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Sensible Decision Support System

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Abstract

The use of intentions in computer-based guidelines may help to make them more flexible, easier to adapt to local standards, easier to evaluate and to improve. We see possibilities of using intentions to reduce the number of unnecessary warnings sent to the user. Building guidelines with use of intentions gives the possibility to reduce the complexity of the guideline flowchart and the use of formalized language makes the description of every step of the guideline insightful for all users. In this contribution we present our approach to intention-based guidelines.

Keywords:

guideline, intention, decision support system

Introduction

Currently there is an increasing use of clinical practice guidelines (CPG) in medicine. CPGs improve the quality of healthcare, lower costs of treatments, reduce practice variability or prevent errors [1]. Clinical practice guidelines are mostly paper-based but the trend is to implement them in computer based decision support systems (DSSs).

Even though computer-based CPGs have a lot of advantages, the users face also some problems like for example lack of flexibility that causes unnecessary reminders or warnings. Reduction of practice variability is mentioned as one of the advantages. However, in some cases following the guideline is not the best treatment for specific patients. Sometimes physicians may choose an alternative treatment that is within the spirit of the guideline. Usually guideline systems will warn the physician, although that is not strictly necessary. When the physician gets too many unnecessary warnings he will stop using the system [2].

In the literature also approaches based on intentions hidden behind actions are discussed. Miksch et al. [3] presents intentions as temporal patterns of actions or states, to maintain, achieve, or avoid. Advani et al. [4] describes intentions as formal temporally extended goals and uses them to build a prototype medical critiquing application. In the Trauma AID project, Webber et al. [5] implement intentions as a commitment to use resources to try and achieve a particular goal. We think that the use of intentions may alleviate the problems mentioned above. Because intentions are stated, a guideline system for example can deduce whether alternative treatments are in the spirit of a guideline and if that is the case can postpone warnings.

In our work we made use of the heart failure guideline which in cooperation with the Cardiology department of the Academic Hospital Maastricht was implemented in the GASTON system [6].

We started our work with the formalization of the paper based guideline and local protocol for treating heart failure and implemented it with the help of the GASTON guideline editor. Figure 1 shows a part of the heart failure guideline flowchart. This is the flowchart at the highest level of the guideline where the guideline is entered. The flowchart is built from primitives, components with predefined logic. The top primitives of both charts are eligibility decisions which allow entering the flowchart only if predefined criteria as stated in the primitives are fulfilled. All white rectangular elements are sub-guidelines which represent other flowcharts containing primitives.

While designing the guideline we noticed that flowcharts become very complex and difficult to oversee. In Figure 2 the flowchart of how to administer angiotensin II antagonist is presented. This flowchart is part of a sub-guideline and in some cases can contain sub-guidelines as well. Without detailed knowledge about the implemented guideline it is very difficult for others to follow the logic or to find possible mistakes.

We evaluated our model with a cardiologist and we faced another problem; the model seems to be not flexible enough. Even though it was according to the guideline and the local protocol, in some cases physicians would like to bypass some steps. For example the protocol describes exactly in what dosage steps the drug should be increased while in some cases the physician would like to increase the dose faster. Current systems would send a warning to the user, but a system that uses intentions is accepting the choice of the physician, as it is in the spirit of the guideline.

