Preface

Data mining focuses on tools and approaches for analyzing data from different scopes or directions including database technology, machine learning, statistics, pattern recognition, information retrieval, neural networks, knowledge-based systems, artificial intelligence, high-performance computing, and data visualization (Han, Kamber, & Pei, 2011).

Data mining is the process of investigating data in order to extract or retrieve useful information. This information can be helpful to make good decisions, increase revenue, decrease cost.

Image Mining is an extension of all aspects of data mining handling image data such as satellite images, medical images, etc. Image Mining is quickly expanding attentiveness because of its ability in discovering useful information from images. Image mining systems that can extract significant information from image data are increasingly claimed. Image mining represents the bound of image processing technology and data mining to help specialists in understanding and analyzing complex images.

The major objective in image mining is to determine how low-level, pixel representation contained in a raw image or image sequence can be efficiently and effectively processed to identify high-level spatial objects and relationships (Hsu, Lee, & Zhang, 2002).

Image mining takes advantages of computer evolution and the progress of diverse disciplines such as artificial intelligence, machine learning, image processing, etc.

The field of health is being revolutionized with scientific and technical progress. Today, Health information technology is exploited by systems that are interested in health and use Information Technologies (IT) to extract useful information from millions of electronic patient records. This information is used for example, to better understand the relationship between symptoms and diseases, drugs and diseases, medications and their results… Health information technology has shown the enlargement of quality of care by enhancing disease surveillance, and decreasing medication errors. The use of Database systems gathering multimedia information (categorical, continuous, and images) about patients, and Knowledge Management technologies can contribute a lot to decision support systems in health care.

Biomedical Image Mining, a new research area, emerged since a large amount of biomedical images are increasingly acquired and stored digitally. These images are the most in the form: X-ray, computed tomography (CT), nuclear medicine imaging (PET, SPECT), ultrasound and magnetic resonance imaging (MRI). Patients’ biomedical images can be computerized using data mining techniques and may help in answering several important and critical questions related to health care. Image mining in medicine can help to uncover new relationships between data and reveal new useful information that can be helpful for scientists in treating their patients.
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Thanks to Biomedical Image Mining, diseases will be not only detected, but also cured due to high-tech imaging and computerized image processing. The trends in recent imaging research focuses on improvement of automated processing of cellular, molecular, anatomical, and functional images, assisted by new technologies and leading to a rapid growing of computer-aided detection and diagnosis. Given the technological progress, the future research promises big evolutions in biomedical domain, principally to detect diseases and to supervise their evolution. The computer-aided image mining will grasp a gigantic advancement to assist doctors in the interpretation of medical images.

The computer-aided image mining approaches will be principally concentrated to assist visual detection, by a qualitative and quantitative analysis of the medical images (i.e. by enhancing the relevant features of the images or suppressing the noises); to assist feature extraction for further quantitative analyses (i.e. by techniques such as boundary delineation, texture analysis); to automatically detect and classify the images (i.e. by integrating the data mining tools, image processing, and signal processing); to guess the anatomical and functional tissue features that are not evidently discovered in the medical images (i.e. by perceiving the physiology or the biomechanics obtainable from images).

RESEARCH TOPICS IN THE FIELD OF BIOMEDICAL IMAGE MINING

Numerous researches have been carried on image mining and biomedical image mining. Various image mining techniques were proposed. Most of the computer-aided methods evidenced to be powerful in assisting medical experts and lead to better results in diagnosing a patient (Antonie, Zaiane, & Coman, 2001).

In image classification: The methods proposed classify the digital images (i.e. mammograms) in two categories: normal and abnormal. The normal ones are those characterizing a healthy patient. The abnormal ones include benign cases, showing for example a tumor. Different methods have been proposed to classify and/or detect anomalies in medical images, such as: Markov models, neural networks, wavelets, fractal theory, statistical methods, methods based on fuzzy set theory (Antonie, Zaiane, & Coman, 2001).

