MedView: A Declarative Approach to Evidence-Based Medicine

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Abstract. MedView is a project that meets the challenges of evidence-based oral medicine by providing a formalisation of clinical examination data and clinical procedures. Tools are provided for knowledge acquisition, knowledge generation, visualisation and analysis of data, and knowledge sharing. The formal declarative model constitutes the main governing principle in MedView, not only in the formalisation of clinical terms and concepts, but in visualisation models and in the design and implementation of individual tools and the system as a whole as well.

1. Introduction

“We’re drowning in information but starved for knowledge”, John Naisbitt exclaimed in 1982 [1]. This is perhaps particularly true for clinical medicine, and the compulsion to search and analyse large amounts of clinical information has been emphasised as a sequel to the immense increase in medical information during the last decades. In addition, the society of today requires that clinicians can justify and explain their decisions and actions to the patient [2]. The increased interest in evidence-based medicine is a direct response to these demands.

The MedView project was initiated in 1995 to support evidence-based oral medicine. The overall goal of the project is to develop models, methods and tools to support clinicians in their daily work and research. MedView focuses on the question: How can computer technology be used to manage clinical knowledge in everyday work such that clinicians more systematically can learn from the gathered clinical data?

MedView meets the challenges of evidence-based medicine by providing a formalisation of clinical examination data and clinical procedures, providing a possibility for recognising patterns and trends otherwise hidden in the monumental amount of clinical information. Tools are provided for knowledge acquisition, knowledge generation, visualisation and analysis of data, and knowledge sharing. The formal declarative model constitutes the main governing principle in MedView, not only in the formalisation of clinical terms and concepts, but in visualisation models and in the design and implementation of individual tools and the system as a whole as well.

This paper describes MedView from the perspectives of fundamental design principles, the declarative model used and knowledge management.

2. MedView

2.1. Analysis and Design

MedView adopts reliable computer science principles with a solid foundation in formal knowledge representation. Basic health care activities and concepts are established and formally defined. The formal foundation provides means for getting insight into the structure and meaning of medical knowledge [2].

At the same time, is important that tools are user-friendly, flexible and extendable by end-users and rapidly are brought into everyday practice [3]. One of the central design principles of MedView is therefore to provide a declarative framework in which user-centred and flexible tools can be developed, tools which, to a large extent, can be re-configured and extended by the users themselves, without the need of computer experts [4].

Thus, a declarative approach is motivated by the need for closing the gap between the formal foundation and clinical practice [2].

Information visualisation is an important component in any system for evidence-based medicine since it can prevent information overload and visually emphasise subtle aspects of clinical processes and data, which otherwise would be hard to discover [5]. Therefore, MedView is designed to take effective visualisation and interaction with data into account. Because of this, tools are optimised for the different clinical activities. For example, the act of entering data is separate from the act of viewing data. Thus, MedView provide a tool for entering data and several ‘viewers’ for viewing data in different ways.

It has been observed that all successful medical visualisation systems have been developed in close co-operation between developers and end-users [4]. MedView has evolved through close collaboration between experts in oral medicine, within the Swedish Oral Medicine Network (SOMNET), and experts in computer science. The collaboration within SOMNET also facilitates harmonisation, i.e., the process of making the formalised activities adapted within the oral medicine community.

2.2. Declarative Model

The declarative model of MedView is based on the assumption that definitions are central tools in all attempts to give a precise and formalised representation of knowledge. The formal declarative model of MedView is given by a theory of definitions [6].

In this model, the conceptual view of a definition is that of a collection of equations, where the left-hand sides (atoms) are defined in terms of the right-hand sides (conditions). Definitions have a logic interpretation, making them suitable for automated reasoning in a computerised system. At the same time, the concept of a definition and the act of defining are simple enough to have obvious intuitive meanings.

