1. Record Nr. | UNINA9910146060903321

Record Nr.	UNINA9910146060903321
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Titolo	Image Processing: The Fundamentals
Pubbl/distr/stampa	[Place of publication not identified], : John Wiley & Sons Incorporated, 1999
ISBN	1-280-55526-2 9786610555260 0-470-85253-4 0-470-84190-7
Descrizione fisica	1 online resource (347 pages)
Disciplina	621.367
Soggetti	Image processing - Digital techniques
Lingua di pubblicazione	Inglese
Formato	Materiale a stampa
Livello bibliografico	Monografia
Note generali	Bibliographic Level Mode of Issuance: Monograph
Nota di bibliografia	Includes bibliographical references.
Nota di contenuto	Why do we process images? -- What is an image? -- What is the brightness of an image at a pixel position? -- Why are images often quoted as being 512 [times] 512, 256 [times] 256, 128 [times] 128 etc? -- How many bits do we need to store an image? -- What is meant by image resolution? -- How do we do Image Processing? -- What is a linear operator? -- How are operators defined? -- How does an operator transform an image? -- What is the meaning of the point spread function? -- How can we express in practice the effect of a linear operator on an image? -- What is the implication of the separability assumption on the structure of matrix H? -- How can a separable transform be written in matrix form? -- What is the meaning of the separability assumption? -- What is the "take home" message of this chapter? -- What is the purpose of Image Processing? -- What is this book about? -- Image Transformations -- What is this chapter about? -- How can we define an elementary image? -- What is the outer product of two vectors? -- How can we expand an image in terms of vector outer products? -- What is a unitary transform? -- What is a unitary matrix? -- What is the inverse of a unitary transform? -- How can we construct a unitary matrix? -- How should we choose matrices U and V so that g can be represented by fewer bits than f? -- How can we diagonalize a matrix? -- How can we compute matrices U, V and

[Lambda]1/2 needed for the image diagonalization? -- What is the singular value decomposition of an image? -- How can we approximate an image using SVD? -- What is the error of the approximation of an image by SVD? -- How can we minimize the error of the reconstruction? -- What are the elementary images in terms of which SVD expands an image? -- Are there any sets of elementary images in terms of which ANY image can be expanded? -- What is a complete and orthonormal set of functions? -- Are there any complete sets of orthonormal discrete valued functions? -- How are the Haar functions defined? -- How are the Walsh functions defined? -- How can we create the image transformation matrices from the Haar and Walsh functions? -- What do the elementary images of the Haar transform look like? -- Can we define an orthogonal matrix with entries only +1 or -1? -- What do the basis images of the Hadamard/Walsh transform look like? -- What are the advantages and disadvantages of the Walsh and the Haar transforms? -- What is the Haar wavelet? -- What is the discrete version of the Fourier transform? -- How can we write the discrete Fourier transform in matrix form? -- Is matrix U used for DFT unitary? -- Which are the elementary images in terms of which DFT expands an image? -- Why is the discrete Fourier transform more commonly used than the other transforms? -- What does the convolution theorem state? -- How can we display the discrete Fourier transform of an image? -- What happens to the discrete Fourier transform of an image if the image is rotated? -- What happens to the discrete Fourier transform of an image if the image is shifted? -- What is the relationship between the average value of a function and its DFT? -- What happens to the DFT of an image if the image is scaled? -- What is the discrete cosine transform? -- What is the "take home" message of this chapter? -- Statistical Description of Images -- What is this chapter about? -- Why do we need the statistical description of images? -- Is there an image transformation that allows its representation in terms of uncorrelated data that can be used to approximate the image in the least mean square error sense? -- What is a random field? -- What is a random variable? -- How do we describe random variables? -- What is the probability of an event? -- What is the distribution function of a random variable? -- What is the probability of a random variable taking a specific value? -- What is the probability density function of a random variable? -- How do we describe many random variables? -- What relationships may n random variables have with each other? -- How do we then define a random field? -- How can we relate two random variables that appear in the same random field? -- How can we relate two random variables that belong to two different random fields? -- Since we always have just one version of an image how do we calculate the expectation values that appear in all previous definitions? -- When is a random field homogeneous? -- How can we calculate the spatial statistics of a random field? -- When is a random field ergodic? -- When is a random field ergodic with respect to the mean? -- When is a random field ergodic with respect to the autocorrelation function? -- What is the implication of ergodicity? -- How can we exploit ergodicity to reduce the number of bits needed for representing an image? -- What is the form of the autocorrelation function of a random field with uncorrelated random variables? -- How can we transform the image so that its autocorrelation matrix is diagonal? -- Is the assumption of ergodicity realistic? -- How can we approximate an image using its K-L transform? -- What is the error with which we approximate an image when we truncate its K-L expansion? -- What are the basis images in terms of which the Karhunen-Loeve transform expands an image? -- What is the "take home" message of this chapter? -- Image

