Intelligent Semantic Information Retrieval in Medical Pattern Cognitive Analysis

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Abstract. This paper will present a new approach to the interpretation of semantic information retrieved from complex X-ray images. The tasks of the analysis and the interpretation of cognitive meaning of selected medical diagnostic images are made possible owing to the application of graph image languages based on tree grammars. One of the main problems in the fast accessing and analysis of information collected in various medical examinations is the way to transform efficiently the visual information into a form enabling intelligent recognition and understanding of semantic meaning of selected patterns. Another problem in accessing for useful information in multimedia databases is the creation of a method of representation and indexing of important objects constituting the data contents. In the paper we describe some examples presenting ways of applying picture languages techniques in the creation of intelligent cognitive multimedia systems for selected classes of medical images showing especially wrist structures.

1 Introduction

One the main problems in accessing information collected in medical databases is the way to transform efficiently the visual information of patterns into a form enabling intelligent selection of cases obtained as an answer to queries directed at selected elements of contents of searched-for images. Therefore this paper will present the possibilities of application of picture languages and graph grammars used as the ordering factor indexing and supporting commitment and semantically-oriented search for visual information in multimedia medical databases.

It is worthwhile to emphasise the very essence of semantic analysis which allows for content-based grouping of images sometimes differing in form though conveying similar diagnostic information about the disease. Generally speaking, we have to consider a great variety of examined medical cases [5, 7].

In medical images an actual shape of anomalies or lesions can vary between the cases due to the fact that human organs vary between individuals, differing in shape, size and location while the forms and progress of pathological lesions (e.g. caused by neoplasm or chronic inflammation process) are unforeseeable [1, 7]. On the other hand, every type of disease leads to some characteristic changes in the

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shapes of visualised organs; therefore this type of information, obtained owing to the application of the method of structural pattern analysis, will constitute information label determining the image content. Techniques proposed in [7] allow the change of a pattern into its syntactic description in such a way that the automatically generated language formula transforms precisely the basic pattern content: the shape of the examined organ and its anomaly caused by disease. Those formalised, automatically generated descriptions of shapes of objects seen on a pattern placed or searched-for in a database, allow for separating the indexing process from the secondary formal features of the recorded patterns. Accordingly, the description is focused on the most important contents.

Graph grammar description algorithms as presented in this paper expand the traditional methods of computer-aided analysis through the interpretation of possibilities directed at tasks supporting medical diagnostics. Additionally, semantic information enables the use of such techniques in tasks of semantically-oriented search for some concrete disease cases in medical image data bases. In practice such tasks were difficult to implement, sometimes even impossible due to difficulties in creating indexing keys that describe image semantics [7]. Expanding analysis possibilities by meaning interpretation allows us to find an answer to questions concerning the medical meaning of the analysed image, semantic information specified by the features of the examined image and classification possibilities of disease units based on lesions on the image. The analysis of images conducted in this paper will go in the direction pointed out by the formulated questions. Its objective will be, in particular, to present and evaluate the possibilities of expansive graph grammar application for the recognition and intelligent meaning analysis of wrist and bones radiogrammes.

2 Linguistic Interpretation of Medical Images

The idea presented here and associated with creating indexing keys allows for an efficient search and categorization of both information specifying the type of medical imaging or the examined structure and meaningful semantic information specifying the looked-for object within the framework of one database. In a special case, apart from the main indexing key allowing the search or archiving of a specified type of medical images e.g. palm radiogrammes, spinal cord images etc., it is possible to create additional indexing labels specifying successive layers of semantic details of image contents. First of all, this information tells us about the progress of a disease detected with the use of the described grammars and semantic actions defined in them. The indexing information is also a description of the external morphology of the imaged organ. This type of description takes the form of a terminal symbol sequence introduced while grammars are defined for individual types of images and organs visible on them. The shape morphology described in this way requires a much smaller memory and computation input for the execution of the archiving operations and for searching for a given pattern. Finally, the lowest level of information useful for a detailed search are the types of recognised lesions and sequences of production numbers leading to the generation of a linguistic description of those lesions. Such productions are defined in the sequential and graph grammars introduced in papers [5]. Their sequences describing successive patterns of morphological lesions can constitute important in-

formation useful for a quick search for such irregularities on image data. Also graph grammars are applied for the task of description of important shape morphology features for the wrist structure [3]. The application of the description created in this way is analogous.

3 Wrist Radiograms Syntactic Description

Real examples of images showing pathological lesions in the form of wrist bone dislocation, and fusion have been shown on Figure 1. Such irregularities are to be detected and interpreted correctly by the syntactic image recognition method described in this paper [3].

Fig. 1. A) Image showing lesions in the form of the lunate dislocation. B) Fusion of the scaphoid with distal row of carpal bones

For making the representation of the examined structures in the form of EDG graphs (graphs with directed peaks and with labelled peaks and edges) [6] it is necessary to define an appropriate linguistic formalism that is an appropriate graph grammar defining a language. The language is defined in such a way that one could describe using it, without any ambiguities, every image representing a spatial system composed of elements similar to the wrist bone system. In this way we create a tool describing all possible shapes and locations of wrist bones, both the correct and pathological ones. The linguistic formalism that we propose in this paper in order to execute the task of mirroring real medical image forms into graph formulas fit for computer processing, will be an expansive graph grammar [7]. After defining such a grammar, every X-ray image will be converted into a linguistic formula built in accordance with the rules of that grammar. The effective parsing of that formula conducted by the computer, compliant with the rules of the created grammar will lead to an automatic assessment of photograph contents. This will make it possible in particular to determine whether the built of a wrist falls within the norm or whether it has pathological deviations.