Developments in area of image clustering are characterized by several techniques: hierarchical clustering algorithms, partition-based algorithms, mixture-resolving and mode-seeking algorithms, nearest neighbor clustering, fuzzy clustering and evolutionary clustering approaches (Antonie, Zaiane, & Coman, 2001).

In recent years, many advanced classification approaches have been widely applied for image classification and clustering. In general, image classification approaches can be grouped as: approaches as per-pixel, subpixel, perfield, contextual-based, knowledge-based, and a combination of multiple classifiers (Lu & Weng, 2007).

- **Per-Pixel Classifiers**: Develop a signature by combining the spectra of all training-set pixels for a given feature. Most of the classifiers per-pixel classification use: maximum likelihood, minimum distance, artificial neural network, decision tree, support vector machine, layered classification, Nearest-neighbor classification…
- **Subpixel Classifiers**: Are based on per-pixel information, in which each pixel is classified into one category and the land-cover classes are mutually exclusive. Used algorithms are: Fuzzy-set classifiers, subpixel classifier, spectral mixture analysis…. 
• **Per-Field Classifier:** Is designed to deal with the problem of environmental heterogeneity, algorithms such as: Object-oriented classification, Map-guided classification, Graph-based, structural pattern recognition, Contextual classifier based on region-growth algorithm, Fuzzy contextual classification, and spectral shape classifier.

• **Contextual Classification:** Exploits spatial information among neighboring pixels to improve classification results. Algorithms are: Iterated conditional modes, point-to-point contextual correction, frequency-based contextual classifier.

• **Knowledge-Based Classifications:** Based on the spatial distribution pattern of land-cover classes and selected ancillary data algorithms: Multi temporal classification based on decision fusion, Rule-based syntactical approach, and Visual fuzzy classification based on use of exploratory and interactive visualization techniques.

Association rules for mining medical images, is also an important research topic in the field of medical image mining. The algorithm performs typically two steps: discovering frequent itemsets and generating association rules. Many powerful algorithms have been proposed, the most popular is Apriori and FP-Tree. Rule mining technique is exploited in biomedical imaging to determine for example, relations between structures and functions of human brain (Sudhir, 2011).

For pattern recognition and trend prediction, neural network are widely used. Neural network models explore simultaneously many hypotheses using parallel networks composed of many computational elements connected by links with variable weights. Biological neural networks can be used for example for tumor detection in digital mammography (Antonie, Zaiane, & Coman, 2001).

**OBJECTIVE OF THE BOOK**

Developments in biomedical image acquirement and storage technologies have led to very great and detailed image databases. Image mining can reveal useful information to specialists and can extract implicit knowledge and relationships not explicitly expressed in these images.

This book addresses the major advanced techniques of data biomedical mining. It deals, principally, with methods and approaches that involve medical image and signal analysis, image retrieval, segmentation of medical images, medical image classification, and biomedical information extraction. In doing so, it demonstrates how the genetic algorithm can be used for noise diminution and filtering MRI Images. It outlines more challenging applications, using imaging techniques (EEG, MEG, fMRI, fNIRS, PET), that were developed such as the brain computer interfacing, or the prediction and detection of epileptic, or the rehabilitation for patients with neuromuscular impairment.

Also, it highlights many biomedical imaging techniques that were developed by their protagonists, in live-cell imaging, to detect diseases at the cellular level. It points to other applications that were interested to image segmentation, classification or image indexing using fuzzy approaches, neural network and a variety of computational intelligence and image processing approaches.

It demonstrates that a combination of a large number of measurements, for example, heart rate, eye movements..., can be exploited to display and interpret such data that will certainly prove a challenge to the imaging communities in future decades.
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TARGET AUDIENCE

This book can be considered as a technical resource for those concerned with imaging and diagnosis, including researchers' scientists, engineers, technology developers, clinicians, academics. The book is also of interest to advanced-level students (Master or PhD) who are attracted to working in a biomedical discipline with an interest in exact science as well as to researchers in areas such as knowledge engineering, artificial intelligence, intelligent information processing, knowledge management, and expert system project.

