Using Agents for Feature Extraction: Content Based Image Retrieval for Medical Applications

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Abstract—**The plethora and variety of medical data (text, diagrams, images, videos, and other types of clinical values), together with the fact that they are stored in worldwide distributed databases, creates new challenges when attempting to retrieve relevant information. Furthermore, this information is usually attached to time. The aim of this work is to present Information System's Architecture for content-based multimedia and information retrieval in Medical Information Systems using intelligent techniques and to discuss some of the open research issues in this area.**

I. Introduction

Medical Information Systems are usually using pattern and indexing techniques, in order to handle the great amount of information. This paper presents system's architecture for content based image retrieval with the use of Agents for low level feature extraction and classification. Agents are divided to three categories. A User Agent who is responsible for user modeling, a Weight Estimation Agent and Feature Agents. Each of the Feature Agents is responsible for a different feature extraction and according to the calculated distance between query image and a set of images, submits his image preference list to the WEAgent, who will coordinate the retrieval procedure and estimate weights for each list. The retrieved list of images is finally defined by WEAgent and submitted to the user who is interacting with the system and may modify the retrieval criteria by his/her preferences. In Section 2 challenges in existing medical systems are briefly presented. In Section 3 are presented the advantages of the use of Agents in such a system whereas in Section 4 the full systems architecture is presented. In Section 5 conclusions and future work is proposed.

II. Open Issues in Medical I. S.

Early this decade, there was a rapidly growing need for information, knowledge management in Medical Information Systems, a need which still remains. This was focused on the need for collaboration between different medical systems developed by multinational and domestic corporations and foundations. Medical Systems have their sources almost everywhere in the world. In such applications one has to navigate through a large number of points placed in different sources. User extracts the information each time according the field of the survey and personal image comprehension. These surveys have to be presented in such a way that a different user can see through the results.

Each of these Medical Libraries is enriched with new images and new patients' records on a daily base. Text- and metadata-based information retrieval techniques cannot reveal all the hidden information one could get from exploring medical image libraries [3]. This is due to the fact that indexing methods in most of these libraries are effected according to a patient identifier. In order to achieve anticipated knowledge extraction, medical images should be indexed by their own visual content. Indexing techniques are based on distributions of general image features (such as color, shape and texture) or even domain-specific features (organs and bones) [8, 10, 11, 12].

There are several techniques to implement and organize digital picture archives by their visual content. Researchers focus on the minimization of the semantic gap between visual similarity and the semantics of images. Apart from that, the similarity of symptoms among diseases can lead to wrong directions in a diagnostic support systems because of the gap of visual interpretation and other textual data. The compatibility between large digital medical image libraries is achieved with the use of the Digital Imaging and Communication in Medicine (DICOM) Standard. An overview was published by USA's National Electrical Manufacturers Association (2000) and is available on the Internet

Generally each reporting of a medical survey, use three interlink components namely Text, Graphics and Tables, each of which can be divided further as one can observe in Table 1.

TABLE I

Textual	Graphics	Tables
Diagnoses	Images	Statistical Results
History Interpretations Pharmaceutical treatment	Images of Region Field sketches X-rays MRA/MRI Statistical Graphics	Qualitative Description (laboratory test results)

Focused on the multimedia part of the system here, a workflow for content based retrieval is proposed as there is a need for interpretation of visual information that an image provides. That, in conjunction with the stored textual information, could lead the user to very rapid and useful knowledge extraction.

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III. FEATURE EXTRACTION TECHNIQUES

There are several methods for feature extraction. The focus here is on general features which are shape, color, texture and spatial layout and the use of them to environmental multimedia databases. Each of these features has a set of different descriptors.

A. *Texture Feature*

One of the most significant features is that of texture. That is because of its importance in a well-known and widely used category namely, SAR images. Texture features can be calculated on Global or Pixel level. [10]

A well-known approach for texture features is that of Laws features, due to its optimal localization properties in both the space and frequency domains. The Laws features have found widespread use in computer vision.

B. *Color Feature*

Color histograms, corellograms, coherence vectors, color invariant features and color moments (*mean* (1^{st} moment), *variance* (2^{nd} moment) *skewness* (3^{rd} moment)) are features commonly used for color representation. Color, as a feature, has three-dimensional values which can make its discrimination potentially superior to the single dimensional gray values of images. Color Agent here, implements RGB Histogram Feature. [9, 14 and 19]

C. *Shape Feature*

Human vision can easily recognise an object by its shape. In computer vision, there are a number of difficulties in developing useful shape feature, as effective image segmentation remains an open problem. After the segmentation of an image into objects or regions, shape features need to be calculated [1]. Thus, these features have little or no importance unless the segmentation is very accurate, in defining an object. Shape representation methodologies are divided into contour, region, and transformation. The criteria for choosing an effective representation feature for an object, is its independence to image transformations, such as translation, rotation and scaling. Here, a shape Agent is calculating **Moment Invariants.** Hu [11] introduced a technique of representing shapes through a vector of seven elements. They are by default translation-invariant and, in order to acquire invariance to rotation, they are reformulated by one of two methods proposed by Hu.

