Fusing a Systematic and a Case-based Repository for Medical Decision Support

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Abstract.

In order to take full advantage of computer-based decision support in clinical practice, it makes sense to combine systems which support the same subject, but contribute to this task in different ways. At the Technical University of Munich, a Combined Clinical Decision Support System (C-CDSS) of this kind has been designed for gastroenterologists. The main goal of the system is to help the physicians in finding information which is relevant for making the right diagnoses or applying the proper therapy to his patients. To achieve this goal, not only systematic knowledge of the medical domain, but also case-based data is useful for a comparison of the actual case with well-documented similar cases of colleagues. The systematic knowledge comprises state-of-the-art textual information and selected multimedia contents in the sense of a standard textbook. The case-based information includes practice-related information on a pool of anonymized cases from clinical routine and also demonstrations of new techniques. By integrating these information resources into one service via a rule-based retrieval system, a powerful decision support system can be generated.

Keywords:

Clinical Decision Support Systems; cased-based reasoning; integration.

1. Introduction

Computer-based *Clinical Decision Support Systems* (CDSSs) can improve the physicians' performance related to drug dosing, preventive care, and other aspects of medical care [1]. There are some types of applications, developed for supporting physicians in making these decisions [2].

The most known are *Clinical Expert Systems.* They claim to imitate human ability of drawing conclusions in a diagnostic process. This methodology is both very costly and problematic, as a computer system works algorithmically whereas a human being usually takes additional expertise, background knowledge and his own practical experience into account. It is almost impossible to formalize the complete medical background of relevant and valid information. In consequence, a computer system can never replace the physician, because it rarely can diagnose diseases as successful as a physician is able to do [5][6].

Another group of supporting systems are *Medical Information Systems* like Medivista [3], MMRL [4] or the Atlas of Gastrointestinal Endoscopy [10]. The main idea of this type of systems is to retrieve relevant information for medical decision making [6]. They are often implemented as a repository with ordered multimedia content (pictures, videos, text or other media) with a graphical user interface. These systems can be used as an online reference textbook and are useful to get medical information in a convenient manner. The information in such repositories can be prepared for access either systematically (e.g. based on ICD-10) or case-based. The systematical approach offers the possibility to use the standardized semantics for information access. But the greatest problem of systematic information systems is the static nature of the content. Furthermore the constraint of existing nomenclature can complicate managing und updating the system. On the other hand, case-based information systems provide practice-related support that can simply be kept up-to-date. But they suffer from the lack of a systematic: usually they cannot be retrieved in a satisfactory way. [11].

To overcome the numerous disadvantages of both approaches, the authors have developed an integration concept for creating a combined information system for medical decision support.

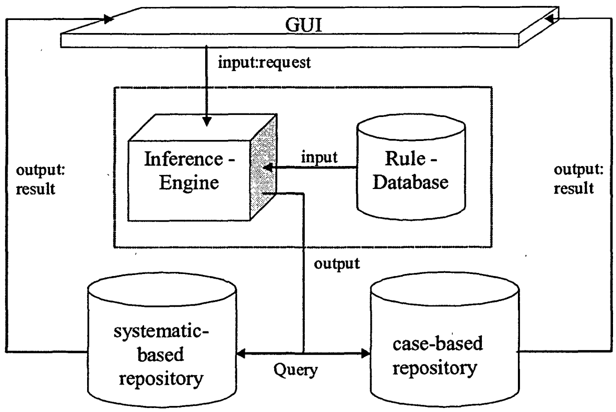

Figure 1: The basic architecture of a Combined CDSS (C-CDSS) fusing systematic-based and case-based repository

2. Concept

Up to now a physician is forced to use separate systems when he has the need to use information from systems of both kinds. This is time consuming and inconvenient. This straightforwardly leads to the main conceptual idea: to build a decision support system which implements one single interface between the physician and the two different information systems (systematic one and case-based one). A rule-based approach has been chosen as core of the new concept, in order to make the system as dynamic and comprehensive as possible – somehow "intelligent", so to say. Two *Rule Sets* of different types are distinguished in the system: 1) The *Reasoning Rule Set* (Rea-RS) describes the reasoning process. 2) The *Relation Rule Set* (Rel-RS) defines relations between the separate information resources. This second ruleset is not mandatory (see below).

A general model of CDSSs comprises an inference engine and a knowledge base as two main parts. In addition, every CDSS needs an user interface for information in- and output [12]. In the framework of the new concept, the knowledge base is assumed to be a composite system with a case-based and a systematic-based *information pool* (*repository*). The output of the rule-based inference engine refers to the information the user is searching for and decides which indices in both repositories match with the request. The architecture of such a system – it shall be called a *Combined CDSS* (C-CDSS) – is depicted in figure 1. The rules of both Rea-RS and Rel-RS are managed in one rule database.

The relation between both repositories can be defined either explicitly via a Rel-RS, or implicitly via an appropriate choice of the database structures. If the database structure of the systematic repository is designed in such a way that its indexing entities fit to the classification axes used for the case-based repository, then this indexing can be used as a starting point for the retrieval of the case-based repository. Alternatively, existing terminology and classification standards (e.g. SNOMED, ICD-10, MeSH) can be used as a meta-classification for the data in both of the repositories. Then, the user – here a gastroenterologist – can choose keywords (or respective codes) from different categories such as 'diagnostic findings', 'symptoms', 'therapeutic procedures' and 'examinations'. Unfortunately, none of these standards is sufficient for to serve as a keyword thesaurus of a C-CDSS, alone. The MeSH code, for example, has been optimized for literature retrieval. It is not meant and not suitable for support of clinical practice.

