Structure of Training Cases in Web-Based Case-Oriented Training Systems

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Abstract

In this paper we discuss the structure of training cases in web-based and case-oriented training systems. We combine the benefits of systems that support a structural representation of knowledge underlying a tutoring case and those that allow a fine granularity of didactical aspects. Our results emerged from the development of a training system in medicine, "Docs 'n Drugs – The Virtual Polyclinic". The abstraction from the proposed training case structure offers a good basis for general case-oriented training systems, an easy exchange of tutoring data, and the web-based indexing of learning material.

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Abstract

In this paper we discuss the structure of training cases in web-based and case-oriented training systems. We combine the benefits of systems that support a structural representation of knowledge underlying a training case and those that allow a fine granularity of didactical aspects. Our results emerged from the development of a training system in medicine, "Docs 'n Drugs – The Virtual Polyclinic". The abstraction from the proposed training case structure offers a good basis for general case-oriented training systems, an easy exchange of tutoring data, and the web-based indexing of learning material.

1. Introduction

Even if computer supported learning has a tradition that can be traced back to the 50's [5], there is again a growing interest and popularity in the use of computers in educational settings today. Governments, universities and companies highly investigate in projects dealing with web-based training in areas like studying, life long learning, further training, vocational training, retraining and knowledge transfer within organizations. The World Wide Web combined with modern technologies provides advantages and new possibilities for establishing up-to-date learning strategies. Especially the field of web-based training, the integration of computer supported collaborative work (CSCW) and intelligent tutoring prevent users from feeling lost when learning with the system.

In order to obtain reusable learning material in web-based training systems, it should annotated according to meta data standards [2], defined [6] and integrated into training systems or media players through languages like SMIL [11]. As a result, search engines can be deployed to support learners, tutors and authors in easily finding needed electronic learning media.

We extend the notion of structured training material from an underlying systematic knowledge to descriptions of didactical aspects. The resulting structure can be applied to several fields like medicine, biology, law, repair services, or criminology. Only few work has been done to examine the field of domain-independent web-based case-oriented training concepts. Most published work uses domain-specific structures.

In this paper, we examine the general structure of cases in such systems. We introduce the project "Docs 'n Drugs – The Virtual Polyclinic", in which we are developing a web-based and case-oriented training system in medicine. Furthermore, we explain the three-layer structure of cases in our system. Next, we transfer the results to other subject areas and generalize them. Finally, we mention related work to this topic and point out the benefits for this approach in a summarizing conclusion.

2. Docs 'n Drugs – The Virtual Polyclinic

The aim of the project "Docs 'n Drugs – The Virtual Polyclinic" (DND) [4] is to develop a web-based case-oriented training system. Currently, the subject domain is restricted to the area of clinical medicine including knowledge and interaction patterns of medical treatment. Since many branches in medicine and computer science are participating in this joint project, system components and training contents in the form of training cases are developed simultaneously.

To complete and deepen the systematic knowledge provided by textbooks and lectures, medical education should also provide practically relevant case-oriented training in medical issues with emphasis on patient contact. However, a patient-centered education requires a large investment of time and human resources, which could hardly be satisfied. For that reason, a web-based and case-oriented training system is an important supplement for medical education.

Since early 2000, the training system is officially embedded in the medical curriculum at the University of Ulm and used by many medical students with different skills and knowledge.

The entire system (called tutoring system) consists of six main components that users are interacting with:

- Training system
- Authoring system
- Administration system
- Intelligent tutoring service
- Telecollaboration service
- Evaluation service

State-of-the-art We have been developing all components as prototypes and evaluating the system for three students' terms. Currently about 80 cases were created with the system and about 300 users are registered. Since early 2001 the system is open to public through web access.

In the following chapters, we will have a closer look at the structure of training cases.

3. Case Structure

As far as the underlying models of training cases are concerned, we identified some important problems of existing implementations. With some systems [1], the incremental creation of general and case-oriented knowledge bases is not possible, upon which concrete training cases could be built. As a result of the lacking separation between case knowledge and its presentation, those systems cannot be easily transferred to alternative domains. Other systems [8] offer detailed expert knowledge models for general tutoring strategies but do not support linking special didactical information with model entities.

