Using topic map standard to deploy a knowledge repository of melanoma case images for diagnosis support

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Abstract: Malignant melanoma is one of the most serious forms of skin cancer. Early diagnosis of malignant melanoma may be a crucial factor in its prognosis. There is an ongoing research to provide advanced and efficient methods for diagnostic support to dermatologists. The purpose of this work is to exploit how topic map standard, a semantic web technology, could be applied to manage dermoscopic images, associated medical findings and clinical data in order to develop a functional diagnosis support system in the field of malignant melanoma cases.

Key-words: Topic map, Malignant melanoma, dermoscopic images, TM schema, Retrieval

1 Introduction

Malignant melanoma is one of the most serious forms of skin cancer and its incidence is increasing worldwide [4]. Early diagnosis of malignant melanoma may play a vital role for its prognosis. It increases the probability of recovery and seems to be effective in reducing melanoma's mortality rate [3,9]. Dermoscopy (dermatoscopy, epiluminescence microscopy, etc) is a non-invasive technique, which permits visualisation of features of pigmented skin lesions, and it is widely used for diagnosis purposes [7,10,23].

As there is an increasing amount of digital dermoscopic images that are produced in medical institutions as well as their related medical findings, it is essential to provide solutions for more efficient information storage and management [16]. Because of the importance of medical imaging, there is increasing interest by informatics researchers to develop new methods and approaches for building advanced repositories of medical images that can be used for diagnostic support by dermatologist [17].

Semantic Web technologies enable representation of data in a structured way providing thus integrated knowledge management support [2]. A medical application system based on semantic standards can ensure interoperability and reusability of dermatological data [12]. Further more semantic web technologies seem to offer the means for provision of enhanced retrieval capabilities and advanced reasoning support [8]. Developing medical applications that integrate semantic web technologies for knowledge representation and information management of medical images and clinical data could be used for diagnostic and teaching support [18, 20].

The main purpose of this paper is to create and maintain a database of medical images for melanoma cases. Added value for this application is the use of topic maps for efficient management of dermoscopic images and associated data. In the following subsection the design and creation of a topic map is presented and potential benefits of encoding information using topic map technology are outlined.

2 Introducing Topic Maps

As it has been aforementioned, as there is a steady increase in incidence of malignant melanomas worldwide, it has been realised that new tools and methods are needed to manipulate the increasing amount of visual information that is produced in that field, towards supporting early diagnosis [16,17].

The scope of this work is to exploit the potential advantages and difficulties of using topic map standard for managing melanoma case images and their related data, in order to create a medical application that provides diagnosis support utilities to dermatologists.

Topic Map is an ISO standard ISO/IEC 13250:2000 [5,6] and also defines a standard interchange syntax specification [22]. It intends to build a bridge between

knowledge representation and information management [1,21]. By providing a standard interchange syntax, exchange, reusability, and interoperability of knowledge among different applications, is supported. TM architecture enables also topic maps to merge[14].

Topic maps are constructed around topics that represent subjects [6]. Associations are used to describe n-ary relationships between topics and they are generally categorised according to association types [14]. Topics that participate in an association play roles that are referred to as association roles. A topic occurrence specifies information that is related to a given subject [6,14]. If the subject is a resource that can be addressed, then the resource address can be used as a subject locator [1].

Topic maps have been designed to represent and manage all subjects and any given relationship between them, in every ontological context [19]. A main advantage of Topic Maps is the clear separation between the description of the information structure (knowledge layer) and the physical information resources (information layer) (figure 1).

A topic map can build valuable information networks above any kind of resources data objects and enables the structuring of information. This network enables advanced navigation and information retrieval in complex data sets [5,13].

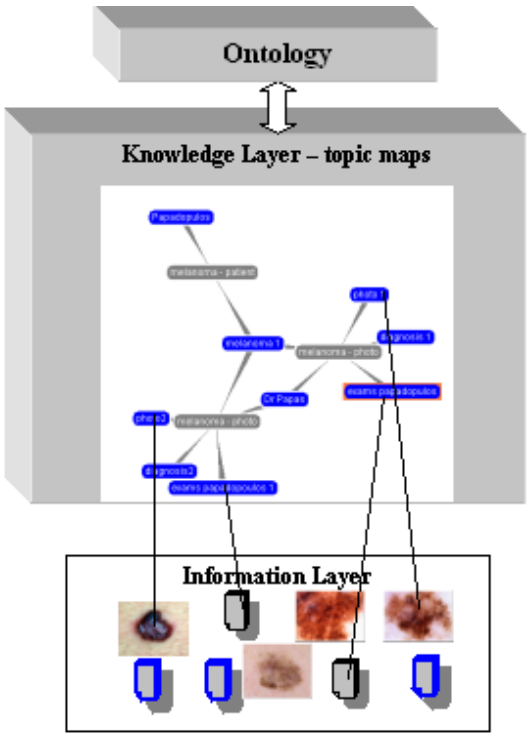

Fig. 1: Clear separation between knowledge and information layer

Although a relational database is a reliable solution, the problem is that queries have to be rewritten in order to support a new class of entity. By using topic maps, user may keep on altering properties and relationships, without having to rewrite program code or queries [1].

