

# Dictionary of Computer Vision and Image Processing

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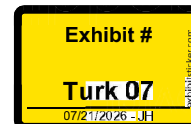
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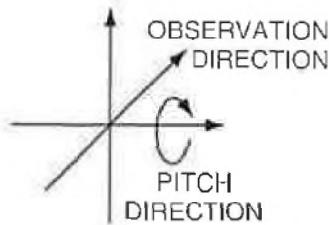
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**pit:** 1) A general term for when a signal value is lower than the neighboring signal values. Unlike signal peaks, pits usually refer to two dimensional images. For example, a pit occurs when observing the image of a dark spot on a lighter background. 2) A local point-like concave shape defect in a surface.

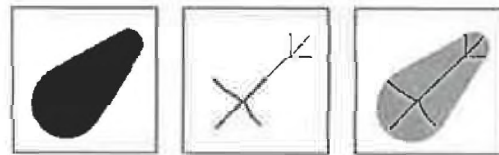
**pitch:** A 3D rotation representation (along with yaw and roll) often used for cameras or moving observers. The pitch component specifies a rotation about a horizontal axis to give an up-down change in orientation. This figure shows the pitch rotation direction:



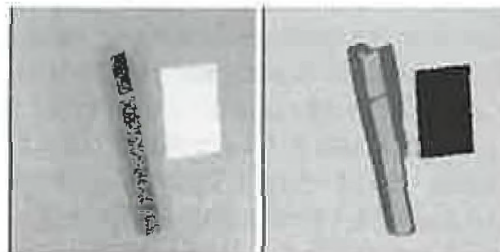
**pixel:** The intensity values of a digital image are specified at the locations of a discrete rectangular grid; each location is a pixel. A pixel is characterized by its coordinates (position in the image) and intensity value (see intensity and intensity image). Values can express physical quantities other than intensity for different kinds of images, as in, e.g., infrared imaging. In physical terms, a pixel is the photosensitive cell on the CCD or other solid state sensor of a digital camera. The CCD pixel has

a precise size, specified by the manufacturer and determining the CCD's aspect ratio. See also intensity sensor and photosensor spectral response.

**pixel addition operator:** A low-level image processing operator taking as input two gray scale images,  $I_1$  and  $I_2$ , and returning an image  $I_3$  in which the value of each pixel is  $I_3 = I_1 + I_2$ . This figure shows at the right the sum of the two images at the left (the sum divided by 2 to rescale to the original intensity level):

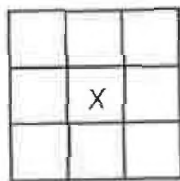
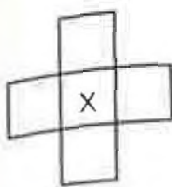


**pixel classification:** The problem of assigning the pixels of an image to certain classes. See also image segmentation, supervised classification, and clustering. This image shows the pixels of the left image classified into four classes denoted by the four different shades of grey:



**pixel connectivity:** The pattern specifying which pixels are con-

sidered neighbors of a given one (X) for the purposes of computation. Common connectivity schemes are 4 connectedness and 8 connectedness, as seen in the left and right images here:



**pixel coordinates:** The coordinates of a pixel in an image. Normally these are the row and column position.

**pixel coordinate transformation:** The mathematical transformation linking two image reference frames, specifying how the coordinates of a pixel in one reference frame are obtained from the coordinate of that pixel in the other reference frame. One linear transformation can be specified by

$$i_1 = ai_2 + bj_2 + e$$

$$j_1 = ci_2 + dj_2 + f$$

where the coordinates of  $\vec{p}_2 = (i_2, j_2)$  are transformed into  $\vec{p}_1 = (i_1, j_1)$ . In matrix form,  $\vec{p}_1 = \mathbf{A}\vec{p}_2 + \vec{t}$ , with  $\mathbf{A} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$

a rotation matrix and  $\vec{t} = \begin{pmatrix} e \\ f \end{pmatrix}$  a translation vector. See also Euclidean, affine and holography transforms.

**pixel counting:** A simple algorithm to determine the area of an image region by counting

the numbers of pixels composing the region. See also region.

**pixel division operator:** An operator taking as input two gray scale images,  $I_1$  and  $I_2$ , and returning an image  $I_3$  in which the value of each pixel is  $I_3 = I_1/I_2$ .

**pixel exponential operator:** A low-level image processing operator taking as input one gray scale image,  $I_1$ , and returning an image  $I_2$  in which the value of each pixel is  $I_2 = cb^{I_1}$ . This operator is used to change the dynamic range of an image. The value of the basis  $b$  depends on the desired degree of compression of the dynamic range.  $c$  is a scaling factor. See also logarithmic transformation, pixel logarithm operator. The right image is 1.005 raised to the pixel values of the left image:



**pixel gray scale resolution:** The number of different gray levels that can be represented in a pixel, depending on the number of bits associated with each pixel. For instance, an 8-bit pixel (or image) can represent  $2^8 = 256$  different intensity values. See

also intensity, intensity image, and intensity sensor.

**pixel interpolation:** See image interpolation.

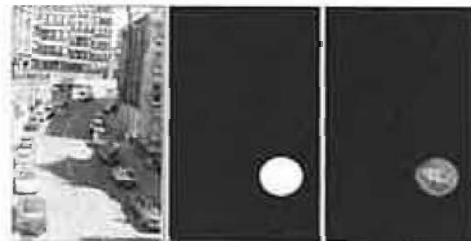
**pixel jitter:** A frame grabber must estimate the pixel sampling clock of a digital camera, *i.e.*, the clock used to read out the pixel values, which is not included in the output signal of the camera. Pixel jitter is a form of image noise generated by time variations in the frame grabber's estimate of the camera's clock.