3. Knowledge Organisation

3.1. Clinical Terms and Concepts

In MedView, clinical data is seen as definitions of clinical terms. Abstract clinical concepts, e.g., diagnosis, examination and patient, are all given by definitions of collections of specific clinical terms. As an example, the following is a small part of an examination record:

Anamnesis = Common

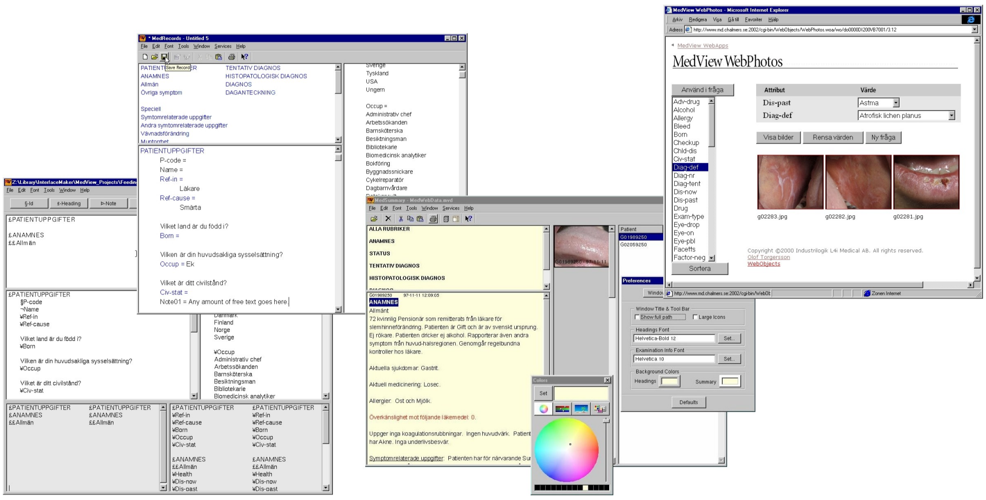

Figure 1: Left to right: InterfaceMaker, MedRecords, MedSummary and WebPhotos.

Common = Drug
Common = Smoke
Drug = Levaxin
Smoke = 4 cigarettes/day

In the above definition, the term *Anamnesis* is defined by the term *Common*, which in turn is defined by the terms *Drug* and *Smoke* and so on.

3.2. Templates and Protocols

Abstract concepts are given by defining templates (or protocols) describing the concept. For example, the terms *Anamnesis*, *Common*, *Drug* and *Smoke* are all part of the template for the concept 'examination'. A concrete instance of an examination record is given by defining terms like *Drug* and *Smoke* in terms of observed values, e.g., *Levaxin* and *4 cigarettes/day*, respectively.

There are also templates defining the layout of text and slot-fillers used in the generation of summaries of examinations (see Sect. 5.1. below).

Templates and protocols are developed by the users themselves using the InterfaceMaker tool (IM), without requiring any programming knowledge (lower left part of Fig. 1).

3.3. Value Classes

In addition to examination records and templates, the knowledge base also contains knowledge structures describing general domain knowledge, e.g., lists and classifications (value classes) of drugs and diagnoses.

Lists and value classes are defined by the users themselves using IM.

4. Knowledge Acquisition

The conceptual model of the knowledge base (KB) used in MedView is that of a collection of definitions. Thus, entering data is the act of creating a definition. To support the act of defining, the MedRecords tool (MR) has been designed and implemented. Since data is entered by the clinician while a patient is being examined, MR was designed to present an un-