ORGANIZATION OF THE BOOK

The goal of this Book is to bring together researchers in healthcare informatics, medical imaging, and biology. It addresses innovative researches along the four sections dealing with biological imaging: their analysis and their relationships. The book is organized into sixteen chapters. A brief description of each of the chapters follows:

- **Chapter 1**: In this chapter some of the fundamental concepts of image processing, image mining, and Biomedical image mining are presented. The purpose is to put the biomedical mage mining domain in its context. Different sorts of medical imaging that provide different types of images such as: X-ray, Computed Tomography, Nuclear medicine imaging…are presented. Image mining techniques: object recognition, Content based image retrieval, image classification and clustering, and image indexing are also included. Afterwards, the biomedical image processing that aims to improve the content of a medical image, to extract more efficient and useful information was introduced.

- **Chapter 2** suggests a Genetic Algorithm (GA) for removal of Rician Noise. This type of disturbance primarily occurs in low signal to noise (SNR) regions. Original low signal is clouded due to presence of Rician noise and measurement gets hindered in low SNR areas. To defeat the trouble real and imaginary data in the image field are rectified, before construction of the magnitude image. The noise diminution filtering (or denoising) is attained by Genetic Algorithm. New genetic manipulator is used that blends crossover and adaptive mutation improve the convergence rate and solution quality of GA.

- **Chapter 3**: This chapter attempts to review different non-invasive brain imaging techniques, like EEG, MEG, fMRI, fNIRS, PET, SPECT and TMS used in the study/research of brain-computer interfacing. The authors argue that each measurement technique has its own advantages and disadvantages, and is used based on the application of brain research. A comparison on some of the salient features of the different brain imaging modalities is outlined.

- **Chapter 4**: The authors present a new tool – iCellFusion – that performs data fusion of images from Phase-Contrast Microscopy and Fluorescence Microscopy in order to correlate the information on cell morphology, lineage and functionality. Prior to image fusion, iCellFusion performs automatic or computer-aided cell segmentation and establishes cell lineages. We exemplify its usage on time-lapse, multimodal microscopy images of bacteria producing fluorescent spots. We
expect iCellFusion to assist research in Cell and Molecular Biology and the healthcare sector, where live-cell imaging is an increasingly important technique to detect and study diseases at the cellular level.

- **Chapter 5** discusses a non-invasive automated heart rate measurement system; that measures the heart rate using facial video. Different color models have been used for measuring the heart rate (used RGB, HSI, YCbCr, YIQ, and CIE LAB). The system uses different steps: record a video, detect face, and analysis using graph normalization. This power spectrum will have a peak if the heart rate is detected.

- **Chapter 6**: The authors are considered X-ray CT reconstruction and EEG source localization as indispensable components of many medical diagnostic and treatment techniques. From a mathematical point of view CT reconstruction and EEG source localization represent high dimensional mathematical inverse problems. They also provide an overview of the different types of algorithms typically used for sparse signal recovery.

- **Chapter 7** presents an analysis of how the process of visual perception is controlled by the eye movements. The authors contend that that visual scan path eye movements reflects the content of the imagined diagrammatic pictures which a person visualizes i.e. the movements of the eyeball are just not random ones. Thus, Visual perception is a kind of cognitive process that controls the eye movement.

- **Chapter 8** argues that social network analysis is a field of research open and adaptable to the medical and health scene. In this Chapter, the authors propose a frame work for mining medical trends using social network. The proposed model is based on a hybrid classification and clustering techniques to analyze medical datasets presented to it. This will be beneficial to all the people such as doctor, healthcare insurers, patients and organizations who are engaged in healthcare industry.

- **Chapter 9** presents novel fuzzy approach connectedness image segmentation with geometric moments (FCISGM) for digital imaging and communications in medicine (DICOM) image mining. As most of the medical imaging data is exchanged in DICOM format, this chapter focuses on the various methodologies available for DICOM image feature extraction and mining. The comparison of existing medical image mining approaches with the proposed FCISGM approach is provided in this chapter. After carrying out exhaustive results it has been found that proposed FCISGM method gives more precise results and requires minimum number of computations compare to other medical image mining approaches resulting in improved relevant outcomes.