**pixel logarithm operator:** An image processing operator taking as input one gray scale image,  $I_1$ , and returning an image  $I_2$  in which the value of each pixel is  $I_2 = c \log_b (|I_1 + 1|)$ . This operator is used to change the dynamic range of an image (see also contrast enhancement), such as for the enhancement of the magnitude of the Fourier transform. The base  $b$  of the logarithm function is often  $e$ , but it does not actually matter because the relationship between logarithms of any two bases is only one of scaling. See also pixel exponential operator. The right image is the scaled logarithm of the pixel values of the left image:



**pixel multiplication operator:**

An image processing operator taking as input two gray scale images,  $I_1$  and  $I_2$ , and returning an image  $I_3$  in which the value of each pixel is  $I_3 = I_1 * I_2$ . The right image is the product of the left and middle images (scaled by 255 for contrast here):



**pixel subsampling:** The process of producing a smaller image from a given one by including only one pixel out of every  $N$ . Subsampling is rarely applied this literally, however, as severe aliasing is introduced; scale space filtering is applied instead.

**pixel subtraction operator:** A low-level image processing operator taking as input two gray scale images,  $I_1$  and  $I_2$ , and returning an image  $I_3$  in which the value of each pixel is  $I_3 = I_1 - I_2$ . This operator implements the simplest possible change detection algorithm. The right image (with 128 added) is the middle image subtracted from the left image:

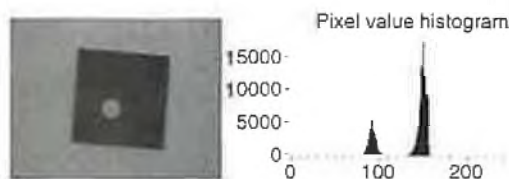




image below shows (in black) the intensity level 80 of the left image.



**intensity histogram:** A data structure that records the number of pixels of each intensity value. A typical gray scale image will have pixels with values in  $[0, 255]$ . Thus the histogram will have 256 entries recording the number of pixels that had value 0, the number having value 1, etc. A dark object against a lighter background and its histogram are shown here



**intensity image:** An image that records the measured intensity data.

**intensity level slicing:** An image processing operation in which pixels with values other than the selected value (or range of values) are set to zero. If the image is viewed as a landscape, with height proportional to brightness, then the slicing operator takes a cross section through the height surface. The right

**intensity matching:** This approach finds corresponding points in a pair of images by matching the gray scale intensity patterns. The goal is to find image neighborhoods that have nearly identical pixel intensities. All image points could be considered for matching or only feature or interest points. An algorithm where intensity matching is used is correlation based stereo matching.

**intensity sensor:** A sensor that measures intensity data.

**interest point:** A general term for pixels that have some interesting property. Interest points are often used for making feature point correspondences between images. Thus, the points usually have some identifiable property. Further, because of the need to limit the combinatorial explosion that matching can produce, interest points are often expected to be infrequent in an image. Interest points are often points of high

state sensor of a digital camera. Photon noise is not independent of the signal, and is not additive. See also image noise, digital camera.

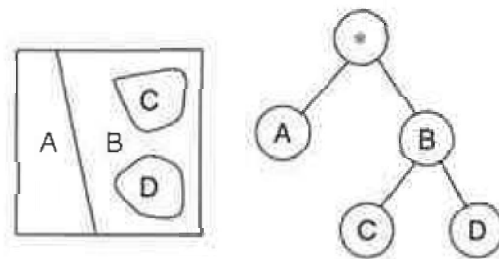
**photopic response:** The sensitivity-wavelength curve modeling the response of the human eye to normal lighting conditions. In such conditions, the cones are the photoreceptors on the retina that best respond to light. Their response curve peaks at 555 nm, indicating that the eye is maximally sensitive to green-yellow colors in normal lighting conditions. When light intensity is very low, the rods determine the eye's response, modeled by the *scotopic curve*, which peaks near to 510 nm.

**photosensor spectral response:** The spectral response of a photosensor characterizing the sensor's output as a function of the input light's spectral frequency. See also Fourier transform, frequency spectrum, spectral frequency.

**physics based vision:** An area of computer vision seeking to apply physics laws or methods (of optics, surfaces, illumination, etc.) to the analysis of images and videos. Examples include polarization based methods, in which physical properties of the scene surfaces are estimated via estimates of the state of polarization of the incoming light, and the use of detailed radiometric models of image formation.

**picture element:** A pixel. It is an indivisible image measurement. This is the smallest directly measured image feature.

**picture tree:** A recursive image and 2D shape representation in which a tree data structure is used. Each node in the tree represents a region that is then decomposed into subregions. These are represented by child nodes. The figure below shows a segmented image with four regions (left) and the corresponding picture tree.



**piecewise rigidity:** The property of an object or scene that some of its parts, but not the object or scene as a whole, are rigid. Piecewise rigidity can be a convenient assumption, e.g., in motion analysis.

**pincushion distortion:** A form of radial lens distortion where image points are displaced away from the center of distortion by an amount that increases with the distance to the center. A straight line that would have been parallel to an image side is bowed towards the center of the image. This is the opposite of barrel distortion.