IV. AGENTS IN CBIR

Medical Information Systems, as mentioned before are distributed all over the world. Thus, information management and processing has to cope with a huge amount of information.

The use of mobile agents has the advantage of distributing the computational cost, as an agent could be built as a stand alone application, running independently on different platforms and operational systems. The distribution of responsibilities gives to the system the ability of parallel computing as each Feature Agent could work independently from the others.

Apart from that, it is observed that the use of a single feature usually lead to poor results. The retrieval results seem to be better if more features are used in conjunction.

V. SYSTEMS ARCHITECTURE

The overall system architecture is presented in Figure 1 and consists of three functions (feature extraction, weight estimator, feedback learning) [17] and three objects (databases, agents and images-UI) There are three databases, which will not be explicitly defined here in the context of their design, whereas Agents will be extensively analyzed. There is a feature database including the different extracted features from the images, a semantic database and a database that user's data (preferences, queries etc) are stored.

A. *Data Bases Searching Agent*

LookforAgent has the duty to execute a round algorithm visiting all collaborating medical systems searching for new index images. Each time a new image is submitted to a system and by the time it is identified, LookforAgent communicates with the other Feature Agents and invites them to calculate a specific feature vector a-priori defined. Apart from that there are other roles for this agent to play.

Another possible future application-use of this agent could involve the use of pheromones as defined by Dorigo et all [6, 9]. A pheromone is information that could spread around any time LookforAgent visits a database to search for new images. As weights are calculated for each user, they cannot be used as pheromones in the present form. There are though, two possible strategies to follow.

One is to calculate each time just before LookforAgent begins his quest, the average of each feature of all users. This average could be used as pheromone level stored as a flag for the proposed each agent's set of images path. System could (will be able) use these flags as a starting point in calculating images and if an acceptable distance is calculated (measured), then these images should be presented right after the perfect match results, in order to reduce time response.

The other (alternative) strategy is (to use) cluster users. Namely is to divide them into a number of different categories, according to their profiles in the database which in fact is the weight vector. The values of the centre vector for each cluster define the dominant user. The value of each weight could be used as in each image database defined as pheromone degree is stored as a flag to the proposed agent images path. The next steps are the same as on the above technique.

If there are a limited number of users, each user could be the single member of a group. This could really boost up systems performance, as each user is defined uniquely by his quests and his preferences, under the condition, that the number of users is low otherwise the advantage of a-priory knowledge will be eliminated by the process time.

The relationship between the number of users and the response time on this second strategy, appear to have the relationship. It is observed that we have a critical point where time and users number give the optimized solution for systems response.

Any time weights change value, could lead Feature Agents to target paths on local or distributed databases. LookforAgent is active when no user has logged on to the System.

B. Feature Agents

There are four Feature Agents, and the represented features are:

1. <u>AgentColorRGB</u>: Extraction of image feature referring to RGB color.
2. <u>AgentTextureHistogram</u> Extraction of image feature referring to texture histogram.
3. <u>AgentTextureLaws</u> Extraction of image feature referring to texture
4. <u>AgentShapeMomentInvariants</u> Extraction of image feature referring to shape.

All agents apart from the extraction are calculating the distance between a submitted query image and those image vectors stored in the database. They will finally construct each of them a list of twenty best fitted images. These lists shall be submitted to the Weight Estimation Agent who will decide which of the Agents list should be more significant for the user.

C. Weight Estimation Agent

Weight Estimation Agent (WEAgent) has the responsibility of weight estimation and intersection among each Feature Agent proposing list. In general a type to calculate this list could be the following:

$$Flist = \frac{(w1 * ListAgColRGB + w2 * ListAgTLaws + .. + w4 * ListAgShpMI)}{ListAgColRGB U ListAgTLaws U....U ListAgShpMI} \qquad (1)$$

Where, $$\sum_{i=1}^{n} wi = 1 \qquad (2)$$

and

n: Number of Feature Agents into the system.

All coefficients of the above type represent the weights and should be equal among them if no previous records of User's preferences exist. That is for User's first login: w1=w2=w3=w4=0.25. User Agent could provide WEAgent with information regarding user preferences.

