the random variations between the elements of a CCD sensor. Plotting the number of occurrences of each deviation on a histogram produces the bell-shaped curve of the normal distribution, which is also called the Gaussian distribution.

Geometric Process

A category of image-processing techniques that change the size and shape of an image rather than its contents. Examples include cropping, scaling and rotation.

Greyscale Image

An image composed of pixels that present shades of grey.

H

Halftoning

An area process that simulates shades of grey in bitmap images with patterns of bitmap pixels. The density of each 2×2-pixel pattern depends on the ratio of black to white bitmap pixels.

Highlights

The range of pixel brightnesses that represent the lighter regions of an image.

High-key Image

An image that represents a naturally light subject.

High-contrast Image

An image with large numbers of pixels in the shadows and highlights.

High Frequency

The high frequency information in an image is represented by large changes in pixel brightness over a small number of pixels.

High-pass Filter

A filter that preserves or amplifies the high frequency information in an image. Sharpening is implemented by a high pass filter.

Histogram

The histogram of an image visualises the distribution of the brightness in the image by plotting the number of occurrences of each brightness.

Histogram Equalisation

An image-processing technique that reveals detail hidden in images with a poorly-distributed range of brightesses.

Horizontal Axis

The line that runs through the centre of an image from the left of the image to the right.

HSB

A colour model that represents each colour with three numbers that specify the hue (H), the saturation (S) and the brightness (B) of the colour.

Hue

The colour in the HSB colour model.

I

Image
An image records a visual snapshot of the world around us.

Image Processing
The field of computer science that develops techniques for enhancing digital images to make them more enjoyable to look at, and easier to analyse by computers as well as humans.

Imaging Device
A piece of equipment that captures an image. Examples include digital cameras, side-scan sonar systems and scanning electron microscopes.

Impulse Noise
Also called salt and pepper noise, impulse noise introduces very light (salt) and very dark (pepper) pixels that stand out from their neighbours.

Interpolation
A method of creating new pixel values from existing pixel values. Examples include nearest-neighbour and bi-linear interpolation.

Input Image
The image transformed by an image-processing routine.

Inversion
A point process that produces an effect similar to photographic negatives: dark pixels become light and light pixels become dark.

K

Kernel
A rectangular grid of convolution weights.

L

Line Edge
A line chain of pixels that separates a region of light pixels from a region of dark pixels.

Linear Brightness Transformation
A category of brightness transformations that lighten and darken images using mathematical functions with curved graphs.

Look-up Table (LUT)
A data structure that minimises the number of calculations required to process an image with a point process. The brightness of each output-image pixel is found in a LUT at the entry indexed by the brightness of the corresponding input-image pixel.

Low-contrast Image
An image that uses only a small range of the available brightness. Low-contrast images are mostly dark, mostly dull or mostly light.

Low-key Image
An image that represents a naturally dark subject.

Low Frequency
The low frequency information in an image is represented by small changes in pixel brightness over a small number of pixels.

Low-pass Filter
A filter that discards or attenuates the high frequency information in an image and preserves the low frequency information. Removing the high frequency information from an image removes the detail and blurs the image. Blurring is implemented by a low pass filter.

M

Median Filtering
An area process that removes noise by replacing the central pixel in a neighbourhood with the median pixel value of the neighbourhood.

Mid-tones
The range of pixel brightnesses that represent the regions of an image in between the shadows and highlights.

Morphological Operation

A category of image-processing techniques that operate on the structure of the objects in an image.

N

Noise

Unwanted changes to the values of the pixels in an image, often introduced by the imaging device during capture. Examples include impulse noise and Gaussian noise.

Nearest-neighbour Interpolation

A method of creating values for pixels with fractional co-ordinates that duplicates the value of the pixel with integer co-ordinates nearest to the fractional co-ordinates.

Neighbourhood Averaging

An area process that removes noise by replacing the central pixel in a neighbourhood with the average pixel value of the neighbourhood.

Non-linear Brightness Transformation

A category of brightness transformations that change the brightness of an image using mathematical functions with straight-line graphs. Examples include inversion and posterisation.

Non-primary Colour

A colour created by mixing the red, green and blue primary colours of the RGB colour model.

NTSC Greyscale

A shade of grey produced by multiplying the brightnesses of the RGB components of a colour pixel by a set of weights that emphasise the green component. Named after the committee that oversees US television.

O

Opening

A morphological operation produced by following an erosion by a dilation. Often used for filling holes in bitmap images.

Outlying Pixel

A pixel with an extreme brightness that is much higher or lower than the brightnesses of the other pixels in the image.

Output Image

An image that contains the results of applying an image-processing routine to an image.

P

Photo Restoration

The application of a series of image-processing routines to enhance a damaged photograph.