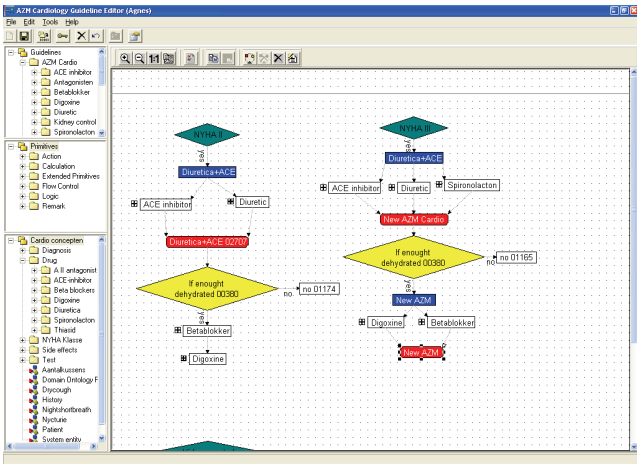

Figure 1 - Flowchart of the heart failure guideline

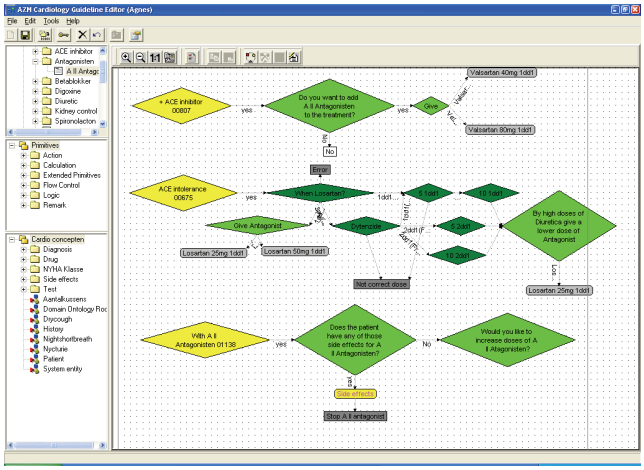

Figure 2 - Complex flowchart of how to administer angiotensin II antagonist

We also used the runtime version of the heart failure protocol for educational purposes. During the course third year medical students were confronted with the guideline and the system. The students had to enter patient data in an EPR that was interfaced with GASTON. After this data entry the students were asked to find out what the paper guideline proposed for treatment. Thereafter they could ask the system for advice. The system provided the patient specific advice very quickly and in this way they could experience the advantage of having system support.

Based on the experience we gained we decided to improve our system. The flowchart should be less complex, so that the maintenance of the flowchart will be relatively easy. Also users should be able to follow the logic of the flowchart and must be able to understand the rationale of the different steps. Also the system should be able to accept, at least initially, alternative actions that fulfill the same purpose. We therefore investigated the adequateness of the use of intentions, as already introduced in the ASBRU project. We want to show that use of intentions in building computer based guidelines can make them more flexible, insightful and reduce the number of unnecessary warnings.

Definitions

Before specifying intentions in more detail, we define some terms we use in association with intentions.

Intention. An intention is a determination to act in a certain way or to do a certain thing; is a high level goal which is abstract and not measurable.

Goal. A goal is an object of one's efforts; something to reach; is situation/state dependent; is concrete and measurable.

Plan. A plan is a proposed or intended method of getting from one set of circumstances to another. They are often used to move from the present situation, towards the achievement of one or more goals. A plan contains a series of actions to be carried out.

Action. An action is a work or an activity in a specific area or field.

Purpose. A purpose is an anticipated outcome that is intended or that guides planned actions.

System

Our system with problem solving methods (psms) related to intentions is being implemented as an addition to the GASTON framework that facilitates the development of clinical guideline application tasks. It consists of three parts: a guideline editor, where intention based guidelines are created; a knowledge base, where ontologies about medical knowledge and intentions are stored; and an execution engine, that during runtime reads data entered into the Electronic Patient Record (EPR) and uses these data to determine, on the basis of guideline information, the action that is the most appropriate for the current patient.

The physician communicates with the system via an EPR. The EPR has bidirectional communication with the execution engine. Further, the execution engine exchanges data with the guideline base and the knowledge base as shown in Figure 3.

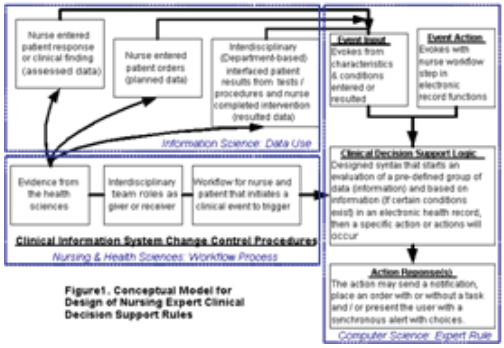

Figure 3 - General architecture of the system

The guideline is built in our system as a flowchart of intention psms. The intention psms can be carried out in parallel or in sequence. When it decomposes into other intention psms it is an intention psm on a higher level. When it does not decompose into other intention psms then it contains a flowchart of actions that fulfill the goal of the intention. The intention on a higher level is fulfilled only when the sequence of the intentions on the lower level is satisfied.