Enhancement -- What is image enhancement? -- How can we enhance an image? -- Which methods of the image enhancement reason about the grey level statistics of an image? -- What is the histogram of an image? -- When is it necessary to modify the histogram of an image? -- How can we modify the histogram of an image? -- What is histogram equalization? -- Why do histogram equalization programs usually not produce images with flat histograms? -- Is it possible to enhance an image to have an absolutely flat histogram? -- What if we do not wish to have an image with a flat histogram? -- Why should one wish to perform something other than histogram equalization? -- What if the image has inhomogeneous contrast? -- Is there an alternative to histogram manipulation? -- How can we improve the contrast of a multispectral image? -- What is principal component analysis? -- What is the relationship of the Karhunen-Loeve transformation discussed here and the one discussed in Chapter 3? -- How can we perform principal component analysis? -- What are the advantages of using principal components to express an image? -- What are the disadvantages of principal component analysis? -- Some of the images with enhanced contrast appear very noisy.
Can we do anything about that? -- What are the types of noise present in an image? -- What is a rank order filter? -- What is median filtering? -- What if the noise in an image is not impulse? -- Why does lowpass filtering reduce noise? -- What if we are interested in the high frequencies of an image? -- What is the ideal highpass filter? -- How can we improve an image which suffers from variable illumination? -- Can any of the objectives of image enhancement be achieved by the linear methods we learned in Chapter 2? -- What is the "take home" message of this chapter? -- Two-Dimensional Filters -- What is this chapter about? -- How do we define a 2D filter? -- How are the system function and the unit sample response of the filter related? -- Why are we interested in the filter function in the real domain? -- Are there any conditions which h(k, l) must fulfil so that it can be used as a convolution filter? -- What is the relationship between the 1D and the 2D ideal lowpass filters? -- How can we implement a filter of infinite extent? -- How is the z-transform of a digital 1D filter defined? -- Why do we use z-transforms? -- How is the z-transform defined in 2D? -- Is there any fundamental difference between 1D and 2D recursive filters? -- How do we know that a filter does not amplify noise? -- Is there an alternative to using infinite impulse response filters? -- Why do we need approximation theory? -- How do we know how good an approximate filter is? -- What is the best approximation to an ideal given system function? -- Why do we judge an approximation according to the Chebyshey norm instead of the square error? -- How can we obtain an approximation to a system function? -- What is windowing? -- What is wrong with windowing? -- How can we improve the result of the windowing process? -- Can we make use of the windowing functions that have been developed for 1D signals, to define a windowing function for images? -- What is the formal definition of the approximation problem we are trying to solve? -- What is linear programming? -- How can we formulate the filter design problem as a linear programming problem? -- Is there any way by which we can reduce the computational intensity of the linear programming solution? -- What is the philosophy of the iterative approach? -- Are there any algorithms that work by decreasing the upper limit of the fitting error? -- How does the maximizing algorithm work? -- What is a limiting set of equations? -- What does the La Vallee Poussin theorem say? -- What is the proof of the La Vallee Poussin theorem? -- What are the steps of the iterative algorithm? -- Can we approximate a filter by working fully

