Preface

This book represents the advances in the development of new approaches, used for the intelligent image analysis. It introduces various aspects of the image analysis, related to the theory for their processing, and to some practical applications.

The book comprises 11 chapters, whose authors are researchers from different countries: USA, Russia, Bulgaria, Japan, Brazil, Romania, Ukraine, and Egypt. Each chapter is a small monograph, which represents the recent research work of the authors in the corresponding scientific area. The object of the investigation is new methods, algorithms, and models, aimed at the intelligent analysis of signals and images—single and sequences of various kinds: natural, medical, multispectral, multi-view, sound pictures, acoustic maps of sources, etc.

New Approaches for Hierarchical Image Decomposition, Based on IDP, SVD, PCA, and KPCA

In Chap. 1 the basic methods for hierarchical decomposition of grayscale and color images, and of sequences of correlated images are analyzed. New approaches are introduced for hierarchical image decomposition: the Branched Inverse Difference Pyramid (BIDP) and the Hierarchical Singular Value Decomposition (HSVD) with tree-like computational structure for single images; the Hierarchical Adaptive Principle Component Analysis (HAPCA) for groups of correlated images and the Hierarchical Adaptive Kernel Principal Component Analysis (HAKPCA) for color images. In the chapter the evaluation of the computational complexity of the algorithms used for the implementation of these decompositions is also given. The basic application areas are defined for efficient image hierarchical decomposition, such as visual information redundancy reduction; noise filtration; color segmentation; image retrieval; image fusion; dimensionality reduction, where the following is executed: the objects classification; search enhancement in large-scale image databases, etc.

Intelligent Digital Signal Processing and Feature Extraction Methods

The goal of Chap. 2 is to present well-known signal processing methods and the way they can be combined with intelligent systems in order to create powerful feature extraction techniques. In order to achieve this, several case studies are presented to illustrate the power of hybrid systems. The main emphasis is on the instantaneous time–frequency analysis, since it is proven to be a powerful method in several technical and scientific areas. The oldest and most utilized method is the Fourier transform, which has been applied in several domains of data processing, but it has very strong limitations due to the constraints it imposes on the analyzed data. Then the short-time Fourier transform and the wavelet transform are presented as they provide both temporal and frequency information as opposed to the Fourier transform. These methods form the basis of most applications, as they offer the possibility of time–frequency analysis of signals. The Hilbert–Huang transform is presented as a novel signal processing method, which introduces the concept of the instantaneous frequency that can be determined for every time point, making it possible to have a deeper look into different phenomena. Several applications are presented where fuzzy classifiers, support vector machines, and artificial neural networks are used for decision-making. Interconnecting these intelligent methods with signal processing will result in hybrid intelligent systems capable of solving computationally difficult problems.

Multi-dimensional Data Clustering and Visualization via Echo State Networks

Chapter 3 summarizes the proposed recently approach for multidimensional data clustering and visualization. It uses a special kind of recurrent networks called Echo State Networks (ESN) to generate multiple 2D projections of the multidimensional original data. The 2D projections are subjected to selection based on different criteria depending on the aim of particular clustering task to be solved. The selected projections are used to cluster and/or to visualize the original data set. Several examples demonstrate the possible ways to apply the proposed approach to variety of multidimensional data sets: steel alloys discrimination by their composition; Earth cover classification from hyperspectral satellite images; working regimes classification of an industrial plant using data from multiple measurements; discrimination of patterns of random dot motion on the screen; and clustering and visualization of static and dynamic “sound pictures” by multiple randomly placed microphones.

Unsupervised Clustering of Natural Images in Automatic Image Annotation Systems

Chapter 4 is devoted to automatic annotation of natural images joining the strengths of the text-based and the content-based image retrieval. The automatic image annotation is based on the semantic concept models, which are built from large number of patches received from a set of images. In this case, image retrieval is implemented by keywords called Visual Words (VWs) that is similar to text document retrieval. The task involves two main stages: a low-level segmentation based on color, texture, and fractal descriptors and a high-level clustering of received descriptors into the separated clusters corresponding to the VWs set. The enhanced region descriptor including color, texture, and fractal features has been proposed. For the VWs generation, the unsupervised clustering is a suitable approach. The Enhanced Self-Organizing Incremental Neural Network (ESOINN) was chosen due to its main benefits as a self-organizing structure and online implementation. The preliminary image segmentation permitted to change a sequential order of descriptors entering the ESOINN as associated sets. Such approach simplified, accelerated, and decreased the stochastic variations of the ESOINN. The experiments demonstrate acceptable results of the VWs clustering for a non-large natural image sets. This approach shows better precision values and execution time as compared to the fuzzy c-means algorithm and the classic ESOINN. Also issues of parallel implementation of unsupervised segmentation in OpenMP and Intel Cilk Plus environments were considered for processing of HD-quality images.

An Evolutionary Optimization Control System for Remote Sensing Image Processing

Chapter 5 provides an evolutionary control system via two Darwinian Particle Swarm Optimizations (DPSO)—one novel application of DPSO—coupled with remote sensing image processing to help in the image data analysis. The remote sensing image analysis has been a topic of ongoing research for many years and has led to paradigm shifts in the areas of resource management and global biophysical monitoring. Due to distortions caused by variations in signal/image capture and environmental changes, there is not a definite model for image processing tasks in remote sensing and such tasks are traditionally approached on a case-by-case basis. Intelligent control, however, can streamline some of the case-by-case scenarios and allows faster, more accurate image processing to support the more accurate remote sensing image analysis.