Finally topic map provide querying and expression of inference rules, enabling thus advanced reasoning support [5,14].

3 Design TM-based repository

In the following subsection the creation of a functional TM-based knowledge pool is presented in detail. It contains digital dermoscopic images of possible melanoma cases, as well as images' related data, doctors' reports, diagnostic findings and patient's information,

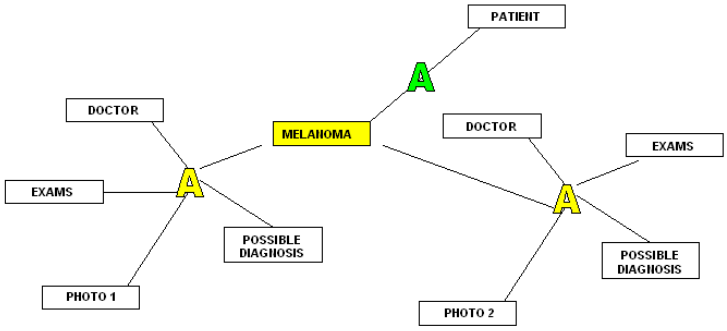

Fig 2: Basic structure of the proposed database

The first step is to identify the basic components that should be included in order to create a knowledge infrastructure of digital images and clinical data.

Figure 2 depicts the basic structure of the proposed database. Each patient will be associated to a concept: melanoma. Each melanoma will be associated to a doctor, possible diagnosis, laboratory exams' results and the actual digital image. This is the backbone of the database.

Appropriate attributes must be defined for all components, so they can be annotated efficiently and describe the knowledge that they inherit.

The properties of images contain a collection of descriptive variables required for calculation of the TDS (Total Dermatoscopy Score) index [15], an efficient tool used widely in diagnosing of melanoma. Calculation of the TDS is based on the 4 variables: the 'Asymmetry, Border, Colors, and Dermoscopic structures' criteria. Each of the criteria is then multiplied by a given weight factor to yield a total dermoscopy score (TDS) by the following formula:

$$TDS = A \cdot 1,3 + B \cdot 0,1 + C \cdot 0,5 + D \cdot 0,5 \qquad (1)$$

This score TDS contributes to the differentiation between benign and malignant lesions: < 4,75 benign skin lesion, 4,75 - 5,45 – suspicious, >5,45 – melanoma.

The properties, which have been decided to be attached to each photo, are: the date, the actual resource path of the photo, the abcd values and the total TDS score. Accordingly, for every patient, properties like name, age and gender are defined.

It must be outlined here, that this is a preliminary database, and a basic design is attempted. The database can be easily expanded and enhanced with many more components and properties. Topic maps enable scalability and expandability of the implemented database, while there is no need to alter the basic schema of the database.

In a topic map the ontology layer will contain topic types, association types, role types and occurrence types while the knowledge base layer contains instances of the types defined in the ontology layer [19].

TOPIC TYPES	ASSOCIATION TYPES	ROLES TYPES	OCCURENCES TYPES
diagnosis	melanoma-patient	as doctor	a
photo melanomatos	melanoma-photo	as melanoma	b
patient		as photo	c
doctor		as patient	d
exams		as diagnosis	e
melanoma		as exams	abcde score
abcde rule			possible diagnosis
			date
			address
			telephone
			age

Table 1: Topic map ontology

Table 1 outlines all the types that must be established in order to encode basic structure of database, that is represented in Figure 2, using topic map standard. In the next section the implementation of the proposed TM-based repository is described.

4 Implementation using Yellow-TM tool

For the realisation of a topic map, Yellow-TM software tool is used. Yellow-TM tool has been implemented, during this research effort, aiming to provide an advanced tool for TM authoring [11]. Yellow-TM is able to offer a form-based editing environment that embodies wizards for navigation in a TM and edit it in a perceivable way. Its main advantage is the implementation of TM schema visual editor, the visualisation functionalities that are provided as well as the provision of enhanced query and retrieval functionalities. Enabling users to express inference rules and integrated queries supports reasoning, which leads to a more efficient information retrieval [11].

TM Visual Schema Editor enables user to define and edit the desired schema for each TM, using a set of wizards. Using this editor all topic types, occurrence types, association types and role types, as well as their properties according to Table 1 has been realized (Fig. 3).

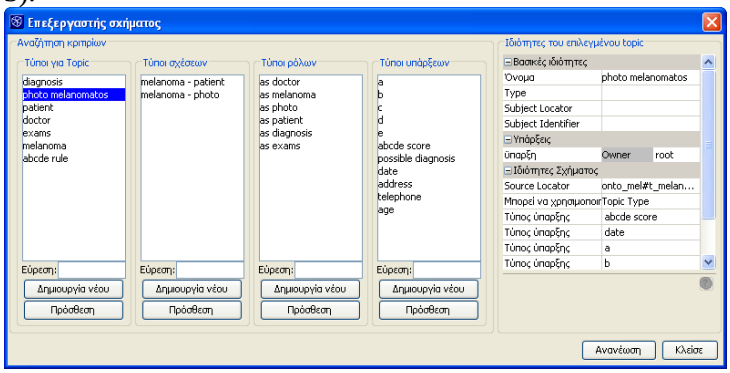

Fig 3. Create TM ontology using TM Visual Schema Editor

For example topic type “photo melanomatos” has been created. Consequently all the desired attributes, according to the design requirements, were assigned using the editable panel on the right of the editor’s window (Fig 3). Properties panel is depicted in more detail in Figure 4.

