A case study of Image Retrieval on Lung cancer chest X-ray pictures

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Abstract: This paper presents a case study of an image retrieval system based on a notion of similarity between images in a multimedia database and where a user request can be an image file or a keyword. The CBIR (Content Based Image Retrieval) system, the current System of Search for Information (SSI) --e.g. PEIR, MIRC, MIR, IRMA, and Pathopic-- and the Current Search Engines (CSE) --e.g. Google, Yahoo and Alta Vista-- make image search possible only when the query is a keyword. This type of search is limited because keywords are not expressive enough to describe all important characteristics of an image. For example, an exact match request cannot be formulated in such systems and in SSI system, users should know natural language (e.g. English, French or German) used. We used XIRS (an XML Image Retrieval System) to set up a similarity distance between images, then to compare the request image with those in a database. An experimentation of XIRS on lung cancer diagnosis is presented. The statistics show that our system is more efficient than leading CBIR systems such as ERIC7, PEIR, PathoPic and CSE.

Keywords: XML, Image retrieval, similarity search, diagnosis, web, Medical Information systems.

I. INTRODUCTION

Users start with *information needs*, which they translate into *query representations*. Similarly, there are *documents*, which are converted into *document representations*. The role of an Information Retrieval (IR) system is to extract from the document representations the information needed by the users and stated in the query representation. The purpose of the search process is to obtain user's needs from a database by comparing the user's requirements with available information. This comparison is carried out by a System of Search for Information (SSI) [3], which is a set of programs with the goal to return to the user the maximum relevant documents available that meet his needs.

The SSI, CBIR (Content Based Image Retrieval) system and the CSE (Current Search Engine) make image search possible only when the query is a keyword. This type of search is limited because these keywords are not expressive enough to describe all important characteristics of an image. To resolve this problem, ERIC7 [6] which is a CBIR system compatible with the MPEG-7 Multimedia standard proposed to the user to search images by features. Hence, in ERIC7 the user can choose between 15 features by navigating within XML files using a tool that generates UML diagrams. However, ERIC7 is limited because the user should be an expert in search for images to recognize these features. He should also be able to read and understand XML files and UML diagrams. We also observe that an exact match request cannot be formulated in such systems.

MPEG-7[8] is a standardization of XML metadata structures called Descriptors (D) and Description Schemes (DS), which are used to describe and annotate multimedia information [11]. The Ds and DSs are defined using the MPEG-7 Description Definition Language (DDL), which is based on the XML Schema Language. Many technologies still need to be developed around the MPEG-7 for extracting, searching and querying multimedia databases, which involves similarity matching including features, content and semantics.

In this work, using XIRS[4], we present a case study of image retrieval in which a request might be an image file or a keyword. We describe an image as an XML document using MPEG-7 standard. We have defined a similarity distance between images which is used to compare the features of the request image to images stored in a multimedia database. The statistics show that our system is more efficient than leading content based image retrieval systems such as ERIC7, PEIR, Pathopic and the CSE. Posting an image for the similarity search in a Database can have an importance in Hospitals to find the diagnosis of the radiographic stereotypes [2], and also used to implement iconic communication systems [7]. As application, an assistant software for lung cancer diagnosis is presented.

This paper is organized in the following way: Section 2 describes the XIRS system; Section 3 is devoted to the case study of image retrieval on lung cancer diagnosis and the discussion.

II. XIRS (XML IMAGE RETRIEVAL SYSTEM)

This section gives a brief description of XIRS. Readers are referred to [4] for a full presentation of the system. XIRS is a set of 3 components: the XIRS Mediator, the interrogation module, and the XIRS Server. Starting from the feature extraction and annotation process of a multimedia asset, the XML documents are generated and stored in a repository.