In the intention psm there is a possibility to write an explanation of the step or to make a link to the paper-based guideline where users can obtain more information about the current step of the guideline. Also the structure of the intention psm allows the designer to express if this intention psm decomposes into other intention psms, 'has sub-intentions' is on, or decomposes into a flowchart of actions, 'has sub-intentions' is off. If 'has sub-intentions' is on it means that success of fulfilling the current intention psm depends on the status of intention psms on a lower level. If 'has sub-intentions' is off it means that to fulfill this intention psm some actions have to be carried out. Further, the contents of the intention psm have to be defined, which are pre-conditions, abort conditions, and goal. The inside of the intention psm is shown in Figure 4.

During the design phase all parameters of every intention psm are defined. In the preconditions part all information needed to decide whether this intention psm may be entered or not are described. Abort conditions contain the description of situations when the execution of this intention psm has to be cancelled. The next part, goal, is a measurable part of the psm. The goal might be set in two ways: by the physician, based on the patient condition (e.g. blood pressure) or by the guideline designer, based on general medical knowledge (e.g. calcium level); also it might contain time constraints.

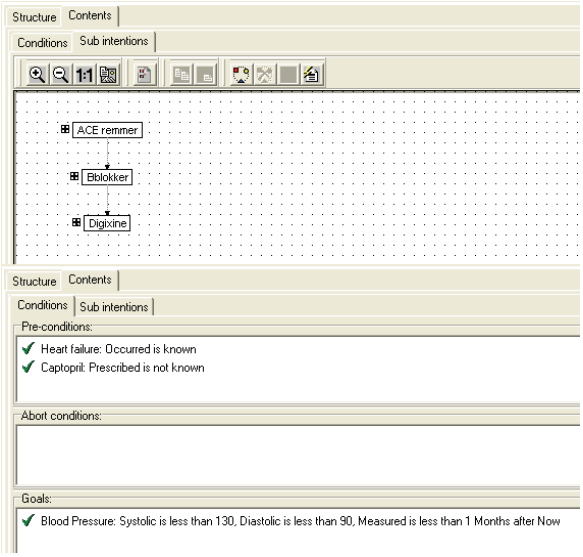

Figure 4 - An example of an intention problem solving method

Mechanism to reason with intentions

Information about the intention and the goal is used during the runtime phase. The execution engine uses that information together with data stored in the EPR and purposes of actions stored in ontology to provide flexible and adequate support to the user.

Before we explain how the mechanism of reasoning with intentions works we would like to introduce more information about the knowledge base (ontology). The ontology is a database where medical knowledge is stored. It is fully compatible with the Gaston system. All entries of the knowledge base have predefined properties. Dependent on the sort of the class of the data, we define mappings, attributes and purpose. For example, between attributes of the drug class we can distinguish prescribed, dose, or frequency; and between attributes of the diagnosis class, occurred or stopdate. Figure 5 shows properties of the drug class.

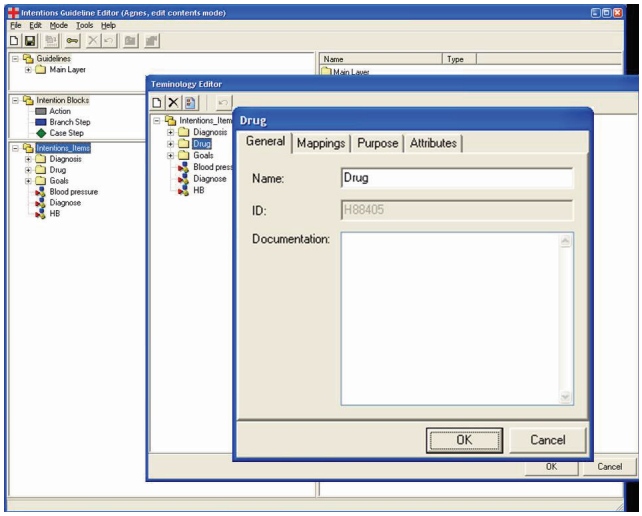

Figure 5 - Properties of the Drug class stored in ontology editor

All data in the knowledge base has a predefined purpose. Both intentions and purposes are standardized so that the system can see whether an alternative action is within the spirit of the guideline (purposes are equal).