Regarding these problems, we divide training cases into three separate layers: the *medical knowledge*, the *case knowledge*, and the *tutoring knowledge*. Accordingly, we identify three different aspects of a training case: general, case-related, and didactical aspects, which correspond to the aspects of real-life human tutor-driven presentations of training cases.

3.1. Medical Knowledge

The medical knowledge defines the general knowledge of the medical application domain. It is case-independent and contains general classifications of main entities of medical cases, e.g. examinations, their results, diagnoses and therapies. Furthermore, relations between these entities can be established to rebuild the decision chain of a medical expert.

As the results of any (clinical, technical, lab, or anamnesis) examination we identified a general class of facts that may show some evidence for certain differential or final diagnoses. These include **r**isk factors, results of technical or lab **e**xaminations, **m**edicaments currently taken, and **s**ymptoms, briefly denoted by REMS. REMS comprise all types of facts that might play a role in the process of finding a diagnosis. They are associated to meta properties, which denote types of properties a REMS can have. Figure 2 illustrates the definition of REMS.

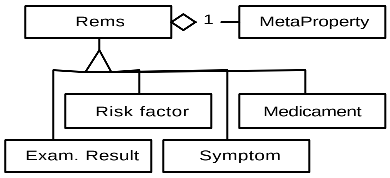

Figure 1. REMS: a generalization of symptoms

With this structure, we identify three important aspects:

1. All REMS are results of an examination. An examination is any medical examination: clinical, technical, lab or anamnesis.
2. Meta properties may be dynamically assigned to REMS. The medical domain knowledge is extremely complex and consequently it is impossible to define REMS completely in advance. This structure allows medical authors to change and to extend these definitions later on demand.
3. REMS can be associated to diagnoses by indication relations. To be more exactly, certain meta properties of a REMS can be related to a diagnosis. The relations are weighted by a set of positive and negative numbers as it can be found in [8], and describe how strong an abstract fact pleads for or against a diagnosis. In further extensions of our systems, these simple relations will be substituted by arbitrarily complex rules.

To integrate media items in the medical knowledge, we define a universal multimedia element type (document, image, audio, video, animation or movie) and allow possible associations to medical entities they describe. Thus, multimedia elements are potentially annotated with any knowledge item and thus may easily be retrieved by search engines later. The whole medical knowledge is based on the open world assumption and therefore incrementally extensible. Figure 2 shows an overview of the medical knowledge model.

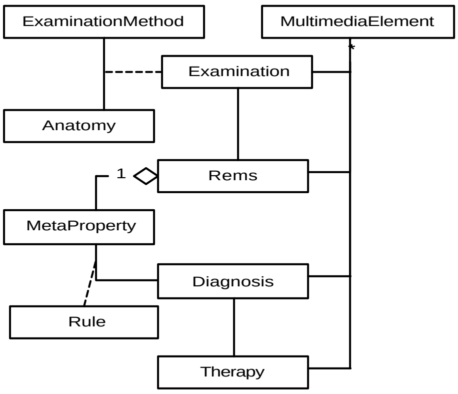

Figure 2. Medical knowledge layer (simplified)

3.2 Case Knowledge

The case knowledge is built on top of the medical knowledge. It identifies the part of the general medical knowledge that is covered by a special case. This includes all possible examinations, REMS, diagnosis, therapies, multimedia elements, and relations between those entities.

A case author has to integrate unimportant and important information into a training case. Unimportant information is required by the system to allow a learner to run into wrong paths when solving the case, as learning by doing mistakes is an important factor in case-oriented training.

Entries of the case knowledge may be annotated with case-dependent text or multimedia elements. The meta properties of REMS are instantiated to real properties with concrete values. All relations among entities (especially properties and diagnoses) may be also specified and weighted in the context of the case.

Referencing entries of the first layer implies that all cases use the same general knowledge (and terminology) and enables the system to support learners or authors during processing or creating cases [9].

3.3 Tutoring Knowledge

We employ two kinds of knowledge to support the tutoring process: didactical and pedagogical knowledge.