II.1 XIRS Mediator

An image is represented as a set of descriptors (features) which are structured as XML nodes and stored in a XML document (see Figure 1). The image is stored in a multimedia database and the XML document is then stored in the XML repository. The XML document used by the XIRS Mediator is obtained by combining two parts:

- «Visual Descriptors» extracted from the image by MPEG-7,
- «Metadata descriptors»: the XML document is completed with some information describing the semantic and contents (e.g. keywords, its author, its size…) coming from the database.

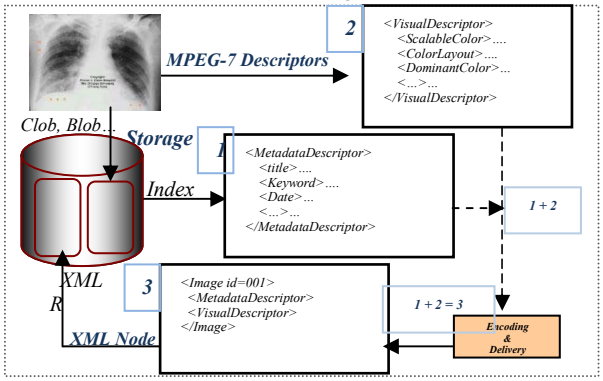

Figure 1. XIRS Mediator

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A fix DTD is used by XIRS Mediator to construct XML documents. Once XIRS Mediator has described an image in XML node, the node is categorized (to prevent too bulky XML documents) and stored in XML documents of the collection. The role of XIRS Mediator is thus to define an image in XML and vice versa.

II.2 Interrogation Module

The data model of the XIRS interrogation module is a simplification of XPath data model presented in [1], where a structured document is a tree, composed of simple nodes, sheet nodes and attributes. A node can be a document, an element, a text, a namespace, an instruction or a comment. Two cases of request arise.

II.2.1 The request is a keyword

A request is a conjunction of sub-requests. We have the following illustration:
Request → sub-request AND sub-request | sub-request OR sub-request | NOT sub-request.
Hence, the similarity distance between an image node N_I and a request node N_q is defined as:

$$\Phi(N_q, N_I) = \begin{cases} \dfrac{|N_q|}{|N_I|} & \text{if } N_q \textit{ matches } N_I \\ 0 & \text{otherwise} \end{cases}$$

Where N_q (resp. N_i) is the number of sub-nodes and $|N_q|$ (resp. $|N_I|$) is the number of sub-nodes+1 in the query node and image node respectively. N_q matches N_I iff N_I belong to the set described by N_q. Note that if Nq matches N_I then $|N_q| = \Phi(N_q, N_I)\,|N_I|$ and $\Phi(N_q, N_q) = 1$.

II.2.2 The request is an image

The comparison between an image and a request amounts calculating a score. The image relevance with respect to the request is calculated by a similarity function noted d(q, I), where q is the

request image and I is an image of the Database. It thus leads to calculate a similarity distance between two XML nodes. Lets I = $(I_1, I_2, \ldots, I_m)$ an image set and T = $(t_1, t_2, \ldots, t_n)$ a keyword set. We describe the image Ij as a vector : Ij= $(w_{1,j}, w_{2,j}, \ldots, w_{i,j}, \ldots, w_{n,j})$ where $w_{i,j} \in \{0, 1\}$ is the term-weighting. f_i denote the function that returns the associated weight of the term ti : $f_i(\vec{I}_j) = w_{i,j}$

The XML node produced by the XIRS Mediator and corresponding to the request image is regarded as a block of requests (like a system of equation with several unknown factors), in which each sub-node (features) is seen as a request. It is thus a question of reassuring when one has a node coming from a XML document of the Database that both sub-nodes are similar.

