GUEST EDITORIAL PREFACE

Special Issue on Medical Image Mining for Computer-Aided Diagnosis (CAD)

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Despite tremendous advancements in modern imaging technology, both early detection and accurate diagnosis of cancer and other life threatening diseases are still unresolved challenges. Today, a variety of imaging modalities exist to identify and characterize morphology and function of suspicious tissues. Analysis of medical images becomes faulty at times, primarily due to the difficulty associated in distinguishing between benign and malignant abnormalities by visual inspection. A clinically feasible solution which could be both sensitive and specific for early detection is still missing. As a consequence, early symptoms of diseases frequently go undetected, until a stage where therapy is costly or unsuccessful.

To resolve this, Computer-Aided Diagnosis (CAD) techniques are developed which use knowledge extracted from large multimodal case databases. These CAD tools serve to provide clinically reliable solutions by assisting the medical experts in decreasing observational oversights; thereby establishing more specific and accurate diagnostic decisions. Sophisticated computer algorithms/programs are developed for pre/post-processing medical images in order to highlight suspicious cases and provide additional key information before these images are analyzed by clinicians or medical experts. This highlights the role of medical image mining techniques towards development of clinically efficient CAD systems for various modalities, like X-Ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasound (US) Imaging. CAD systems catalyze the performance of radiologists/medical experts by providing sophisticated computer-based analysis leading to precision in diagnosis. These techniques also reduce the manpower and high system costs involved in double reading of medical images for accurate analysis.

Recent years have seen rapid advancements in development of medical image mining techniques for design of CAD systems. The aim of this special issue is to provide the latest advancements in the area of medical image mining for CAD system design. Numerous papers have been submitted to this special issue, and presently six papers are selected for inclusion (in this issue), each focusing upon a different CAD based system, dealing with modalities like CT scan, MRI, US and Chronic Wound images.

Medical image fusion is a sophisticated CAD technique that facilitates the retrieval of complementary information from medical images. It is the process of combining and merging complementary information into a single image from two or more source images to maximize the information content of images and minimize the distortion and artifacts in the resulting image. Fusion of CT and MR images aid in combining complementary information; which is useful from diagnosis point of view. CT helps in accessing the extent of disease; yet it is limited in soft-tissue contrast, needed for differentiating tumors from scar tissues. On the other hand, MRI scores over CT in terms of soft tissue discrimination. This is necessary because the soft tissue contrast allows better visualization of tumors. This highlights the need of multimodal medical image fusion for extracting clinical information to explore the possibility of data reduction along with better visual representation. In this special issue, the works discussed in the first and the fifth articles contains the comprehensive reviews on multimodal medical image fusion methodologies deployed for CAD.

In the first article, Chavan and Talbar presented a review of feature based fusion algorithms using Discrete Fourier Transform, Discrete Cosine Transform, Discrete Wavelet Transform, Dual Tree Complex Wavelet Transform, Daubecheis Complex Wavelet Transform and M-Band Wavelet Transform. The outcomes of their analysis projects, that the M-Band Wavelet Transform and Daubechies Complex Wavelet Transform techniques are better when compared to other transforms. In the fifth article, Bhateja et al., presented a comparative analysis and evaluation of multimodal medical image fusion methodologies employing wavelet as a multi-resolution approach and ridgelet as a multi-scale approach. Principal Component Analysis (PCA) based fusion algorithm has been employed in both ridgelet and wavelet domains for purpose of minimisation of redundancies. Wavelet transform contains temporal information, i.e. it captures both the location and frequency information. On the other hand, ridgelet transform provides reliable detection and representation of edges. Experimental results show that the image fused in wavelet domain is more refined in representing spectral and spatial information. On the other hand, image fusion in ridgelet domain yielded a fused image that represented shapes and soft tissue details of tumor more effectively. The outcome of this analysis highlights the trade-off between the retrieval of information content and the morphological details in finally fused image in wavelet and ridgelet domains.