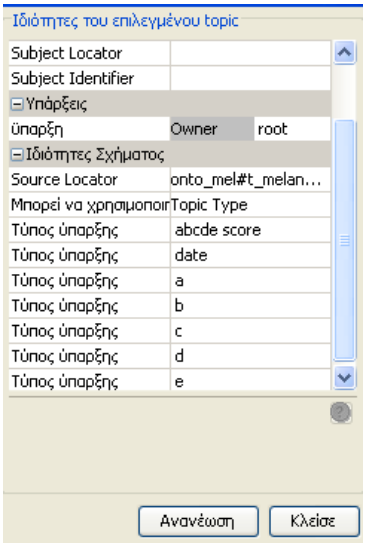

Fig 4: Define properties for topic type “photo melanoma”

In detail actual resource address can be used as a subject locator of the topic "photo melanomatos". Date, abcd values and the total TDS score are defined as occurrences in the topic.
Yellow-TM tool displays visually the TM concepts providing a dynamic graphical representation (Fig. 4). Topics and associations of the TM are represented as nodes, while roles are represented as arcs that connect topics and associations. (Fig 5). In order to edit any of the TM concepts, the user can add topics, change the properties of a topic and define new associations and roles according to TM Schema, simply by right clicking on the desired node.

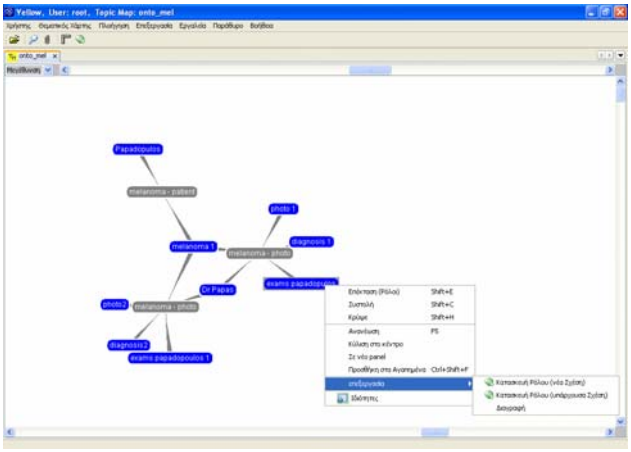

Fig 5. Visualisation of TM - add new instance

Topic properties are displayed in a separate docable panel. For example, name, age and gender have been defined in topic map schema as occurrences types, assigned to topic type patient. In Figure 6, properties of a new topic that has topic type "patient" is represented. User may fill in the corresponding values.

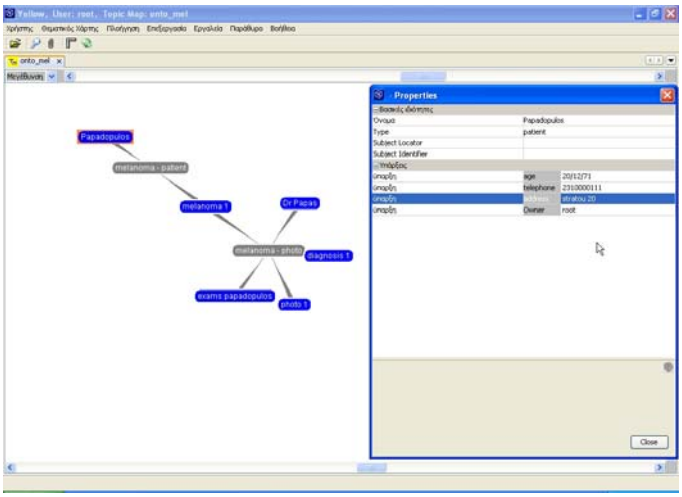

Fig 6. Properties panel of a new topic (topic type "patient")

Once TM schema is established, new instances of the types defined in the ontology layer can be added to the database. Thus a functional database based on topic map is established.

5 Conclusions

The purpose of this work is to use topic map standard in order to create a semantic-web enabled diagnosis support system in the sensitive field of malignant melanoma cases. In the context of this paper the first step of this research effort, the design and realisation of a TM-based knowledge pool that contains digital dermoscopic images of possible melanoma cases as well as associated data, was presented in detail.
Yellow-TM tool employs a 3-tier architecture, as database and TM-engine are placed on the TM server side. Users can simultaneously request and locate information. They can navigate, browse and visualize or update the corresponding medical data, which is subsequently stored in TM-based database. The current effort of this research work, is to provide an easy to use graphical user interface, that will enable users to encode medical data to topic map structure in a simple way.

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