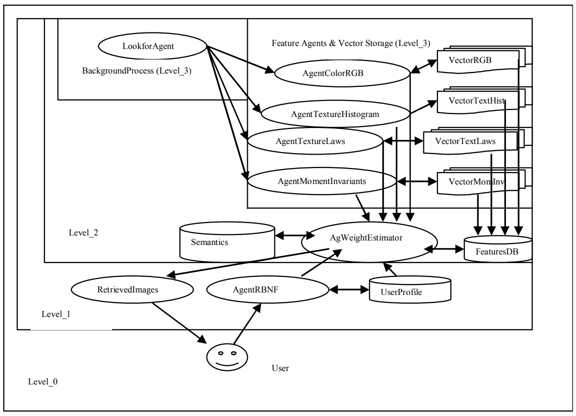

Fig. 1. System's Architecture, where four levels of the System are appeared.

Thus, whenever a user rejects an image this image is linked to the Agent that proposed it and diminishes the agent's coefficient. If it is linked to more than one agent's all linked agents weights are diminished, but if it is linked to all agents no action is taking place. Weight estimation for Feature AgentXX is simple:

$$\alpha_i = \frac{NumAcceptedImagesListAgXX}{NumProposedImagesListAgXX} \qquad (3)$$

for weight i:

$$w_i = \frac{a_i}{\sum_{k=1}^{n} a_k} \qquad (4)$$

If there are no rejected images, one could use a gradation by degree of accuracy defined by the user. A rank is acquired by User Agent. This could be very helpful as a weight could be easily defined.

A similar approach, using agents for feature extraction is presented in [4]. The present systems' architecture though is quite different, and focuses to increase systems' response through user modeling. Thus, user preferences defining each Feature Agent weight, and not a predefined voting algorithm as in [4]. Further more for each paper the created set of agents differs in quantity and type of calculated features. In addition, the presented methodology uses a neural network radial base function.

D. User Agent

A user often has to handle information from different sources asynchronously. Thus, a user profile could help in many different ways. First there would be no redundancy of rejecting every time a similar query is submitted and relevant information is retrieved, and if useful maybe stored in a local computer's Hard Disc. Apart from that, building a profile would be helpful as user feedback process time will be reduced.

This Agent could provide the Weight Estimation Agent with information that is used for the estimation of the weights, as the rejected images will reduce the wait for the Feature Agent that proposed them. If there are no rejected images, one could use a gradation by degree of accuracy defined by the user. This could be very helpful as a percentage-weight could be easily defined.

E. Coordination

Contemporary image retrieval Information Systems use techniques borrowed from the field of Pattern Recognition [14, 15, 16, and 17] and an example is that of Figure 1, [13]. This is a case of a Neural Network-based System, which utilizes Radial Base Functions. The user submits a query image to the system and then each Agent extracts a feature extractor for the query image, e.g. shape, texture and color. The corresponding heterogeneous feature vectors and the stored in database feature vectors are compared and the distance between them is calculated as a metric value vector. Metric value vectors are forwarded to a combiner, which is based on a Radial Basis Function Neural Network and yields the ranked list of the retrieved images. That list is submitted to the weight estimation Agent who will formulate the final list. Next, the system receives user feedback for the results and trains the Radial Base Function Network and modifies the coefficients on F_list type, according to this feedback. The system returns to the metric value combiner until a positive user judgment is fed back.

VI. CONCLUSION

There are quite a few obstacles to the achievement of effective retrieval of Medical data (medical images, values of tests, diagrams, Physicians notes etc) as they are often imprecise, missing or patient record related. These cases are regular in Medical Information Systems; where as in DBMS are treated as exceptions. Advanced information retrieval techniques should be adopted that will assume an imprecise representation of the semantics of documents. Apart from that, these types of data have different forms of representation and a large number of data types are required for the storage of facts. The structure of medical data is generally heterogeneous and time plays a significant role as images and symptoms usually leading to a diagnosis may differ from one patient to another, or even be different for the same patient if taken in different time periods (i.e. blood test results in patients with lupus). Users tend to formulate queries with vague conditions and they modify their query statements iteratively depending on the responses of the system.

Pattern Recognition techniques of the field of content based image retrieval can give a boost to the system iff there is a relation with a Knowledge base or a Semantic representation of some features.

The combination of different feature extractors for an image results in a better performance for the system in a shorter time as the some of the time consuming processes are executing in a parallel way

VII. FUTURE WORK

Using a single feature for image retrieval, as mentioned above, is usually not effective. The combination of different techniques from the Pattern recognition and Expert Systems field could improve the performance of our Medical System. The heterogeneous data of such application could be handled separately and the resulting lists lead to one single ranked list. By the proposed system structure, our aim is to work in a parallel way and reduce systems response time.

The proposed system could be used in many different applications where content based image retrieval is applied, not only to medical systems, eg: Environmental Information Systems [14].

This work is still in progress, there are no preliminary results and quite a few open issues to study. Our future research will focus on additional feature agents. Further more, there will be study on the optimal combination of calculated features and the minimum required computer sources with the maximum retrieval efficiency.

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