If a feature of an image is indexed by tj and if tj < tk then it is also indexed by tk. Therefore, one can extend the vector Ii so that: $w_{k,i} = 1$ if $w_{j,i} = 1$ and tj < tk, otherwise $w_{k,i} = 0$. The usual similarity measure used in XIRS is given in *Formula 1*, where q_n and S_n are XML nodes representing the query image and one image of the database. S_{sn} and q_{qn} are sub-nodes of S_n and q_n respectively. V is the vocabulary of non-structural terms; weight (S_n, t, S_{sn}) is the weight of term 't' in XML context S_{sn} in node S_n .
The XIRS grammar gives a complete description of the request language used. The axiom of the grammar is **Query**, non-terminal symbols are in **bold**, terminal symbols (tokens) are in *italic* and the production rules are described as follow(see table 1)

Query → **r1** | **r2**
r1 → **ExpressionA** **ExpressionB**
ExpressionA → *keyword* **SuiteExpressionA** | *(keyword)* **SuiteExpressionA**
SuiteExpressionA → **ExpressionA** | ε
ExpressionB → **BooleenOperator** **r1** | ε
BooleenOperator → *OR* | *AND* | *NOT* | ε
r2 → **ExpressionStructure** **SuiteExpressionStructure**
ExpressionStructure → *elementName[* **Condition** *]*
Condition → *@attributName = keyword* | **r1** | ε
SuiteExpressionStructure → **BooleenOperator** **ExpressionStructure** | ε

Caption:
ε denotes an empty string
keyword: terminal symbols representing a keyword
elementName: terminal symbols representing a name of tag
attributName: terminal symbols representing a name of attribute

Table 1. XIRS Grammar

$$d(q_n ; s_n) = \sum_{s_{sn} \in S_n} \sum_{q_{qn} \in q_n} \Phi(s_{sn}, q_{qn}) \sum_{t \in V} weight(q_n, t, q_{qn}) \frac{weight(S_n, t, s_{sn})}{\sqrt{\sum_{\substack{s_{sn} \in S_n \\ q_{qn} \in q_n \\ t \in V}} weight(S_n, t, s_{sn}) \times weight(q_n, t, q_{qn})}}$$

Formula 1. Similarity distance between two nodes.

Figure 2. Lung Cancer

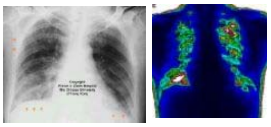

Figure 3. Lung

For over 100 years, The CLA (Canadian Lung Association) [2] has been dedicated to its mission of promoting and improving lung health. According to the CLA, there are about 39 lung diseases : *Acute bronchitis, Asbestosis, Asthma, Avian flu, Bronchiectasis, Bronchitis, Bronchopulmonary dysplasia (BPD), Chronic cough, Severe acute respiratory syndrome (SARS), Lung cancer, Tuberculosis, etc.* A **Chest x-ray** exams can help the Doctor to confirm if a patient has or not a lung disease. The final diagnosis depends on many tests. - *Medical history, Sputum analysis, Bronchoscopy, Needle Biopsy and Mediastinoscopy…*

III. CASE STUDY AND DISCUSSION

III.1 Application on lung cancer diagnosis.

III.1.1 Interface (see Figure 4).

For the experiment, we applied our system on diagnosis search, especially on lung cancer. Lung medicine presents a lot of diseases and each disease has its own chest X-ray and diagnosis.

Our target when setting up this decisional software is to help users (doctors, medical students/researchers or patients) to check if they have a lung disease by analyzing their chest x-ray pictures (see Figure 2 and 3) to produce a diagnosis containing their possible treatments and the way to avoid a lung disease.

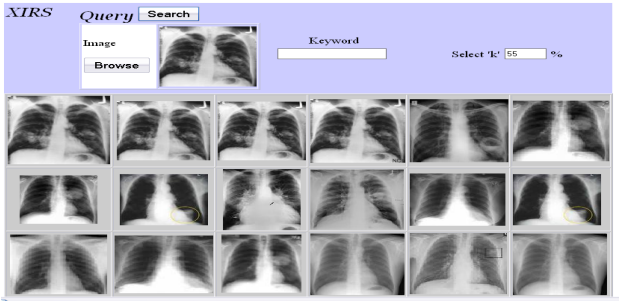

Figure 4. XIRS Interface, the request is an image file.