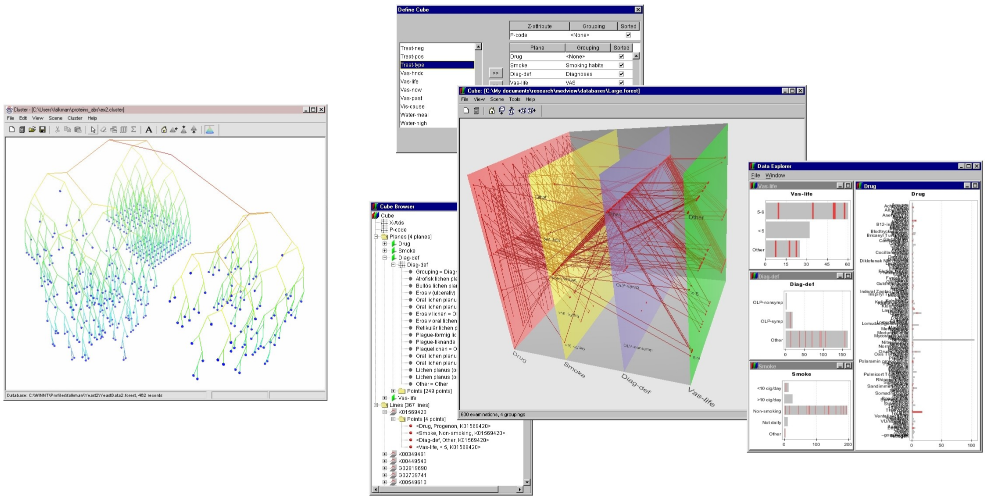

Figure 2: SimVis (left) and The Cube (right).

obtrusive, non-technical interface to the user (the upper left window in Fig. 1).

In MR, the user is presented to an examination template. Using value classes, free text and digitised images, the user completes the definition by defining the descriptive parameters of the template, e.g., *Anamnesis*, *Smoke* and *Diagnosis*, in terms of observed values. The basic clinical data thus gathered is stored as a new examination record in the KB.

5. Knowledge Generation and Application

5.1. Generation of Summaries

The basic viewer is MedSummary (MS). The view of the KB presented by MS is that of a textual summary of one or more examination records using natural language generation.

MS uses a summary template and a slot-filler definition together with one or more examinations to generate a summary text, which is then presented together with any associated images (lower right window in Fig. 1). By defining different templates using IM, the user can experiment with different texts without having any linguistic expertise.

5.2. Multidimensional Analysis

An examination is a definition of specific examination terms. Clearly, for a given collection of examinations, such a term can be viewed using a two-dimensional diagram with the x-axis as a time line and with the values of the term on the y-axis. Thus, an overview of the total set of terms can be given by multiple parallel diagrams. This view can be generalised into a dynamic 3D parallel coordinate plot [7] with support for direct manipulation.

The Cube was designed to implement the above view of the KB. The Cube itself is modelled using the declarative model of MedView. The overall design of The Cube is shown to the right in Fig. 2: Dimensions of The Cube are selected (upper left), the 3D parallel coordinate plot can be inspected (middle), the (definitional) structure of the Cube can be examined in detail (lower left) and the user can explore statistics about the dimensions (right).

5.3. Interactive Data Exploration

SimVis is another viewer based on a similarity assessment-based interaction model for exploring data. SimVis was designed to help clinicians to classify and cluster clinical data.

SimVis consists of three modules. The first module is used for constructing similarity measures between definitions. Based on the similarity values, a 3D hierarchical clustering of the KB is created and inspected using the second module of SimVis (left part of Fig. 2). The similarity values themselves can be examined in detail using a third module. All parts of the similarity model, including the resulting similarity values, are given as definitions.

6. Knowledge Sharing

The clinics participating in MedView maintain local KBs that are regularly added to a central KB shared by all clinics. Tools for accessing the KB over the Internet are being developed (as an early example, see the WebPhotos application in the upper right part of Fig. 1). Clinicians also communicate knowledge using summaries created by MS.

Recently, an application for generating customised patient information has been developed. An application for using MedView in education is also under development.

7. Conclusions

MedView is in daily use at a growing number of clinics within SOMNET. Since 1995, clinical data from nearly 3000 examinations have been collected into the knowledge base.

MedView is rather unique in that it applies a uniform declarative model to all aspects of a system aiming at supporting evidence-based medicine, from the implementation framework used to the design of the overall system, from fundamental knowledge structures to interaction and visualisation models.

The GALEN project [8] has a similar approach, in that it provides a uniform representation language for medical terminology and medical concepts together with a common framework for application builders. Compared to GALEN, MedView focuses more on recent work on component-based [9] and user-centred [10] visualisation, emphasising the tight coupling between users, visualisation and data.

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