The mechanism to reason with intentions and purposes is executed during runtime and compares those two pieces of information. If the action taken by the physician does not match the action stored in the guideline our system compares the purpose of the action stored in the EPR with the intention of the preferred action as mentioned in the guideline. No warning will be sent to the user if his decisions are made in the spirit of the guideline.

Real life data test

At the current stage of the project we concentrate on testing the system with real life patient data. In order to be able to test the guideline system we developed a simple EPR which cooperates with GASTON. Based on the results from this trial we want to see how the advice given by our system compares with decisions made by the physician; how flexible is system in giving advices when decisions are not exactly the ones mentioned in the guideline, but when they are still within its spirit.

The results of those experiments we would like to present during the conference.

Discussion

In this project we concentrate our efforts on extending existing software to obtain computer based guidelines that are easier to implement (reduced complexity), to evaluate, and are more flexible in processing received data. In this discussion we would like to point out the biggest advantages of our software.

Building guidelines with use of intention problem solving methods gives the possibility to reduce the complexity of the guideline flowchart. Figure 6 shows two levels of the heart failure guideline. The background window contains sub-intentions while the front window shows the inside of one of the sub-intentions.

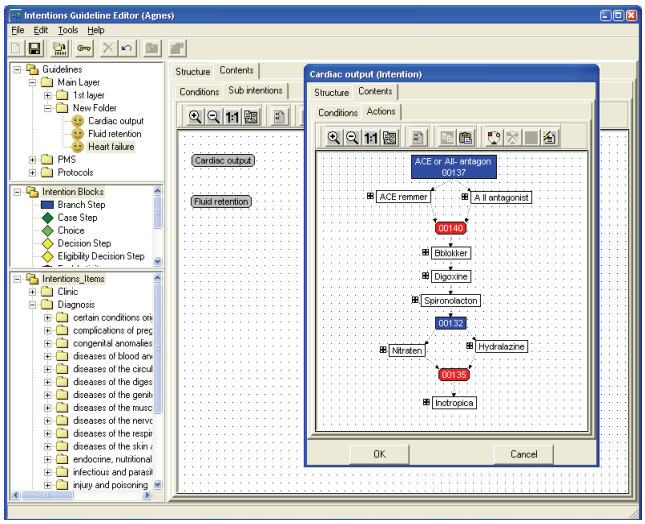

Figure 6 - A part of the heart failure designed with the use of intention psms

The user describes the preconditions, intentions and goals of every step by use of a formalized language. As Patel et al. [7] pointed out in her work, translating paper based guidelines into computer based ones is not easy. Already in the design phase we can make a lot of mistakes. Guidelines are developed by experts (e.g. physician) like also by non experts (e.g. computer scientist) and they may interpret information differently. Developers interpret the guidelines based on their knowledge, so different level of experience influence the way guideline is translated. When a computer scientist analyses the protocol he concentrates on surface information when given a text description of the clinical problem, while a physician includes the underlying clinical model.

The use of an ontology editor where medical knowledge with its attributes is stored has a number of advantages. By use of time-related concepts (e.g. prescribed, stopdate) it is possible for our software, based on date stored in the EPR, to follow the guideline and give relevant advice if needed. Another property, purpose, is used in the runtime and gives possibility to deliver flexible advice within the spirit of the guideline. Namely, the action stored in the EPR is compared with the one mentioned in the guideline. Even if the action taken is not the same as an action stored in the guideline, it is possible that the user will not receive any warnings. The purpose of the action taken by the user is verified then in the ontology and compared with the intention of the guideline. If user prescriptions are within the

spirit of the guideline, the system is accepting the choice the user made.

By use of intentions, we built a new kind of guideline flowcharts where the priority is set on fulfilling the goal than on following the guideline step by step.

The evaluation of our work will give us an answer to our hypothesis; is the use of intentions in building computer based guidelines making them more flexible, insightful and reduces the number of unnecessary warnings? In this study we have shown that the inclusion of intentions into GASTON is possible and intention based guidelines can be constructed.

Acknowledgments

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