Formalization of Clinical Practice Guidelines

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Abstract: Clinical practice guidelines are textual recommendations based on the consensus of medical experts with the aim to solve diagnostic and therapeutic problems. For more advanced use in real medical applications it is necessary to find out mathematical models of physicians’ decision-making processes. The acquisition of a formal model from text-based guidelines is a crucial point for development of decision support systems. We introduce a system for formalization and presentation of medical knowledge contained in clinical practice guidelines where knowledge formalization is based on the GLIF model.

Keywords: biomedical informatics, formalization of medical knowledge, clinical practice guidelines, GLIF model

Introduction

Clinical practice guidelines (CPG) are developed as textual recommendations by groups of medical experts on topics selected by a local scientific authority (expert medical society) or by a national health institution. Their goal is to improve the quality of medical care and to achieve treatment standardization. The outcoming text is created for a specific group of physicians, other health professionals or patients. For computer implementation and processing it is necessary to have guidelines structured explicitly [1]. CPGs are published mostly in printed versions as a paper or as a part of a paper in scientific journals. Nowadays, CPGs are published mostly on the Internet, too. Formalization of guidelines by means of a general GLIF model presents a suitable additional educational tool for their easier knowledge implementation in comparison with the classical paper form [2, 3]. It also allows to use patients’ data from an electronic health record (EHR) system. The formalization of CPGs can function as a feedback for authors to remove uncertainties and information inconsistencies in CPGs [4].

The aim was to create an easy-to-use system for converting medical knowledge included in text-based clinical practice guidelines into a formal model and save it in a widely applicable format (XML). The goal was to use it in developed applications for presentation, educational purposes and also in more complex systems for decision support in future.
1 Single purpose application

As the first step of using knowledge extracted from text-based guidelines we developed a web-based tool, which included the decision-making algorithm of the 1999 WHO/ISH Hypertension Guidelines. After a completion of a special form, physicians receive an automated assessment of a patient’s cardiovascular risk based on three groups of items – risk factors, target organ damages and associated clinical conditions known from the guidelines paper form. All completed patient’s items are used for a computation of his/her individual cardiovascular risk presented as a highlighted field of the known table from the guidelines paper form. When the drug treatment is recommended, a list of items for selecting the right drug treatment based on graded indications and contraindications can be filled in for an individual patient to obtain a list of recommended drug classes [5]. A significant disadvantage of this application was the necessity of a special application for every newly used guidelines and manual data entry for each individual processed patient.

2 GLIF based applications

2.1 GLIF model

For knowledge formalization in clinical practice guidelines we decided to use the universal and widely respected GLIF model. GLIF specifies an object-oriented model for guidelines representation and syntax for guidelines utilization in software systems as well as for their transfer. GLIF guidelines are mostly given as a flowchart representing a temporarily ordered sequence of steps. The nodes of the graph are guidelines steps and the edges represent continuation from one step to the other. The guidelines steps are: action step, decision step, branch and synchronization steps, and a patient state step [6], [7]. The decision step specifies several criteria of condition for each decision option. The strict-out criterion is evaluated at first. If the strict-out criterion is evaluated as true, the rest of criteria is not evaluated. This option is forbidden. In the opposite case the strict-in criterion is evaluated. If the strict-in criterion is false too, the rule-in and rule-out criteria are evaluated. The ranking of rule-ins and rule-outs is left for the user who may use his or her clinical judgment or may develop their own ranking schemes.

The GLIF model is graphical and therefore it is necessary to code it in the XML form. Syntax for a guidelines describing language is a part of a guideline model specification. In a language form encoded guidelines consist of a sequence of guidelines steps. Some attributes of a guidelines step contain next guidelines steps. It enables sequential representation of a graph structure in the guidelines language [8]. GLIF also enables a connection of particular guidelines in one complex sequence suitable for usage in clinical practice. It is shown in the GLIF model of formalized 2003 European Guidelines on Cardiovascular Disease Prevention in Clinical Practice and those of associated diseases, which offers to physicians a system for a decision support and checks their decision algorithms in comparison with those of guidelines [9].
2.2 GLIF model construction

A GLIF model construction and implementation of text guidelines are not easy. The whole process can be divided into several stages (see Fig. 1).

