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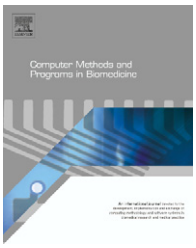

Improved Biliary Detection and Diagnosis through Intelligent Machine Analysis

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ABSTRACT

This paper reports on work undertaken to improve automated detection of bile ducts in magnetic resonance cholangiopancreatography (MRCP) images, with the objective of conducting preliminary classification of the images for diagnosis. The proposed I-BDeDIMA (Improved Biliary Detection and Diagnosis through Intelligent Machine Analysis) scheme is a multi-stage framework consisting of successive phases of image normalization, denoising, structure identification, object labeling, feature selection and disease classification. A combination of multiresolution wavelet, dynamic intensity thresholding, segment-based region growing, region elimination, statistical analysis and neural networks, is used in this framework to achieve good structure detection and preliminary diagnosis. Tests conducted on over 200 clinical images with known diagnosis have shown promising results of over 90% accuracy. The scheme outperforms related work in the literature, making it a viable framework for computer-aided diagnosis of biliary diseases.

1. Introduction

Computer-aided diagnosis (CAD) systems are becoming increasingly important with the introduction of many advanced imaging systems and technological tools for medical practitioners. The inventions allow the medical practitioner to gain better visualization and understanding of the anatomy, abnormalities, diseases and their corresponding effect, and are tremendously helpful in making accurate diagnoses and in treatment planning. However, often with huge volume and sophistication of both the acquired and generated data comes the tediousness and difficulty in selecting or examining a particular aspect or subset of the data. CAD systems help alleviate this problem by making it easier for many aspects of the data to be presented in the way best suited to the medical practitioner. Advanced systems are even able to undertake sophisticated high-level processing to detect and highlight potential problem cases to the medical expert.

This paper proposes a framework for developing part of a CAD system for the examination and preliminary diagnosis of diseases affecting the bile ducts. The aim of a CAD system is never to replace the medical specialists in their ability and responsibility in making the diagnosis, but to be able to aid in providing information effectively and possibly flagging potential problem cases for further diagnosis. To the knowledge of the author, there is no well-known CAD system for biliary diseases, although some efforts towards developing related algorithms for use in parts of such CAD systems have begun in recent years [1–5].

Diseases affecting the bile ducts, either directly or indirectly (caused by pressure or blockage as a consequence of surrounding organs and structures pressing onto the bile

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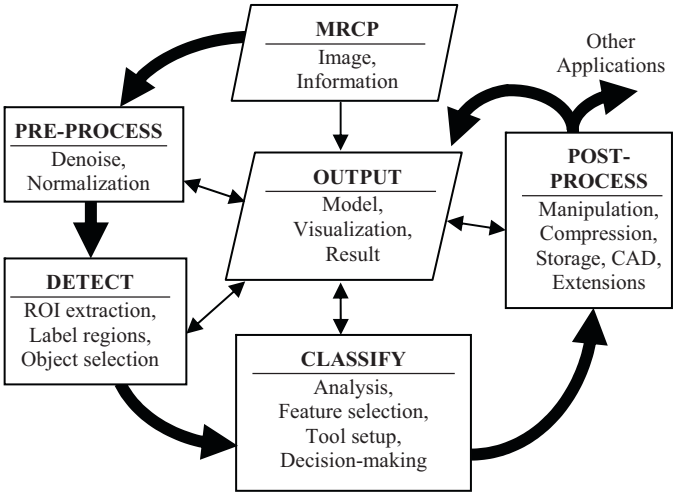

Fig. 1 – Proposed I-BDEDIMA framework and common activities.

ducts), are often diagnosed nowadays via magnetic resonance cholangiopancreatography (MRCP) [6]. This special sequence is acquired using the magnetic resonance imaging (MRI) equipment and a typical examination using this non-invasive and non-ionizing imaging technique may produce over a hundred images in several series. As the biliary structures are located in the abdominal area, it is difficult to acquire clean MRCP images without the influence of non-biliary tissue and parts of other organs. There is also the presence of noise, acquisition artifacts and partial volume. Although the human specialist quickly learns to overcome these shortcomings based on their anatomical knowledge, it is much more difficult for a computer system. The intensity ranges of various parts of the biliary structures in the grayscale MRCP image tends to overlap with the background and other structures, compounding the problem further for automated systems.

In addition, although the general anatomical aspects of healthy humans are somewhat similar (but not identical), the variations in patients suffering from diseases, abnormalities and other afflictions, can be significant. Diagnostic images are commonly used for the latter and CAD systems need to be able to handle such cases. This is especially true in MRCP images of the bile ducts where it is rare that the images acquired from two patients are similar. In addition, the acquisition orientation in 3D can significantly influence the observable parts of the anatomy, making analyzing individual 2D images all the more difficult.

The framework presented in this paper concentrates on automated diseased biliary structure detection and preliminary diagnosis on 2D MRCP images, as this is still the most common form of images acquired using conventional MRI equipment and is the de-facto diagnosis images used by radiologists. Latest innovations in technology include functional and 3D MRCP, but these are still very rare in most hospitals worldwide. As the target is for preliminary disease detection, the algorithms and settings used for an example application within the proposed framework in this paper are intentionally aggressive, but may be fine-tuned as desired for more delicate detection.

2. Proposed I-BDeDIMA framework

The proposed framework is named I-BDeDIMA, an acronym for Improved Biliary Detection and Diagnosis through Intelligent Machine Analysis. Essentially, I-BDeDIMA includes improving the visualization, structure detection and disease diagnosis related to the bile ducts, especially through examination of MRCP images. The general framework may be represented by the stages shown by the flowchart in Fig. 1. The main aspects of the framework are in pre-processing (usually includes noise reduction and image normalization), biliary structure detection (includes object identification, labeling and selection) and classification (often using statistical or advanced tools for feature selection and decision making). Post-processing is included in the framework as the results of the preceding stages are often used by, or cooperatively incorporated into, larger integrated systems. In practice, all stages would have intermediate results and models that may be displayed, operated on, or used by other stages. Fig. 1 only shows the generic framework, which is extensible to much larger roles and types of activities.

3. Developed application

To examine the effectiveness of the proposed framework, a sequence of viable algorithms is selected and customized to the framework with the intention of evaluating its performance on clinical MRCP images. The multi-stage algorithm proposed in this paper under the I-BDeDIMA framework uses dynamic thresholding for background reduction and image normalization; multiresolution wavelet coefficient reduction for denoising; segment-based region growing and region selection to identify the biliary structure and eliminate unrelated objects; and statistical analysis and an artificial neural network (ANN) for disease classification. Fig. 2 presents the flowchart of the sequence of algorithms used. The details of each stage of the algorithm are described below. All the values recommended were determined experimentally for the clini-