For the analysis of wrist radiogrammmes an xpansive graph grammar was defined.

$$G_{exp}=(N, \Sigma, \Gamma, P, S)$$

Non-terminal set of peak labels

N= {ST, ULNA SCAPHOID, LUNATE, TRIQUETRUM, PISIFORM, TRAPEZIUM, TRAPEZOID, CAPITATE, HAMATE, M1, M2, M3, M4, M5}

Terminal set of peak labels Σ={r, u s, l, t, p, tm, tz, c, h, m1, m2, m3, m4, m5}

Γ - edge label set {s<p<q<r<s<t<u<w<x<y<z}

Start symbol S=ST

P – is a finite production set presented on Figure 2.

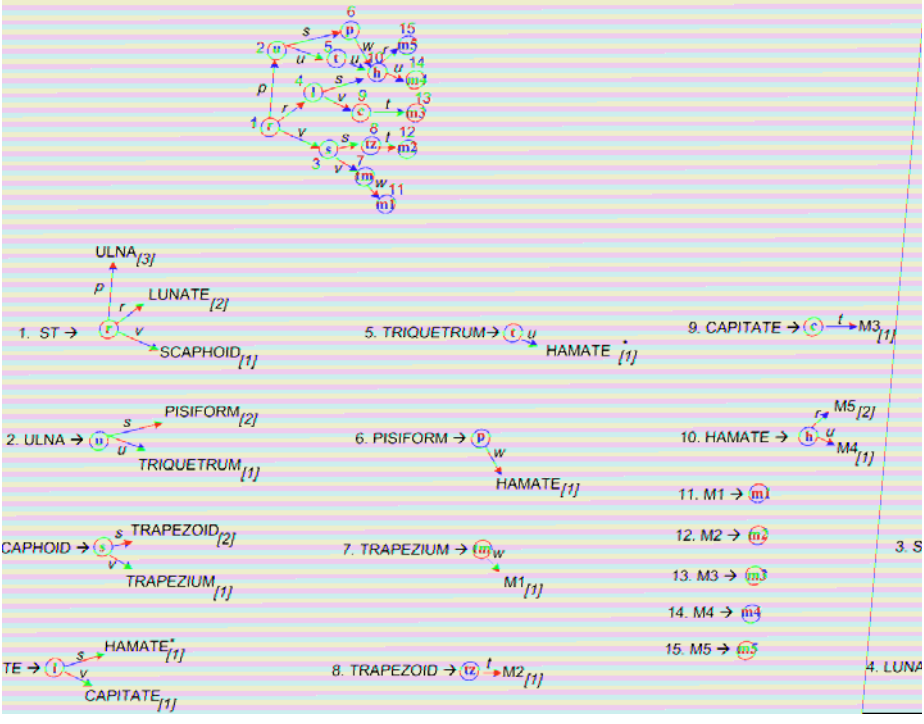

Fig. 2. Production set introducing a representation of the correct build and the number of bones in the wrist

4 Selected Results

As a result of cognitive multimedia analysis using linguistic approach it is possible to quite efficiently describe, mine and search pathogenesis information of the deformations viewed on selected x-ray images, what means the possibility of recognize and quick search some kind of diseases even on images absolutely not similar one to other.

The methods prepared were aimed at building an automatic detection and semantic interpretation system for detected regularities as well as the diagnosed irregularities in

the carpus bones. It is worth notice, however, that the test data set used for defining the output rules in the presented grammar was composed of only about 30 radiogrammes. Despite such an insignificant representation and, owing to a great descriptive and generation power of the used graphs, it is possible to classify practically any number of analysed images. The initially assessed efficiency exceeds the 90% threshold. On the other hand, the appearance of difficult and ambiguous cases can be quickly considered by enriching grammar formalisms by new (so far not considered due to lack of empirical data) reasoning rules and by specifying the meaning interpretation or such new cases. This is also the direction that will be followed in the conducted research.

5 Conclusions

The semantic approach to indexing and searching of multimedia medical databases seems to be a more efficient and appropriate method than the traditional indexing methods [2, 4] due to the presence of distinguishable objects visible in the discussed medical patterns, which by virtue of their shape define pathological disease symptoms. A structural description of medical image contents becomes easier and more unambiguous than an analogous description applied to a different category of patterns, for examples scenes. Nevertheless, after defining an appropriate graph grammar, the methodology described here can be utilised to describe any patterns. It will enable therefore the creation of object-oriented semantic description of contents of those data and it will also constitute the key to their indexation and search. An additional advantage of structural description methods is a potential of additional analysis of the examined images in the course of archiving and defining the semantic meaning of lesions visible on them; this is performed by imitating a qualified professional's understanding of medical images.

Syntactic information, together with contour representation in the form of terminal symbols as well as production number sequences describing discovered pathologies, constitute the representation of patterns placed in the database or searched-for [7].
In the course of the analysis of selected images in each case we obtain a type of recognized symptom and a sequence of production numbers, which lead to grammar derivation of shape description of such lesions. Such sequences create the proper description of analyzed shapes and are stored in indexing record. In every case those spots are highlighted where any irregularities have been identified. For each of them there are detailed descriptions in the program representation relating to the previously listed information used as indexing keys.

The approach to the generation of structural-semantic representation of medical patterns in multimedia databases with the use of context-free and EDT graph grammars [7] presented in this study is an entirely new solution. Preliminary research reveals that such approach proves to be an extremely efficient and universal tool enabling visual data compression and unambiguous data representation. An important point is that the proposed indexation technique has been optimised with an aim to find diagnostic information, easily observed in the shape of organs visible on patterns and dependent on disease symptoms.

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