In the stage of GLIF model construction from text guidelines, it is important to find a logical and process structure of guidelines, all fundamental parameters and their interrelationships. Cooperation of an informatician and a medical specialist (the author of text guidelines is preferred) is more effective. The result of this cooperation is a graphic GLIF model that corresponds with the text guidelines. The construction stage is the most important and difficult stage. The specialist can use the developed user-friendly GLIF editor in the construction stage (see Fig. 2).

In contrast to systems that attempt to automate the conversion of text-based guidelines into a formal model usable in the health information systems [10, 11, 12], the GLIF editor offers the easy way of this model creation, which could be done by one
of guidelines authors. The usability of the GLIF editor was tested on a number of guidelines created by the Czech Society of Cardiology.

In the stage of GLIF model implementation, the graphic model of guidelines is coded into XML. Moreover, a list of basic and derived parameters is created. Basic parameters represent measurable values directly. Derived parameters are obtained in an arithmetical, logical or logically-arithmetical operation above basic parameters. The cooperation of IT specialists and medical experts also plays an important role in the creation of a basic and derived parameters list. The result is a data model that serves as an interface between the GLIF model and real input data stored in EHR (Electronic Health Record). It is important to pay attention to the definition of all criteria of conditions (strict-in, strict-out, rule-in, rule-out) for each decision option.

2.3 Applications using GLIF model of CPGs

The educational version of the CPG presentation system was designed to be able to combine the HTML text, GLIF model graphs and specialized presentation modules where the standard GLIF model presentation would be too complex. Guidelines are shown in any Java enabled Internet browser (e.g. Internet Explorer with installed Java Runtime Environment). The Glifview is a GLIF model browser that can present any formalized medical guidelines in a user-friendly manner (see Fig. 3). The educational version of CPG using the GLIF model leads a physician through the decision tree usually with yes-no alternatives in dependence on the physician’s knowledge of patient’s data. If a value of some variable is not available, the physician can continue and simulate both possible alternatives in the concerned decision step.

![Figure 3: Glifview example](image-url)

The processing version of CPG enables physicians to put patient’s data into the model directly. There is a list of all the variables used, the values of which are to be filled in by a physician. Compared to the educational system the browser goes
automatically through the GLIF model graph evaluating conditions of decision steps. If some conditions cannot be evaluated, as the needed data items are not available, the browser stops and highlights the branch from the root to the current step. Thus it can serve as a reminder of missing data necessary for a correct decision. Then the user inputs missing data (or simulates data) to the browser manually to be able to continue in visualization.

The Medical Knowledge Representation System (MEKRES) for diagnostic and treatment support is developed. The system will automatically offer to participants (patient, general practitioner, operator, …) relevant formalized guidelines on the basis of acquired patients’ data (monitored or saved in EHR). The selection of personalized guidelines will be provided according to key attributes of CPGs in cooperation with generally accepted standards, nomenclature and classification systems (see Fig. 4).

Medical knowledge and guidelines will be modelled by extended GLIF models (Knowledge Representation Model - KREM). The key attributes (code of a disease and others) will be added to the GLIF model for an easier identification and searching for a formalized guideline.

![Knowledge Representation System](image)

**Figure 4: Knowledge Representation System**

### 3 Conclusions

Several applications for formalization and presentation of guidelines were developed in the EuroMISE Center. The GLIF editor enables an easy way to create GLIF models of text-based CPGs. For educational purposes and usage in clinical practice the Glifview component and processing guidelines system were created. Several projects with a similar purpose have been developed all around the world recently [13, 14, 15]. The creation of a proper system of formalisation and presentation of CPGs is a tendency of using the generally accepted format (GLIF) and widening it for our needs in the context with our future plans.

These applications are employed in the test mode in the EuroMISE Center. In cooperation with the Czech Society of Cardiology and the Society of General Practice some of their CPGs were formalized (e.g. CPG for the Management of Arterial Hypertension, Guidelines for Treating Tobacco Dependence, Guidelines for Diagnosis
and Treatment of Acute Myocardial Infarction, Guidelines for Diagnosis and Treatment of Pulmonary Embolism). These applications also serve as educational tools and they are prepared for use with EHR.

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