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Knowledge-based Electronic Medical Record

(matching different level knowledge handling technologies)

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Abstract. The electronic medical record (EMR) is a central issue of health care computing. Pursuing the knowledge-based focus of interest, this paper reports the results of 3GEMR (3. Generation Electronic Medical Record management system), a subproject of CUBIQ [1].

As a thesaurus the SNOMED International [2] was chosen. As a structure of medical data the problem oriented medical record was selected. The knowledge handling methodology was a PROLOG extension worked out for project CUBIQ.

The result of the application development is a prototype, which is able to handle the whole SNOMED as a knowledge-base. The prototype conducts a structured interview which collects patient data including medical history and complaints of patient. These data originate a hierarchic set of "problem lines". The physician can enter his findings and results of tests. The working diagnosis evokes a plan. The data of a patient are presented by a graphic user interface, that shows three layers of information. The prototype is filled up with rules describing the conceptual network of history data, complaints, findings related to chest pain as a group diagnosis

Some problems aroused while development of 3GEMR was going on. While the original SNOMED III source database was converted to PROLOG understandable format, we have discovered several problematic areas. There are problems with the hierarchic structure within and among modules. Even the increasing number of dimensions, now called modules did not solve the problem of multiple (sometimes hidden) hierarchies within one module. A next problem was the limited capability of SNOMED to represent time related data. While the problems were numerous, SNOMED was able to represent most of the patient related data.

The next level was the proposed data structure of medical record. The set of meta-rules describing the problem-oriented record had to be modified and extended during the development. Representing medical history and duration of complaints emphasised the problem of time related data presentation and uncertainty. The problem oriented basic structure based on Weed's approach turned to be applicable in building a patient data-base.

The programming environment on the technical level was able to provide a usable environment for running the 3GEMR management system.

The original approach to build an electronic medical record management system instead of scratch from already proved tools and resources turned to be useful. Experience shows that advantages and disadvantages of using such tools and resources are balanced.

1. Introduction

The electronic medical record (EMR) is a central issue of health care computing. Previously the trend of EMR development was analysed [3]. Two emerging focus of interest, the multimedia extension of EMR and the knowledge-based EMR was mentioned. Pursuing the second, knowledge-based focus of interest, this paper reports the results of 3GEMR (3. Generation Electronic Medical Record management system), a subproject of CUBIQ. The hypothesis of 3GEMR, started in 1994 was to develop a state of the art EMR management system instead of the usual "from scratch" method, based on already proven tools and resources. The development of EMR was influenced by work of Rector et al [4].

2. Methods

To build an electronic medical record the following components were needed:

- a thesaurus of medical data and concepts (a resources handling method)
- a structure for medical data and concept representation (a conceptual framework)
- a set of functions for medical data and concept handling (a processes handling method)

As a thesaurus the SNOMED International was chosen. SNOMED International is a multimodal thesaurus of medicine related concepts. It contains over 140 thousand concepts, involving a broad spectrum of not only strictly medical concepts as e.g. diseases and anatomic terms but linkage and modifier terms as well.

As a structure of medical data the problem oriented medical record based on Weed`s original idea was selected. The problem oriented data handling is in contrast with traditional, time oriented data accumulation enables building of causal medical concept networks, thereby simulating medical thinking in making diagnostic and therapeutic decisions [5].

The knowledge handling methodology was a PROLOG extension worked out for project CUBIQ. The rich set of functions developed in project CUBIQ enables frame based knowledge handling, inheritance, parallel processing, a quasi-three dimensional graphic user interface and other tools.