Pixel

A square unit of visual information that represents a tiny part of a digital image.

Pixel Depth

The number of colours or shades of grey a pixel can present. Bitmap pixels have depth two, typical greyscale pixels have depth 256, and typical colour pixels have depth 16,777,216.

Pixel Neighbourhood

A region of pixels processed by an area process. Typical neighbourhood dimensions are 3×3 pixels and 5×5 pixels.

Point Processes

A category of image-processing techniques that calculate the value of each output-image pixel from the value of the corresponding input-image pixel. Examples include inversion and pseudo-colour.

Posterisation

A linear brightness transformation that reduces the number of brightnesses in an image.

Pseudo-colour

A point process that divides the range of brightness in a greyscale input image into groups and assigns each group a colour. Each output-image pixel is assigned the colour that represents the group into which falls the brightness of the corresponding input-image pixel.

Potential Edge

Edge detectors flag all large changes in pixel brightness over a small number of pixels as a potential edge. An edge-analysis system then decides whether the change in brightness represents the border of an object—a real edge—or some other feature of the object, such as its texture.

Primary Colours

The colours red, green and blue from which all other colours in the RGB colour model are mixed.

Q

Quantization
The calculation that maps the fractional measurements made by imaging devices onto proportional integer pixel brightnesses.

R

Ramp Edge
A region of pixels that separates a region of light pixels from a region of dark pixels. The pixels in the region change gradually from light to dark.

Raw Colour
The colour of the pixels in an image captured by a colour CCD before the two unknown RGB-component brightnesses of each pixel have been interpolated from the known brightnesses of the corresponding components of neighbouring pixels.

Resolution
The number of pixels available to represent the details of the subject of a digital image.

RGB
A colour model that represents each colour with three numbers that specify the amounts of red (R), green (G) and blue (B) that produce the colour.

RGB Colour Cube
Visualises the amounts of red, green and blue required to produce each colour in the RGB colour model as a point in a cube at co-ordinates (x, y, z).

Roof Edge
A region of pixels that separates a region of light pixels from a region of dark pixels. The pixels in a roof edge increase in brightness to their maximum at the apex of the roof and then decrease to meet the region of pixels on the other side of the edge.

Rotation
A geometric process that turns an image about its centre by a specified angle.

Rotation Hole
An output-image pixel not assigned a value when the input image is rotated with forward mapping.

Row-Column Co-ordinates
The pair of numbers that locate a pixel in the rows and columns of the rectangular grid of pixels that represent a digital image.

S

Sampling
The process of mapping a continuous quantity of electromagnetic radiation, such as light or X-rays falling on a sensor, onto a discrete, rectangular grid of pixels.

Saturation
The component of the HSB colour model that controls the amount of white mixed into the hue.

Scale Factor
A fractional number that controls whether a scaling process enlarges or reduces an image. Scale factors between zero and one reduce images; scale factors greater than one enlarge images.

Scaling
A geometric process that changes the size of an image.

Scanner
An imaging device that focuses light reflected from a document onto a CCD that moves across and down the document.

Scanning Electron Microscope
An imaging device that uses electrons to capture images of microscopic objects. A SEM fires a beam of electrons at the surface of the sample and counts the number of electrons dislodged from the surface by the beam; the greater the number of dislodged electrons, the brighter the corresponding point in the image.

Sequential-index Co-ordinate
The number that locates a pixel in an image when the pixels in the image are laid end to end in a sequence.

Shadows
The range of pixel brightnesses that represent the darker regions of an image.

Sharpening
An area process that emphasises the detail in an image.

Side-scan Sonar System

An imaging device that uses sound waves to capture images of underwater objects. Side-scan sonar systems measure the strength of the acoustic reflections of sound waves directed at the sea bed; the stronger the acoustic reflection, the brighter the corresponding pixel in the image.

Step Edge

The ideal edge shape characterised by a large, immediate change in pixel brightness from a region of light pixels to a region of dark pixels.

Structuring Element

The rectangular grid of binary values used by morphological operations to assign a new value to a pixel in a bitmap image.

Subtraction

A point process that identifies the pixels that differ between two input images.

T

Thresholding

A point process that produces a bitmap version of a greyscale image. Black bitmap pixels represent greyscale pixels darker than a threshold brightness; white bitmap pixels represent greyscale pixels lighter than the threshold.

Thermal Camera

An imaging device that measures the amount of infra-red light emitted by the subject of the image. Hotter objects emit more infra-red light, which show up as the brighter regions of a thermal image.

Thermal Image

A greyscale image captured by a thermal camera. Often enhanced with pseudo-colour to assign the same colour to regions of pixels that represent similar temperatures.

V

Vertical Axis

The line that runs through the centre of an image from the top of the image to the bottom.