Didactical knowledge identifies pieces of shown information realized by multimedia and hypertext elements, and questions asked to the learner [7]. It describes how these entities can follow each other and what choices the learner has to navigate through the resulting entity network. Besides sequences and alternative choices also conditional branches and loops can be realized. We distinguish between guided, half-guided and unguided training cases, where the learner gets a different kind of freedom or responsibility to process cases. For example, guided cases, which only contain sequentially ordered pages, are ideal for beginners while unguided cases are suitable for experts.

Pedagogical knowledge allows the system to build up a model about the knowledge of the user when steering through a training case. For this purpose we allow authors to annotate learning entities with elements of the case knowledge. Based on those facts rules can be described by the author to say under which conditions didactical entities have to be presented.

4. Generalization

In this chapter, we generalize our case structure of the medical application domain to other subjects. When analyzing the three layers described above, only the first layer, the medical knowledge layer, is specific to the subject area. The second and third layers are general and may be transferred to other subjects without modification.

The medical knowledge layer has to be adapted to the specific entities of the destination subject. In general, we call this layer *domain knowledge*. Meta properties, rules, and multimedia elements are application-independent concepts. For the remaining entities, transformations to equivalent concepts in the destination subject can be easily found. Table 1 shows some examples of such a transformation.

Table 1. Examples of case concept transformations.

Medicine	Law	Chemistry
examination	question	lab examination
REMS	fact	result
diagnosis	law	evidence of material
therapy	judgment	measure
Criminology	**Repair Services**	**Generalization**
observation	inspection	inquiry/investigati on
indication	irregularities	result/fact
crime	damage	problem abstraction/

		identification
condemnation	repair	solution

The proposed general structure of training cases allows the development of tutoring systems for all domains where case-oriented learning occurs, and practicing the hypothesize-and-test strategy [10] for problem solving plays a main role.

Particularly, general pedagogical strategies can be implemented that use relations and rules between case entities. They allow the system to automatically correct and comment the choices of the learner when finding the right problem hypothesis. Furthermore, mechanisms can be realized that trace back argumentation steps to give hints to useful further investigations. The DND system implements both tutoring strategies.

6. Related Work

In research, there are many systems and projects that realize different aspects of computer supported learning. In Germany, for example, there are the project CASUS and ProMediWeb [1] – the latter is the web-based variant of the first one. In contrast to DND, CASUS and ProMediWeb are bound to the medical domain. They feature a fixed structure of a medical case, which aims at finding the correct diagnosis. There is no intelligent tutoring component and therefore learners may not be supported within the training process.

D3-Tutor [8] realizes aspects of intelligent tutoring, based on an expert knowledge model. It uses a case structure that focuses on finding correct diagnoses. In contrast to the other mentioned projects, D3-Tutor provides a framework that may be adapted to other learning areas. Exemplified knowledge bases for biology and car mechanics show the adaptability of their structure.

In the Adele system [3], probabilistic networks are used to represent domain knowledge for feedback and tip mechanisms. However, experiences with DND showed that authors prefer rather simple argumentation formalisms when formulating tutoring cases.

Finally, all these systems do not differentiate between and combine general, case-oriented and tutoring knowledge.

7. Conclusion

We generalized the DND approach to a general case structure and showed its applicability for other case-oriented training. Except from being application-independent, this approach entails further benefits:

- Only one of three layers has to be adapted when changing the subject area.
- The domain knowledge can be built up incrementally case by case and within the development of a single case.
- On each level, it is possible to exchange data with other training systems using that structure. An XML document type definition may simply be derived from the general structure.
- The general domain knowledge, including multimedia elements, may be used in meta data based search engines or in systematic knowledge databases.
- Authors and learners of different sub areas of the application domain have to agree upon and learn the same terminology.

7. Future Work

In the future, we extend the rule entity of the domain knowledge for more flexibility. We provide the intelligent tutoring service with more functionality like user modeling and tutor process adaptation, and improve the user interface for the training and authoring system. Furthermore, we want to build training cases in other subjects to practically prove this generalization.

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