Advances in Image Analysis - Nature Inspired Methodology

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Preface

The development of human society relies on natural resources in every area (both material and spiritual). Nature has enormous power and intelligence behind its common daily appearance, and it is generous. We learn in it and from it, virtually as part of it. Nature-inspired systems and methods have a long history in human science and technology. For example, in the area of computer science, the recent well-known ones include the artificial neural network, genetic algorithm and swarm intelligence, which solve hard problems by imitating mechanisms in nature. Nature-inspired methods are also being quickly developed and applied in other areas. In this book volume, the authors just try to pick up a drop from the sea of nature's intelligence, and apply it in a specific area. The authors hope that it may inspire the readers' interest of nature's intelligence when exploring in their own areas of science and technology.

The research work in this book volume is supported by WSEAS on the topic of "Advanced Image Processing Techniques". Nature-inspired methods in image processing have attracted more and more attention and research efforts. Related work has achieved promising results in practical tasks, which indicate that it is a direction potentially leading to breakthroughs of new image analysis techniques. Methods inspired by physical electro-magnetic field make up a main branch of this direction, which have been successfully applied in the practical applications including: recognition of human ear, face and gait; extraction of corner, edge, and shape skeleton in images. The existing methods inspired by electro-magnetic theory generally belong to two categories: analysis of the virtual field generated by the image (such as the "force field transform"), and deforming a shape or curve under the virtual force field generated by the image (such as the "active counter model").

The authors have been exploring in the area of nature-inspired image analysis for years, and have published a series of papers about their novel methods and results. These methods are mainly inspired by the theory of electro-magnetic field, which reveal the structure properties of the image by electro-magnetics inspired transforms. In these transforms, the formulas in electro-magnetic theory are adjusted to more generalized forms in order to suit practical image analysis tasks, and some novel viewpoints which take the image as a virtual field are presented. Several types of methods have been proposed from different aspects of field theory (vector field, scalar potential field, and field source distribution). The work in the paper seires indicate that the physics inspired virtual field is a novel way of designing new effective image transforms. There are other nature inspired methods proposed in the paper series including: image segmentation inspired by the physical deformable grid, image feature extraction inspired by the artificial swarm, and the measurement of image local property by fractal feature. Because this series of papers mainly concentrate on nature-inspired methodology, they are now gathered and published as a book volume.

Nature-inspired methodology itself means continuous exploration in the rich resource of the intelligence shown by nature. Therefore, this book volume does not mean the end and final conclusion of the authors' on-going work. Further promising results in both theory and practice are expected. And the authors hope their research attempts shown in the book volume may inspire new ideas of others, which will surely be much more valuable than the book volume itself.

Xiaodong Zhuang,
Nikos E. Mastorakis

Summary

In electro-static fields and magneto-static fields, the field and its source are two indivisible parts of a physical system. The field is derived from the source, and it naturally reflects the characters of the source distribution. On the other hand, the source may be mathematically inverted from the field. Therefore, the field and its source can be regarded as two domains of a special transform, and either of them can represent the characters of the other. The potential and the field intensity have a similar relationship, which means they are two different presentations of a same physical system.

Images can be regarded as a two-dimensional distribution of data. Image transform is the basic technique in image analysis, which finds a clearer and more convenient representation in the transform domain for better analyses. The natural transforms implied in the theory of physical electro-magnetic field just satisfy the need of the transform and feature extraction in image analysis. Moreover, the mathematical forms of electro-magnetic formulas have a unique advantage of the balance between local and global analysis, which is needed in many practical tasks.

In recent years, there have been increasing research efforts in nature inspired methods for image analysis. Promising results have been obtained in edge detection, corner detection, shape skeletonization, ear recognition, etc. Existing research focuses on scalar potential field, but the work on vector field transform is rare. The direct application of the formulas of physical fields is common, but there is much less work of adjusting and altering the forms of physical formulas to suit practical applications better. Moreover, most of the existing work in this area takes the image as the source and produces its virtual field, but the inverse transform from the image as a field to its virtual source is not investigated in previous research work. In the paper series of this book volume, the authors try to widen the research of physical field inspired methods in image analysis.

