PREFACE

In recent years we have witnessed a rapid development of science in the field of biomedical engineering. It is believed that it is now one of the key areas for the development of world economy and welfare of societies. Both governments and private companies are investing significant financial resources to develop innovative technologies in this field.

Medical diagnostics is a very important part of biomedical engineering. In the era of overcrowding, aging population, the development of many civilization diseases and the lengthening of the lifespan of people, it becomes necessary to develop IT systems that will support and accelerate the diagnosis of diseases. Thanks to the development of such areas as electronics, computer science or physics, it has become possible to introduce—into modern health care systems—medical imaging technologies, such as computed tomography, magnetic resonance imaging, ultrasonography, nuclear imaging, thermography and virtual microscopy, which are capable to present pathogenic changes with very high accuracy. Paradoxically, high accuracy of medical imaging gives rise to many problems because diagnostic devices generate huge amounts of raw data, which then must be pre-processed and analyzed by specialists. This requires large amounts of computing power, which results in a long waiting time for obtaining diagnostic images. In addition, high resolution images significantly increase the time required by specialist to analyze them. As a result, we obtain a time-consuming diagnostic process and reduction of the number of patients being diagnosed. To support medical staff in this problem, it is necessary to develop effective methods of processing raw data into final images with no loss of quality and to develop computer-aided diagnosis systems. Various methods from areas such as image processing, statistics, machine learning, data mining and artificial intelligence are employed to accomplish these tasks. Recent advances in these fields allow the development of effective methods of image reconstruction and segmentation, automatic selection and evaluation of relevant regions of images, morphometric measurements and automatic classification of disease.

Despite many successes confirmed by numerous journal articles, conference proceedings and books, medical imaging and diagnostics still remain a challenging task, and room for improvement and new potential applications exist. It is a great pleasure for us to introduce four interesting articles on biomedical engineering published in a special section of the *International Journal of Applied Mathematics and Computer Science*. The presented works are a result of a seminar that was held at the University of Zielona Góra, Poland, on 16 November 2012. This scientific meeting entitled *Selected Problems of Biomedical Engineering* was organized jointly by the Polish Chapter of the IEEE Control Systems Society, the Commission for Engineering Cybernetics of the Poznań Branch of the Polish Academy of Sciences as well as the Committee on Automation and Robotics of the Polish Academy of Sciences. The seminar was addressed to both experts and young researchers, who could introduce their newest research achievements to the audience of leading scientists in biomedical engineering. The meeting hosted speakers from the Technical Universities of Warsaw, Poznań, Częstochowa and Gliwice, as well as the West Pomeranian University of Technology in Szczecin and the University of Zielona Góra. A total of eight speakers presented and discussed their latest achievements. After the meeting, selected speakers extended their presentations to full articles. All of these have passed the journal review process, which guarantees their high quality. Finally, four papers have been included in the present special section on *Selected Problems of Biomedical Engineering*.

In the first paper, *An analytical iterative statistical algorithm for image reconstruction from projections*, Cierniak presents a statistical model-based iterative approach to image reconstruction from computed tomography data. He formulates an algorithm based on a maximum likelihood method with the objective adjusted to the probability distribution of measured signals obtained from an x-ray tomography with parallel beam geometry. In order to prove the effectiveness of the approach, some experimental results are included in the paper. They show that an objective that is exactly tailored statistically yields the best results, and that the proposed reconstruction algorithm creates images with better quality than a conventional back-projection one.

