Developing a Diagnosis Aiding Ontology Based on Hysteroscopy Image Processing

Marios Poulos[1] and Nikolaos Korfiatis[2]

[1] Laboratory of Information Technology, Department of Archives and Library Science, Ionian University, Ioanni Theotoki 72, 49100, Corfu, Greece
[2] Department of Economics, University of Copenhagen, Øster Farimagsgade 5. 26, 1353, Copenhagen, Denmark
mpoulos@ionio.gr,nikolaos.korfiatis@econ.ku.dk

Abstract. In this paper we describe an ontology design process which will introduce the steps and mechanisms required in order to create and develop an ontology which will be able to represent and describe the contents and attributes of hysteroscopy images, as well as their relationships, thus providing a useful ground for the development of tools related with medical diagnosis from physicians.

Keywords: ontologies, metadata, hysteroscopy, medical imaging, medical diagnosis.

1 Introduction

Hysteroscopy [1] is a medical endoscopic method used by physicians for the inspection of uterus using an endoscopic device. This particular method is increasingly used by physicians due to the ability of the user to record camera images on the different phases of the endoscopic inspection during a therapy. The goal of this paper is to describe the stages of an ontology development process targeted to the description, annotation and retrieval of medical images generated during the endoscopic examination with a hysteroscope.

In this particular case, the semantic approach using an ontology approach can be considered as particularly useful since the problem domain requires the specification of a representational vocabulary for a shared domain of discourse [2]. Via ontology description, one can accurately represent the specific domain that is interested in, dividing the main concepts in classes and describing their relationships and restrictions.

Ontologies are considered crucial in medicine. Pinciroli [3] describes them as "the backbone of solid and effective applications in health care". Ontologies contribute to the medical science domain in many ways; first of all they provide the establishment [4] of a certain vocabulary so that all implicated persons can communicate in a unified way, providing also ways for interchange between several different shareholders[1]. Moreover, by using ontologies data exchange [4] can be accomplished between heterogeneous systems. Ontologies are also used to support decision making systems in

[1] The National Center for Biomedical Ontology- http://www.biontology.org

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medicine [5]. When dealing with medical images, problems in data retrieval may be a deterrent to the physicians' work that need to find images similar to the addressing problem as quick as possible. Even in cases where similar images can be retrieved quite fast, still most of the images are not annotated. However, the acquisition of similar images [6] accompanied with the proper annotation is crucial for the physician in order to study the disease category and solve the clinical problem.

This paper aims to provide a framework which will introduce the steps and mechanisms required in order to create and develop an ontology capable of representing and describing hysteroscopy images and their relationships, in order to provide the physician with a useful aiding tool in medical diagnosis of endometrial cancer. The creation of a database that will contain the hysteroscopy images is necessary so that the creation of the ontology can be accomplished.

The rest of the paper is organized as follows: Section 2 analyzes the proposed methodology: the hysteroscopy image processing, the creation of the database where the image data will be stored, and the ontology development. Section 3 discusses implementation scenarios, and section 4 concludes the paper with arguments for possible extensions and future research.

2 Methodology

The section describes a set of three steps that need to be carried out so that a diagnosis the aiding tool can be created using a specially engineered ontology for this domain.

2.1 Hysteroscopy Image Processing

This step lies in acquiring and organizing medical images received from the hysteroscopy instrument, particularly focusing on the following tasks:

- Subsequent digital image processing in order to detect in their content morphological characteristics of medical interest (e.g. deformities, cancers etc.). This shall be achieved through comparison of the image's interior findings against predefined patterns, using non conventional algorithms.
- Enriching the images with respective semantic concepts and private metadata, in order to facilitate the classification and identification of an image among a large medical image database which shall be explicitly built for this purpose.
- Continuous recalculation and reorganization of image metadata depending on new concepts which may have some research interest value.

This approach actually introduces a novel way of image management and resides in organizing the image database in a way that enables content-based image. This can be achieved by using alternate image processing algorithms, based on analytical geometry rules [7]. Therefore, this study can be used as a retrieval tool, by means of semantic metadata already implanted in them.

2.2 Clinical Evaluation and Questionnaire Process

In this step the file of each patient must be completed. Each image will be accompanied by certain information on the patients' health condition (such as laboratory testing etc.) . In order to complete this step, not only the information from laboratory testing is included along with the image but also a specially formed questionnaire that provides details that can affect the physicians' diagnosis and the medical history of the patient.

2.3 Ontology Development

This step lies in the development of the medical ontology. Our main goal is to provide all similar images to the physician, in order to help throughout the medical diagnosis procedure. What is most important to our goal is to define the main concepts of the hysteroscopy images and the patients' history so that the physician can make requests and effectively compare the information he is studying. In this step the following elements must be described:

- Medical images from hysteroscopy procedure, in which patients will be subject to.
- Information obtained from the clinical evaluation and the questionnaire.
- Their relationships and restrictions.

By choosing this ontological approach, hysteroscopy acquired images can be properly retrieved, containing the patients' history, thus enabling semantic description of such critical knowledge, and giving the opportunity to the physician to be able to compare the clinical problem that has been raised.