The abnormalities of the kidney may arise due to the formation of stones, cysts, cancerous cells, congenital anomalies, blockage of urine etc., which can be identified by ultrasound imaging. For surgical operations it is very important to identify the exact and accurate location of stone in the kidney along with other structural abnormalities like kidney swelling, change in position and appearance of stone. The second article in this issue by Viswanath and Gunasundari discusses a methodology for computer-aided detection of kidney stone using Modified Distance Regularized Level Set Segmentation. The methodology involved preprocessing using Gabor filters for smoothening to remove speckle noise. Distance Regularized Level Set Segmentation (DR-LSS) does not require any expensive re-initialization and possesses very high speed of operation. The pre-processed ultrasound image is then segmented using (DR-LSS). Extracted region of the kidney after segmentation is applied to wavelet subbands (via lifting scheme) to extract energy levels. These energy levels are trained by Multilayer Perceptron (MLP) and Back Propagation Neural Networks to identify the type of stone with an accuracy of 98.6%.

In third article, Desai and Kulkarni recalled the notion of increased risk of cancer as a side-effect for patients undergoing repeated CT scanning. HYPR has emerged as the most promising method for low dose imaging. The drawback of this technique lies in terms of heavy computation resource and time requirements. However, the said issues can be addressed effectively by latest hardware supporting GPU. The authors in this article presented a modified highly constrained back projection (M-HYPR) technique to address low dose imaging. The weight matrix module, being root cause for huge computation time has been modified in this work. Considerable speed up factor is recorded in comparison to original HYPR (O-HYPR) on a single thread CPU implementation. To summarize, M-HYPR yields an improved speed up factor up to 5.71 as compared to O-HYPR on single processor architecture. In addition, the quality of the reconstructed image is consistent in all architectures, especially when explored under GPU environment.

The work of C. Chakraborty, in the fourth article presents a framework to give clinicians the possibility to monitor emergency home bound patients using Telemedicine in a fast and precise manner. Tele-medical agent (TMA) can collect the chronic wound data using smart phone and send it to the Tele-medical hub (TMH) for better treatment consultation. Here, the identification of chronic wound status has been made based on color variation over a period. In TMH, the wound image has been segmented using Fuzzy C-Means which gives highest segmented accuracy i.e. 92.60%, in comparison to those of Bayesian classifier. The smart phone supported prototype system has been demonstrated with snapshots using very compatible and easy to integrate Hypertext pre-processor (PHP) and MySqL.

Better in-depth resolution, reduced artifacts, and improved contrast–to–noise ratio are the current outcomes of the advancements in various medical imaging modalities. However in many practical situations, complete projection data is not acquired leading to blur, resolution degrades, increment in noise leading to artifacts in computed tomography scans. Such ailments, in the acquisition stage are responsible for degrading the image quality of and eventually hinder the diagnostic accuracy. The last article in sequence by Desai and Kulkarni presents a comprehensive survey of techniques for minimization of streaking artifact due to metallic implant in CT images. Algorithmic complexity and computational time are significant factors influencing clinical applicability of Metal Artifact Reduction (MAR) algorithms. This review article also focuses upon the problematic issues and outlook for the future research. Reduction of such artifacts can help to improve clinical diagnosis, to assess response to therapy, surgery and radiation therapy planning, prognosis assessment, and above all enable accurate quantification.

The interpretation and analysis of medical images represents an important and exciting part of medical image mining and pattern recognition. In a nut-shell, this special issue has highlighted new advancements in medical image mining techniques with respect to different modalities like CT, MRI, US and Wound images. This issue purposes to present articles dealing with performance enhancements of various sub-modules of CAD systems. Various CAD sub-modules discussed under above articles include: medical image acquisition, pre-processing operations like noise suppression & contrast enhancement, post-processing via fusion, segmentation for features extraction and finally classification for automated diagnosis. Successful treatment of life threatening diseases depends on early detection and diagnosis; thus, objective and quantitative analysis facilitated by the application of computers to biomedical image analysis leads to a more accurate diagnostic decision by the clinicians.

As guest editors, we hope that spectrum of research works covered under this special issue will be of value for multitude of readers/researchers working in the domain of CAD systems (for disease diagnosis). At the same time, we are also grateful to the authors for making their valued research contributions to this issue and their patience during crucial revision stages. The technical standards and quality of published content is based on the strength and expertise of the reviewer board members who have been grossly involved in providing high quality reviews for the submitted papers. Our special thanks go to the Editor-in-Chief of the International Journal of Rough Sets and Data Analysis (IJRSDA), Dr. Ahmad Taher Azar, Benha Unversity, Egypt, for all his help, support, efficiency and competence rendered to this special issue.

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