Preface

Contemporary methods classified as image recognition techniques and computer vision systems have been developing very rapidly in many domains. They are used in advanced hardware technologies as well as in a series of methodologically complex algorithmic solutions allowing diverse images recorded by computer systems to be visualized, classified, and analyzed. Such techniques are also increasingly applied in practice, not just to help solve complicated scientific problems of interpreting complex images: they have been implemented and are accessible to a broad group of users. Among the many usage areas of methods related to computer image recognition techniques, which attract a lot of interest due to the possibility of their broad use in practical applications, we can also list such subjects as the analysis of complex images and scenes aimed at of their semantic interpretation, techniques for reconstructing 3-D images and visualizing them in augmented reality environments, as well as advanced methods of recognising images used in man–machine interfaces.

The most recent discoveries and state-of-the-art technical solutions from the above fields are of great importance for the further development of advanced computer vision and image recognition systems. Their invention required solving many major, very difficult problems of image algebra, cognitive image interpretation, and creating a technology for 3-D rendering, and thus creating 3-D images and virtual objects with which the user can interact in an augmented reality environment. The development of image recognition methods in the above areas went so far that we now have innumerable practical applications of such techniques and methods, available in almost every facet of life (sports, science, leisure, work, etc.), scientific disciplines (IT, medicine, geology, chemistry, natural science, automation and robotics, etc.), or areas of human activity (e.g., space research, oceanography, weapon design, defence, and security of both the state and individuals).

The available image recognition technologies and algorithms can also be analyzed from the scientific, theoretical perspective. This perspective should also lead us to appreciate the solutions available in this area: in recent years, the capabilities of such systems have come close to the perceptual analysis of images which is achieved only by the vision systems of primates (including mainly humans). This requires not only with the ability to record stereo-vision and 3-D

images but also to perceptually analyze them or understand the meaning of a given image or scene.

Although the capabilities of computer image analysis that have appeared recently do not work as well as the processing of visual information in the human visual system yet, it seems that soon we might see technical solutions with abilities close to the most advanced biological vision systems. This research area is still open and related to research on neuro-biological and psychological cognitive processes, as well as technological attempts to construct an artificial brain that could be used to build cognitive humanoid robots [1].

The topics of this monograph will contribute to similar, interesting schools of research on modern systems of image recognition and their practical applications. This book will present selected topics, both theoretical and practical, from this broad area of contemporary IT.

Within the scope of practical applications of advanced Image Analysis methods, we will try to show some important, practical uses of such techniques to analyze selected medical images, and in particular of the brain and carotid arteries. In this area, we will discuss the complete methodology of processing, analyzing and interpreting diagnostic results of example computed tomography images. With regards to practical applications, we will also discuss an innovative method of recognizing gestures and motions which can obviously be used widely in areas associated with analyzing medical images, but can also find its application in similar fields, e.g., as a fully functional man–machine interface.

In this monograph, we will also try to get the reader interested in selected topics of theoretical and methodological nature. For this purpose, we will not only discuss selected methods and techniques of image analysis and recognition, but also present significant problems related to new approaches and computational paradigms in the field of computer-based image understanding and semantic image analysis. Such capabilities have appeared after the development of techniques for cognitively analysing of image patterns, which the authors spend many years on [2, 3]. The presentation of such topics will constitute an interesting supplement to the practical applications discussed in this book.

However, it is worth noting that both the presented theoretical subjects and practical solutions are open in nature and can be improved by researchers wishing to make their own contribution to the development of these methods, or to improve the operation of the algorithms presented in the following chapters. This is why the described solutions will be accompanied by example source codes of the implemented algorithms, and also broad literature allowing the reader to extend their knowledge of the area of interest to them.

As this book is interdisciplinary in nature, on the one hand presenting advanced algorithms for image recognition and on the other their use to analyze the images of the brain and carotid arteries, but also because it describes not just practical methods but also advanced theoretical formalisms, we can briefly state that it will touch upon the following subjects:

1. Discussing and defining methods of perceptual image analysis based on the existing processing and the recognition algorithms [2, 4].
2. Indicating the possibility of using cognitive image analysis for the semantic interpretation of medical images [1].
3. Developing a methodology for computer-based semantic analysis of brain and carotid artery perfusion images [5, 6].
4. Developing effective algorithmic and implementation solutions for visualising selected 3-D structures [7].
5. Developing the GDL (Gesture Description Language) technology as an innovative solution for Natural User Interfaces [8].

These subjects will be discussed in six subsequent chapters of this monograph, including five main chapters and the summary.

The Preface talks about the entire topical scope of this book and the directions of contemporary scientific research on image recognition and cognitive vision systems. We will also present the areas of scientific research conducted by the authors, dealing with techniques of advanced analysis and recognition of images.

The lengthy first chapter reviews selected methods of initial image analysis, major classification techniques including a list of holistic and syntactic methods, and introduces to techniques of semantic image analysis. This chapter also contains source codes of example implementations of selected image processing methods.

Chapter 2 presents the idea behind the semantic analysis of images, based on the resonance processes. It defines the cognitive resonance model and the methods of its implementation using image languages. The possibilities of conducting a semantic analysis are illustrated with medical samples of diagnostic images showing brain perfusion maps and computer 3-D reconstructions of carotid vessels.

Chapter 3 presents the authors' original approach to the semantic analysis of two types of medical images. The first of them is the analysis and detection of lesions in the blood perfusion of brain tissue, portrayed in CT (computed tomography) images. For these images, the complete examination methodology is presented, which allows lesions be detected and their meaning interpreted. The second example is the ability to make 3-D reconstructions of carotid arteries aimed at diagnosing morphological changes of these structures and detecting brain ischemia conditions. For both cases of images analyzed, example results produced by the developed algorithms are presented, and the codes of example procedures making it possible to conduct such analyses are given.

Chapter 4 deals with techniques for creating 3-D visualizations and 3-D rendering. It presents a series of notions from image algebra and techniques for 3-D transformations of images. It also gives examples of hardware implementations of such methods, as well as the source codes of the proposed data visualisation methods.

Chapter 5 discusses the currently available interfaces for image communication between humans and computers with their use in practical applications and mobile

devices, but it also presents an innovative GDL technology. The authors of this monograph have proposed the GDL technology which allows users not only to communicate with computers, but also supports sophisticated analyses of human motions and gestures, e.g., during navigation, behavioral analyses, the psychological interpretation of gestures, and also in physical (exercise) therapy.

The last chapter of this monograph contains a summary of the authors' significant research achievements in the field of advanced image recognition techniques and their practical applications. The summary will also chart the possible further research directions in which this discipline can be developed.

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