in the frequency domain? -- How can we express the system function of a filter at some frequencies as a function of its values at other frequencies? -- What exactly are we trying to do when we design the filter in the frequency domain only? -- How can we solve for the unknown values H(k, l)? -- Does the frequency sampling method yield optimal solutions according to the Chebyshev criterion? -- What is the "take home" message of this chapter? -- Image Restoration -- What is image restoration? -- What is the difference between image enhancement and image restoration? -- Why may an image require restoration? -- How may geometric distortion arise? -- How can a geometrically distorted image be restored? How do we perform the spatial transformation? -- Why is grey level interpolation needed? -- How does the degraded image depend on the undegraded image and the point spread function of a linear degradation process? -- How does the degraded image depend on the undegraded image and the point spread function of a linear shift invariant degradation process? -- What form does equation (6.5) take for the case of discrete images? -- What is the problem of image restoration? -- How can the problem of image restoration be solved? -- How can we obtain information on the transfer function H(u, v) of the degradation process? -- If we know the transfer function of the degradation process, isn't the solution to the problem of image restoration trivial? -- What happens at points (u, v) where H(u, v) = 0? -- Will the zeroes of H(u, v) and G(u, v) always coincide? -- How can we take noise into consideration when writing the linear degradation equation? -- How can we avoid the amplification of noise? -- How can we express the problem of image restoration in a formal way? -- What is the solution of equation (6.37)? -- Can we find a linear solution to equation (6.37)? -- What is the linear least mean square error solution of the image restoration problem? -- Since the original image f(r) is unknown, how can we use equation (6.41) which relies on its cross-spectral density with the degraded image, to derive the filter we need? -- How can we possibly use equation (6.47) if we know nothing about the statistical properties of the unknown image f (r)? -- What is the relationship of the Wiener filter (6.47) and the inverse filter of equation (6.25)? -- Assuming that we know the statistical properties of the unknown image f(r), how can we determine the statistical properties of the noise expressed by Svv(r)? -- If the degradation process is assumed linear, why don't we solve a system of linear equations to reverse its effect instead of invoking the convolution theorem? -- Equation (6.76) seems pretty straightforward, why bother with any other approach? -- Is there any way by which matrix H can be inverted? -- When is a matrix block circulant? -- When is a matrix circulant? -- Why can block circulant matrices be inverted easily? -- Which are the eigenvalues and the eigenvectors of a circulant matrix? -- How does the knowledge of the eigenvalues and the eigenvectors of a matrix help in inverting the matrix? -- How do we know that matrix H that expresses the linear degradation process is block circulant? -- How can we diagonalize a block circulant matrix? -- OK, now we know how to overcome the problem of inverting H; however, how can we overcome the extreme sensitivity of equation (6.76) to noise? -- How can we incorporate the constraint in the inversion of the matrix? -- What is the relationship between the Wiener filter and the constrained matrix inversion filter? -- What is the "take home" message of this chapter? -- Image Segmentation and Edge Detection -- What is this chapter about? -- What exactly is the purpose of image segmentation and edge detection? -- How can we divide an image into uniform regions? -- What do we mean by "labelling" an image? -- What can we do if the valley in the histogram is not very sharply defined? -- How can we minimize the number of misclassified pixels? -- How can we choose the minimum error threshold? -- What is the minimum error threshold when object and background pixels are normally distributed? -- What is the meaning of the two solutions of (7.6)? -- What are the drawbacks of the minimum error threshold method? -- Is there any method that does not depend on the availability of models for the distributions of the object and the background pixels? -- Are there any drawbacks to Otsu's method? -- How can we threshold images obtained under variable illumination? -- If we threshold the image according to the histogram of ln f(x, y), are we thresholding it according to the reflectance properties of the imaged surfaces? -- Since straightforward thresholding methods break down under variable illumination, how can we cope with it? -- Are there any shortcomings of the thresholding methods? -- How can we cope with images that contain regions that are not uniform but they are perceived as uniform? -- Are there any segmentation methods that take into consideration the spatial proximity of pixels? -- How can one choose the seed pixels? -- How does the split and merge method work? -- Is it possible to segment an image by considering the dissimilarities between regions, as opposed to considering the similarities between pixels? -- How do we measure the dissimilarity between neighbouring pixels? -- What is the smallest possible window we can choose? -- What happens when the image has noise? -- How can we choose the weights of a 3 [times] 3 mask for edge detection? -- What is the best value of parameter K? -- In the general case, how do we decide whether a pixel is an edge pixel or not? -- Are Sobel masks appropriate for all images? -- How can we choose the weights of the mask if we need a larger mask owing to the. presence of significant noise in the image? -- Can we use the optimal filters for edges to detect lines in an image in an optimal way? -- What is the fundamental difference between step edges and lines? -- What is the "take home" message of this chapter?.

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Image processing has been one of the most active areas of research in recent years. The techniques involved have found significant applications in areas as diverse as video-conferencing, image communication, robotics, geoscience, and medicine.; Providing a step-by-step guide to the basic principles underlying all image processing tasks, this book features numerous worked examples, guiding the reader through the intricacies of reaching the solutions.