3 Implementation Plan

In this section an initial RDF representation of the proposed ontology is presented, as well as an implementation strategy that will lead to a running ontology capable of collaborating with the database, provide feedback to the physicians, and become the basis of a decision support system.

The root class is named `Hysteroscopic_Procedure` and consists of three main classes: `Image_obtain`, `diagnosis` and `decision_Stages`.

The `Image_obtain` class has to do with the manipulation of the image and the image processing tasks embodied in the categorization procedure.

The Diagnosis class consists of the four main classes – categories in which the patient can belong in the diagnosis procedure. The main patient categories can be seen in Fig.2.

The third class, `Decision_Stages` (depicted in Fig. 3), is connected with the class Diagnosis. In the Decision_Stages class all the necessary information for the diagnosis can be found, such as the questionnaire filled in by the patient containing crucial information so that the physician can be assisted on taking a decision related with the clinical problem.

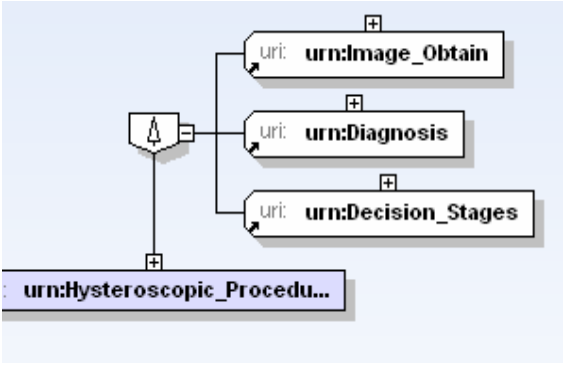

Fig. 1. The Hysteroscopic_Image class

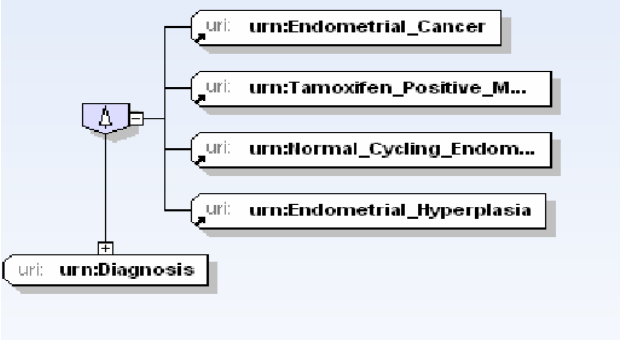

Fig. 2. The Diagnosis class

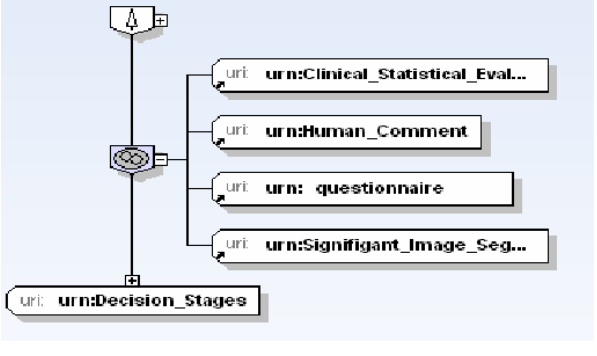

Fig. 3. The decision stages class

The RDF representation can be extended to OWL 2 [8], a semantic web standard based on the original OWL definition designed for use by applications that need to process the content of image based information, which is applicable in the case of medical images. The tool that can is going to be used for the development of the

medical ontology in OWL is Protégé [9] which enables concurrent access to all parties related with the ontology design process.

OWL 2 ontologies can easily be used with the image data which will be stored in a relational database package. The primary goal after the development of the medical ontology will be to use OWL to integrate it with the relational database containing the hysteroscopy images, and then perform queries against the aggregate collection to answer realistic questions that could not be answered without the addition of an OWL 2 ontology on the description of the medical images. Then the integrated ontology/database system will be further integrated with an inference mechanism which will eventually produce the desired decision-support system. The architectural choice in that case is to use the Jess rule engine in order to provide inference abilities to the developed application [9].

The integrated decision support system will be capable of assisting the physician in the diagnostic procedure and will constitute an aiding diagnostic tool for the scientific community.

4 Conclusion – Future Plans

In this short paper we have presented an approach to address the problem of representing and describing hysteroscopy images and their relationships, in order to provide the physician with a useful aiding tool in medical diagnosis of endometrial cancer. Towards this direction a three-step methodology was proposed including the hysteroscopy image processing, a clinical evaluation and the development of a medical ontology to represent and describe hysteroscopy images and their relationships. The ontology will be seamlessly integrated with a relational database containing hysteroscopy image data and an inference engine to constitute a decision support system that will assist the cancer diagnostic procedure.

Ongoing work at this stage aims at completing the implementation of the medical ontology in OWL, bind it with the database and integrate them with the inference engine into the proposed decision support system.

Moreover it should be stated out that the project introduced in this paper constitutes only a part of a larger project which is scheduled to run in the near future. In this part and in the larger project, the hysteroscopy images acquired by patients and the medical assistance which is necessary in order to create the diagnosis aiding tool, will be obtained is collaboration with the Medical School of the University of Ioannina.

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