Technically, the retrieval of information is performed via search categories (so-called axes). The user chooses one ore more axes by assigning search values from a suitable thesaurus (so-called attributes). The attributes can be chosen from selective lists offered by the graphical user interface. They are taken from standardized classifications such as ICD-10, ICPM and OPS [7], and handled as a hierarchical structure in order to keep the user interface simple and ergonomic. On the basis of interviews with physicians, the final set of axes supported by the system has been determined.

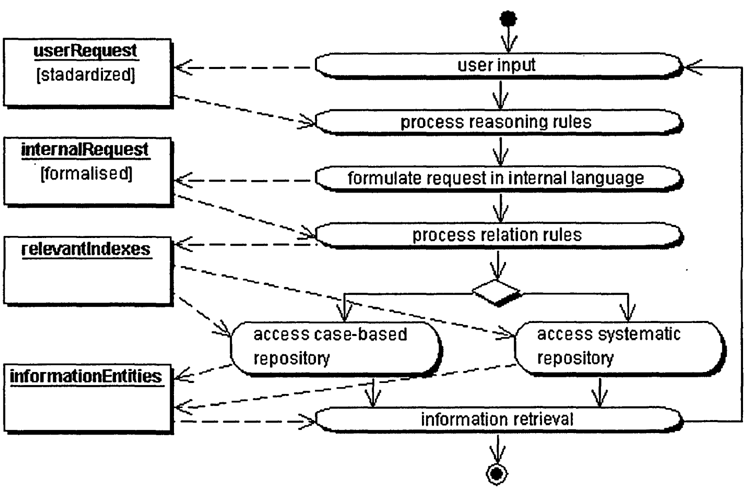

Figure 2: Data retrieval process in a C-DSS

Figure 2 describes the data retrieval process. User input is used to determine the scope of information the physician is asking for. Technically, this is performed by processing the reasoning rules with the inference engine. The result is a request expressed in a system-internal language. During the retrieval process of the physician, the rules describing the relation between both information repositories should be embraced. In this way the physician can access different information sources through a common GUI. Each entry from the case-based repository and the information from the systematic information system will be indexed. The indexes are the basis for the information retrieval. Reasoning rules and relation rules are stored in a database for a quick access to both repositories.

The rules we consider for the reasoning process consist of two parts, an IF-clause, called the conditional part and a THEN-clause, the activation part. The conditional part handles the chosen attributes, the activation part describes the matched information indexes in a formal way. Whenever a user selection matches the conditional part of a rule, the activation part is triggered. This means that additional, appropriate entries or information will be found. The act of evaluating the rules is done by the inference-engine. Whenever the physician makes a request in the form of a selection he will receive links to corresponding documents, pictures, videos or other media. E.g.: if the physician wants to find information about diseases associated with pancreas, he can choose the attribute 'pancreas' from the axe 'localization'. In this way he will receive all the available information that belongs to his selection.

An administration module of the system simplifies adding and deleting rules and managing data. The axes are managed in a flexible and dynamical way, so that update und further development are possible at any time.

3. Implementation

The proof-of-concept in the form of an early C-CDSS prototype is done in the framework of the project ENDOTEL at the Dept. of Medical Statistics and Epidemiology of the Technical University of Munich. The complete functionality inclusive of the inference engine is programmed in Java. Java Server Pages (JSP) are deployed to realize the graphical user interface. The structured data of the Endoscopy Information System (EIS) [13] are available in a MS Access database. The case-based data are created in the ENDOTEL Store-and-forward Teleconsultation Service EST [13]. In a preparatory anonymization step, all confidential data are removed from the EST cases, then the cases are stored in the C-CDSS MySQL database. This step is supported by the EST client software [13]. The system can be accessed via a web browser und is mainly addressing physicians in gastroenterology.

4. Discussion

The early C-CDSS prototype is realized with a self-developed inference engine. Utilization of external inference engines such as CLIPS or JESS is considered for future versions. JESS is a commercially available inference engine to develop expert systems and is only free for research work. It is the Java version of CLIPS [9]. The decision of whether to use an external inference engine or to keep the implemented one, depends 1) on the amount of rules being used, 2) on the manpower needed for the incorporation into the Java environment, and 3) on how well it helps to accomplish the overall system's requirements.

An unresolved issue is how to finally choose the axes as well as their dependencies. It is possible to handle each of them individually or to manage some of them in dependency of other ones. The second method allows an early reduction of attributes. As to creation and application of rules, a further difficulty lies in the impossibility to make a strict separation between the different search categories and their values. It seems probable that one will have to design some other systematic for the search.

Due to the fact that the implementation of the inference engine depends on the functionality of the graphical user interface, it was necessary to decide, how the axes and attributes of the corresponding selective lists are logically combined with each other. The logical AND was chosen as the probably most intuitive and common expectation of a user. A primary search without application of any search rule then only finds information fitting to all of these attributes. To extend the search result, the user has to make a new request. The question is whether this is advantageously or not. With regard to the performance of the system, it was decided to follow this strategy. Furthermore, it was decided to manage the attributes hierarchically, so that the user passes several levels which rarefy the already chosen attributes. Though the implementation of the hierarchy causes higher implementation costs, it seems reasonable with regard to ergonomics.

5. Conclusion

The realization of the simple and convincing main idea of combining the information of different types of resources to create a more comprehensive and efficient C-CDSS for support of clinical day-to-day work is far from being trivial. However, the big potential for a significant improvement of IT support for the physician in his core processes (diagnostics and therapy) by providing methodological as well as case-based reference information for comparison with his actual case, justifies the efforts to push the development of such systems.

6. Acknowledgement

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List of acronyms

CDSS	Clinical Decision Support System
C-CDSS	Combined CDSS
RD	Rule Dataset
Rea-RD	Reasoning RD
Rel-RD	Relation RD

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