In the paper *Nuclei segmentation for computer-aided diagnosis of breast cancer*, Kowal and Filipczuk present a computer-aided breast cancer diagnosis system for the analysis of cytological images of fine needle biopsies. They propose a robust segmentation procedure giving satisfactory segmentation results even when objects in the microscopic images are densely clustered. The method assumes that centers of the nuclei are determined using conditional erosion performed on a binary mask obtained with adaptive thresholding and *k*-means clustering. Then the multi-label fast marching algorithm initialized with these centers is performed to obtain the final segmentation. The approach was tested on 450 microscopic images of fine needle biopsies. The task was to classify them as either benign or malignant. Experimental results show that the proposed medical decision support system would provide accurate diagnostic information because classification accuracy reaches 100

In *Recognition of atherosclerotic plaques and their extended dimensioning with computerized tomography angiography imaging*, Markiewicz *et al.* raise the issue of automatic discrimination of atherosclerotic plaques within an artery lumen based on numerical and statistical thresholding of images and their advanced dimensioning as a support for pre-operative vessel assessment. A crucial step in the staging of an atherosclerotic alteration is recognition of the plaque in the computerized tomography angiography image. To solve this problem, statistical an linear fitting methods, including the least squares approximation by polynomial and spline functions, as well as the error fitting function were used. Moreover, the authors proposed new descriptors of atherosclerotic changes such as the lumen decrease factor, the circumference occupancy factor and the convex plaque one. Finally, ways of reducing computational complexity of the presented algorithms were discussed.

In their paper *From the slit-island method to the Ising model: Analysis of irregular grayscale objects*, Mazurek and Oszustowska-Mazurek apply the slit island method for image analysis of irregular grayscale objects and their classification using fractal dimension. They show that the method is not functional in some cases. By transformation of the input image from unipolar to bipolar, the authors reformulated image analysis using the Ising model context. In order to classify grayscale objects, the area-perimeter curve was approximated by the polynomial. Finally, the proposed technique was applied to classify cervical cells nuclei.

We would like to express our gratitude to all paper reviewers as well as the authors who contributed their original research papers. We hope the reader will find this special section very interesting and share our opinion that the presented papers make a significant contribution to the development of biomedical engineering.

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Marek Kowal received his M.Sc. and Ph.D. degrees in electrical engineering from the University of Zielona Góra, Poland, in 2000 and 2004, respectively. Currently, he is an assistant professor in the Institute of Control and Computation Engineering at the same university. He has published about 40 papers in refereed journal and conference papers. He is an author of one monograph and four book chapters. His current interests include medical diagnostics, image processing, fuzzy logic, as well as fuzzy and stochastic geometry. Doctor Kowal has taken part in the realization of a number of research projects sponsored by the State Committee for Scientific Research in Poland and the European Commission: INCO-Copernicus on *Integration of quantitative and qualitative fault diagnosis methods within the framework of industrial application* and the 5th FP EU RTN on *Development and application of methods for actuator diagnosis in industrial control systems, DAMADICS*. He is currently involved in the realization of the research project on *Diagnosis of breast cancer based on microscopic images of the material acquired by fine needle biopsy without aspiration*, sponsored by the National Science Centre in Poland. He was the chair of the organizing committee of the 11th International Conference on *Diagnostics of Processes and Systems, DPS2013* (Łagów Lubuski, Poland, 2013). He is also a member of the IEEE.

Józef Korbicz has been a full-rank professor of automatic control at the University of Zielona Góra, Poland, since 1994, and a corresponding member of the Polish Academy of Sciences since 2007. His research interests include computational intelligence, fault detection and isolation, and control theory. He has published almost 370 scientific works, authored and co-authored 8 books and co-edited 7. He has served as the chairperson for several significant international conferences and workshops (e.g., *Control and Fault-Tolerant Systems, SystTol* or *Advanced Control and Diagnosis, ACD*, whose steering committee he now chairs), and has been a visiting professor at top-ranking universities abroad. Currently, he is the deputy chair of the Committee on Automatic Control and Robotics of the Polish Academy of Sciences, a senior member of the IEEE, a member of the IFAC SAFEPROCESS TC and a member of the Polish Central Commission for Scientific Degrees and Titles. He also heads the Institute of Control and Computation Engineering at this home university and is the editor-in-chief of the *International Journal of Applied Mathematics and Computer Science*.