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Knowledge Acquisitions and Medical Image Analysis: Mutual Enrichment for Decision Support

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Abstract: The integration of knowledge acquisition from medical images and medical CBIR is discussed. Sources and development tendencies of this idea are presented. The implementation of these tendencies in SonaRes system is presented.
Keywords: medical images analysis, CBIR, knowledge acquisition, decision support

1 Introduction

Knowledge acquisition from medical images and usage of artificial intelligence (AI) technique in medical content-based image retrieval (CBIR) are developed mostly as two parallel directions. But during last several years the idea of combining these directions in frame of one system has been implemented by researchers of different counties.

In this paper the implementation of idea to joint knowledge acquisition from medical images and AI techniques application to medical images databases CBIR in frame of one system is considered. The idea sources and development tendencies during last 5 years are discussed. The idea implementation examples are presented: CASAD and SonaRes systems in which development author participated.

2 Knowledge-based image retrieval

Application CBIR to medicine has been successfully provided during last decade. In detailed review of current status and future of CBIR in Radiology [1] more general tendencies are summarized. These investigations relieved that for medical images retrieval is not only content-based but knowledge-based. This fact determines the arrival of image mining [2] - application of variety of AI techniques to medical CBIR. Mainly it means the usage of preliminary knowledges for reduction of retrieval process. According to this one of the major challenge in medical imaging [3] is the "knowledge acquisition bottleneck" – problem of formalization of medical experts' knowledge. To avoid this problem researchers propose a number of extensions and improvements of methods

of knowledge acquisition and wide palette of corresponding software tools.

Although the formalization of knowledges, acquired from images, as ontology has been provided during many years, the application of knowledge-based retrieval in medicine inspired the further development of this method. Image analysis ontology, which describes visual features and existing methods of image analysis, is joined with applied domain ontology to establish the relation between concepts of both ontologies [4].

The project that should be mentioned in medical CBIR is general frameworks for Image Retrieval in Medical Application (IRMA) [5]. The IRMA system is generally the server that holds images, features and methods for feature transforms. Productive and well tested algorithms of IRMA are successfully used till very latest researches [6].

Setting of regions of interest (ROIs) [7] is one more aspect that is actively used in CBIR and should to be noted. ROIs concept helps to facilitate the process of medical expert knowledge acquisition. ROIs marked by expert can then be associated with some domain knowledge instances, for example, the image subjects in the ontology.

3 Integration in frame of one system

The integration of knowledge acquisition from medical images and medical CBIR supposes more than joining them in frame of one system. In systems which implement this idea the full “life cycle” is organized. Unprocessed images and domain knowledges are the system input. Using CBIR classification new domain knowledges are obtained and saved (usually in knowledge base). On the next step the obtained knowledges are used for refining CBIR.

Let us show how this integration is implemented in some modern medical decision support systems. The first example is the system for research in breast cancer grading using a knowledge-guided semantic indexing of histopathology images, described in [8]. Segmentation of images and features extraction serve as the input for the semantic classification step based on criteria rules modeling. In turn the conceptual rule-based annotations are updated by results of previous step. The second example EchoCardio Lab [9] of the European HEARTFAID Project is an infrastructure providing integrated management of different type data of echocardiography workflows. Decision support services and image

analysis facilities interaction is implemented in frame of this infrastructure.

The last example describes the idea implementation details in the systems CASAD and SonaRes. The SonaRes decision support system [10] provides a second opinion for abdominal sonography specialists with necessary explanations and images that are similar to the currently examined case. In frame of SonaRes we propose our way to avoid acquisition "bottleneck". During the SonaRes system building the methodology of knowledge acquisition from medical domain experts and software tools to support this process are developed. Working with images we used the ROIs concepts. ROIs are important for SonaRes because of specific of ultrasound images. The ultrasound images specific feature that most seriously affects retrieval process is dependence on transducer location. So, for images of one pathology, taken from right and left transducer location, comparison as whole can be vain. To provide the ROIs marking and rules attaching to the images, the special toolkit was developed. In the current version of SonaRes system the role of annotated images in decision making process is to be a correct helpful illustration, if the investigator is not sure how to interpret an ultrasound image. These images are associated by experts to the corresponding rules, as well as images ROIs are defined for corresponding facts (particular characteristics of the organ). The CBIR used in SonaRes are developed and tested in the frame of IRMA project. To provide the integration of knowledge accumulated in SonaRes (rules, annotated images) and algorithms of medical images storage and processing of IRMA the CASAD (Computer-Aided Sonography of Abdominal Diseases) system of type of data warehouse of standard reference images was developed. The "life cycle" in SonaRes is provided by pull-put scheme. Formalized knowledges are used to classify the images and reduce the retrieval. Found visual features similarity presumes the presence of predefined pathology on particular image and after confirmation the image can be added to "model" images collection as visual representation of knowledge.

4 Conclusions

The integration of knowledge acquisition from medical images and medical CBIR in frame of one system became modern tendency because of possibility of techniques mutual enrichment. Both domains have some

advanced development tendencies. The implementation of these tendencies in SonaRes system is presented.

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