Tissue Segmentation Methods Using 2D Histogram Matching in a Sequence of MR Brain Images

In Chap. 6 a new transductive learning method for tissue segmentation using a 2D histogram modification, applied to Magnetic Resonance (MR) image sequence, is introduced. The 2D histogram is produced from a normalized sum of co-occurrence matrices of each MR image. Two types of model 2D histograms are constructed for each subsequence: intra-tissue 2D histogram to separate tissue regions and an inter-tissue edge 2D histogram. First, the MR image sequence is divided into few subsequences, using wave hedges distance between the 2D histograms of the consecutive MR images. The test 2D histogram segments are modified in the confidence interval and the most representative entries for each tissue are extracted, which are used for the kNN classification after distance learning. The modification is applied by using LUT and two ways of distance metric learning: large margin nearest neighbor and neighborhood component analysis. Finally, segmentation of the test MR image is performed using back projection with majority vote between the probability maps of each tissue region, where the inter-tissue edge entries are added with equal weights to corresponding tissues. The proposed algorithm has been evaluated with free access data sets and has showed results that are comparable to the state-of-the-art segmentation algorithms, although it does not consider specific shape and ridges of brain tissues.

Multistage Approach for Simple Kidney Cysts Segmentation in CT Images

In Chap. 7 a multistage approach for segmentation of medical objects in Computed Tomography (CT) images is presented. Noise reduction with consecutive applied median filter and wavelet shrinkage packet decomposition, and contrast enhancement based on Contrast limited Adaptive Histogram Equalization (CLAHE) are applied in the preprocessing stage. As a next step a combination of two basic methods is used for image segmentation such as the split and merge algorithm, followed by the color-based K-mean clustering. For refining the boundaries of the detected objects, additional texture analysis is introduced based on the limited Haralick's feature set and morphological filters. Due to the diminished number of components for the feature vectors, the speed of the segmentation stage is higher than that for the full feature set. Some experimental results are presented, obtained by computer simulation. The experimental results give detailed information about the detected simple renal cysts and their boundaries in the axial plane of the CT images. The proposed approach can be used in real time for precise diagnosis or in disease progression monitoring.

Audio Visual Attention Models in Mobile Robots Navigation

In Chap. 8, it is proposed to use the exiting definitions and models for human audio and visual attention, adapting them to the models of mobile robots audio and visual attention, and combining with the results from mobile robots audio and visual perception in the mobile robots navigation tasks. The mobile robots are equipped with sensitive audio visual sensors (usually microphone arrays and video cameras). They are the main sources of audio and visual information to perform suitable mobile robots navigation tasks modeling human audio and visual perception. The audio and visual perception algorithms are widely used, separately or in audio visual perception, in mobile robot navigation, for example to control mobile robots motion in applications like people and objects tracking, surveillance systems, etc. The effectiveness and precision of the audio and visual perception methods in mobile robots navigation can be enhanced combining audio and visual perception with audio and visual attention. There exists relative sufficient knowledge describing the phenomena of human audio and visual attention.

Local Adaptive Image Processing

Three methods for 2D local adaptive image processing are presented in Chap. 9. In the first one, the adaptation is based on the local information from the four neighborhood pixels of the processed image and the interpolation type is changed to zero or bilinear. The analysis of the local characteristics of images in small areas is presented, from which the optimal selection of thresholds for dividing into homogeneous and contour blocks is made and the interpolation type is changed adaptively. In the second one, the adaptive image halftoning is based on the generalized 2D Last Mean Square (LMS) error-diffusion filter for image quantization. The thresholds for comparing the input image levels are calculated from the gray values dividing the normalized histogram of the input halftone image into equal parts. In the third one, the adaptive line prediction is based on the 2D LMS adaptation of coefficients of the linear prediction filter for image coding. An analysis of properties of 2D LMS filters in different directions was made. The principal block schemes of the developed algorithms are presented. An evaluation of the quality of the processed images was made on the base of the calculated objective criteria and the subjective observation. The given experimental results, from the simulation for each of the developed algorithms, suggest that the effective use of local information contributes to minimize the processing error. The methods are suitable for different types of images (fingerprints, contour images, cartoons, medical signals, etc.). The developed algorithms have low computational complexity and are suitable for real-time applications.

Machine Learning Techniques for Intelligent Access Control

In Chap. 10 several biometric techniques, their usage, advantages and disadvantages are introduced. The access control is the set of regulations used to access certain areas or information. By access we mean entering a specific area, or logging on a machine (PC, or another device). The access regulated by a set of rules that specifies who is allowed to get access, and what are the restrictions on such access. Over the years several basic kinds of access control systems have been developed. With advancement of technology, older systems are now easily bypassed with several methods, thus the need to have new methods of access control. Biometrics is referred to as an authentication technique that relies on a computer system to electronically validate a measurable biological characteristic that is physically unique and cannot be duplicated. Biometrics has been used for ages as an access control security system.

Experimental Evaluation of Opportunity to Improve the Resolution of the Acoustic Maps

Chapter 11 is devoted to generation of acoustic maps. The experimental work considers the possibility to increase the maps resolution. The work uses 2D microphone array with randomly spaced elements to generate acoustic maps of sources located in its near-field region. In this region the wave front is not flat and the phase of the input signals depends on the arrival direction, and on the range as well. The input signals are partially distorted by the indoor multipath propagation and the related interference of sources emissions. For acoustic mapping with improved resolution an algorithm in the frequency domain is proposed. The algorithm is based on the modified method of Capon. Acoustic maps of point-like noise sources are generated. The maps are compared with the maps generated using other famous methods including built-in equipment software. The obtained results are valuable in the estimation of direction of arrival for Noise Exposure Monitoring.

This book will be very useful for students and Ph.D. students, researchers, and software developers, working in the area of digital analysis and recognition of multidimensional signals and images.

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