- **Chapter 10** proposes a model based on neural network and use it for breast cancer diagnosis and classify benign and malignant images. In this model, different features are extracted from the whole image without manual selection of region of interest. This chapter proposes to investigate the WBCD (Wisconsin Breast Cancer Dataset) which comprises of 683 patients and implements the chosen features to train the back propagation neural network.

- **Chapter 11**: In this chapter, the authors propose a new indexing approach on medical “image scanner” databases combining the analysis process of the texture characteristics with the information contents. The proposed model is based on the digital image components using the vector of characteristics. This vector represents the morphological processing result on image texture. It is linked to semantic attributes of the image using the annotations of medical professionals. The context of the study is based on “Mammographic Image Analysis” (MIAS) in databases.
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- **Chapter 12** supports the idea that Content Based Image Retrieval (CBIR) is the efficient retrieval of relevant images from large databases based on features extracted from the image. The authors state that the emergence and proliferation of social network sites such as Facebook, Twitter and Linkedin and other multimedia networks such as Flickr has further accelerated the need of efficient CBIR systems. In this chapter we note, also, that to mine multimedia data there is a need mine combination of two or more data types such as text and video, or text, video and audio. The solution is to develop new and advanced mining tools to operate on the multimedia data.

- **Chapter 13** reviews issues surrounding the variety of computational intelligence and image processing approaches developed and used for the nuclei segmentation. The authors present the threshold based segmentation problem and treated it as an optimization problem with an objective of preserving both the size and volume of the cell nuclei and also to segment the nuclei region from the original microscopic Pap smear image with the help of Particle Swarm Optimization (PSO) and Ant Colony Optimization techniques (ACO).

- **Chapter 14** identifies Molecular dynamics simulation as an important tool to capture the dynamicity of biological molecule and the atomistic insights. The chapter shed light on the theories, the requirements of molecular dynamics in biological studies and application of molecular dynamics simulations. Molecular dynamics simulations are widely used to study protein-protein interaction, protein-ligand docking, and effects of mutation on interactions, protein folding and flexibility of the biological molecules. This chapter also discusses different methods and algorithms for predicting protein tertiary structure, their strengths and weaknesses.

- **Chapter 15** discusses the fundamental steps (such as artifact removal, features extraction, features selection, classification, regularization of noisy output, and decision function, etc.) of the prediction and detection of epileptic seizure through the analysis of EEG signals. The authors present also challenging issues in near future for emerging technologies, and future trend of research for high accuracy in detection and prediction.

- **Chapter 16**: The main aim of this chapter is to put up the technique of Electromyography (EMG) based Functional Electrical Stimulation (FES) as a promising rehabilitation method for patients with neuromuscular impairment. FES is mainly used to provide short duration electrical pulses to those muscles which suffer from nervous disorder in order to treat them. EMG has been in use for many clinical applications. The authors propose future research directions and aspects of EMG based FES system to be explored and improved.

CONCLUSION

Biomedical Image mining associates a multi-and interdisciplinary fields that incorporate distinct types of activities that aim to improve the image quality and to understand how to use images to their full capacity. Many technical advances continue to be made in all modalities in materials science, physics, computer science, nuclear...to produce modern methods for processing 3D images and acquiring useful and valuable information about tissue composition, morphology and function. Other developments in imaging technology such as molecular biology and nanotechnology can enlarge the biomedical Image mining applications to study, for example, gene expression or the functional of a human organ.
The chapters that compose this book were written by researchers in their diverse fields and reveal significantly how the technology developments (Advances in digital radiography, novel instrumentations, more powerful computers) and advanced methods for image analysis and processing algorithms used to improve images and extract knowledge, can provide a significant range of biomedical applications.

It would not be possible to provide a full coverage of all modalities in a single book, but we hope that the selected chapters for editing this book will help the specialists and researchers who are interested in the field of biomedical image mining to develop and apply the existing methods or to be inspired to develop novel ones.

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