This book volume is the collection of the authors' recent original work mainly in the area of physics-inspired methods for image analysis, which provide a new kind of natural representation of image structure imitating the electro-magnetic field. Three virtual vector field transforms (diffusing vector field, curling vector field, compressing vector field) are proposed based on the electro-static or magneto-static analogy. A scalar virtual potential field (relative potential field) is also proposed for image analysis. Besides, two different virtual source reverse methods (potential source reverse, curling source reverse) are proposed imitating the physical fields derived from the static charges and static current distribution. The edge vector field is also presented, and the virtual magnetic field generate by it is also investigated. In the above work, the basic properties of the virtual fields are analyzed and experimentally investigated, and their possible applications in image analysis are also studied by experiments. The experimental results indicate the impressive research value of physical field inspired methods in image analysis.

Other methods proposed in this book volume include: an image segmentation method inspired by physical deformable grid, a biological swarm inspired method for feature extraction, fractal representation of image local feature, and a social insect inspired method for task allocation in parallel processing tasks. The experimental results of the proposed methods show the promising wide application of nature inspired methods in practice.

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SUBJECT INDEX

Dr. Xiaodong Zhuang received his degrees of both B.Sc. and M.Sc. in the Electronics and Engineering Department of Qingdao Ocean University (Qingdao, China). He received his Ph.D. degree in the Computer Science Department of China Ocean University (Qingdao, China). He is now associate professor in the Electronics and Engineering Department of Qingdao University (Qingdao, China). He is also a post-doctoral researcher under the supervision of Professor Nikos E. Mastorakis, and a researcher in the WSEAS research department (Greece). He has served as visiting researcher in the Oceanic Remote Sensing Laboratory (ORSL) of the Chinese Education Ministry since 2006, and he served as a researcher in the "Professor Partnership Program" of Nvidia Corporation in 2010.

The research interest of Dr Xiaodong Zhuang includes: Image Segmentation and Analysis, Speech Processing and Recognition, Parallel Programming, Algorithm Simulation in C and Matlab. He has been in charge of several research projects supported by WSEAS research department, Qingdao University, Nvidia Corporation, and ORSL respectively. He has published near 50 papers in journals and conferences. He has served as a supervisor for master students of "Signal and Information Processing" in Qingdao University since 2006. He has been an active reviewer of several international journals ("Artificial Intelligence in Medicine", Elsevier, "Journal of Qingdao University - Natural Science Edition", "Computers in Biology and Medicine", "Medical Engineering and Physics", "Biomedical Signal Processing and Control", "Neural Computing and Applications" etc.)

Prof. Dr. Nikos E. Mastorakis received his B.Sc. and M.Sc. (Diploma) in Electrical Engineering from the National Technical University of Athens and the Ph.D. in Electrical Engineering and Computer Science from the same university. He also received the B.Sc. (Ptychion) in Pure Mathematics from the National University of Athens. He has also studied Medicine in the University of Athens.

He have served as special scientist on Computers and Electronics in the Hellenic (Greek) Army General Staff (1993-1994) and taught several courses in the Electrical and Computer Engineering Department of the National Technical University of Athens (1998-1994). He has also served as Visiting Professor at the University of Exeter, School of Engineering (UK, 1998). He is currently Full Professor in the Industrial Engineering Department of the Technical University of Sofia (Bulgaria) as well as he is Full Professor and Head of the Division of Electrical Engineering and Computer Science at the Military Institutions of University Education (MIUE) - Hellenic Naval Academy, Greece (1994-...).

Prof. Dr. Nikos Mastorakis was the first that solved with several different approaches the former unsolved problem of Multivariable Factorization and published it. He was also the first scholar that completely solved the problem of stability for Multidimensional Systems using Genetic Algorithms. Also, was the first that constructed Electronic Musical Instrument with the spaces of the Byzantine music. He is an active researcher in Applied Mathematics and Computer Science (Systems Theory, Control, Optimization Theory, Algorithms Theory, Signal Processing, Robotics, Computational Intelligence).

The editor of over than 200 Books and the author of 5 books, Dr. Mastorakis has published over than 600 papers in international books, journals and conferences. He is an active reviewer of 26 International Journals and member of the Editorial Board of 13 International Journals. Dr. Mastorakis has received several awards (Royal Society of England, Hellenic National Research Foundation, etc) for hisacademic studies and his scientific research.

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