3. Results

The result of the application development is a prototype, which is able to handle the whole SNOMED as a knowledge-base (a thesaurus). The prototype conducts a structured interview (run preferably by an assistant) which collects patient data including medical history and complaints of patient. All data are tried to be converted to SNOMED terms with the help of an on line browser. These data originate a hierarchic set of "problem lines", i.e. a working group-diagnosis based on PROLOG inference of the knowledge-base. The physician can enter his findings, results of laboratory and imaging tests. All these data are added to the patient data base to result in problems, i.e. a mentioned working diagnosis on a more specific hierarchic level. The working diagnosis evokes a plan, that consists of further diagnostic and/or therapeutic steps. The offered plan is evaluated by the physician. Entering of incoming results of test, changes of complaints and findings will result in a cyclic growth of the electronic medical record where already opened problem lines can be eliminated, used further on or new problem lines might be opened. The data of a patient are presented by a graphic user interface, that shows three layers of information in a three dimensional space. The upper layer collects history data, complaints, symptoms, findings and results of test. The upper layer is connected with the middle layer by lines, which are aimed at the problem line boxes, presented there. The middle layer is connected with the lower layer again by lines, that point to plan actions, either diagnostic or therapeutic steps are initiated. Boxes represent data collections at each layer, lines represent inferences done by the PROLOG or human inference engine. Several tool are available e.g. zooming, hiding, moving boxes and lines in respect with their content. Layers, boxes and lines are presented in a quasi-three-dimensional space where a trembling movement might be turned on or off for better overview. Negative (excluding) connections among patient data are handled as well as positive (evoking) connections.

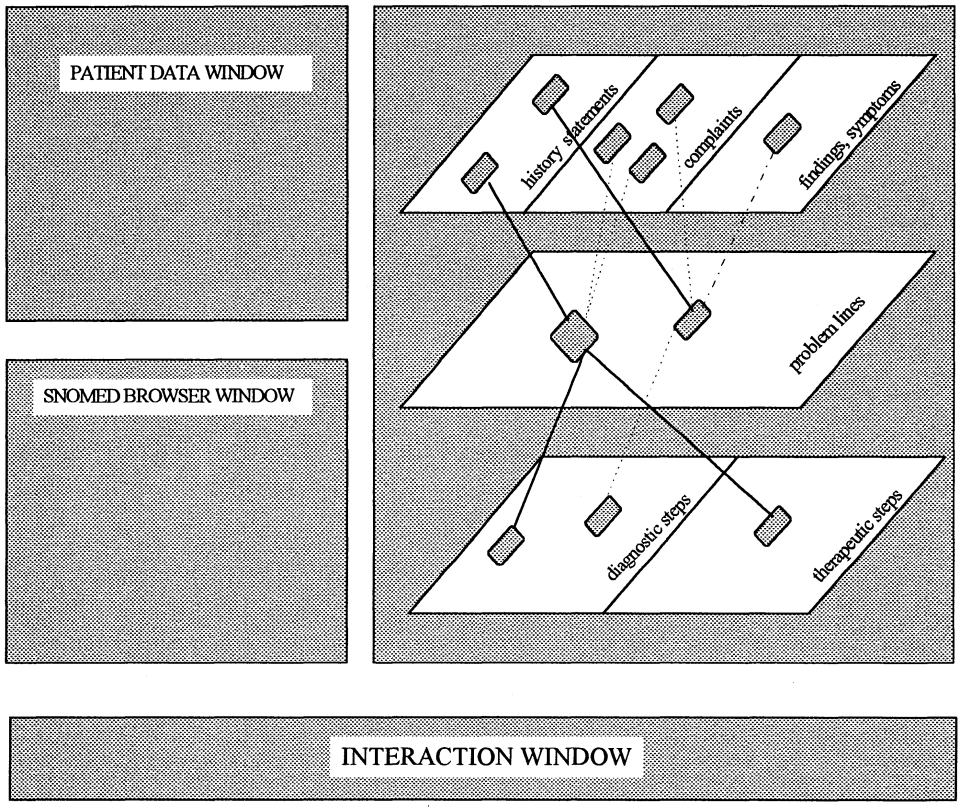

fig. 1. user interface of 3GEMR

The prototype knowledge-base is filled up with rules describing the structure of medical record (a meta-knowledge part) and with rules describing the conceptual network of history data, complaints, findings related to chest pain as a group diagnosis. A story board is written to show two cases of program assisted interview, to discriminate between cardiac origin and reflux esophagitis origin of chest pain. (The knowledge base consists of other problem lines connected to the broad "chest pain" syndrome of course, as e.g. musculosceletal and pleural plain)

4. Discussion

Some problems aroused while development of 3GEMR was going on. It is worth to discuss the problems on several level. The first level was the thesaurus level. SNOMED International (= SNOMED III) was awaited to be a conceptual extension of the hierarchic SNOMED II. Indeed the new version contains significantly more concepts in more modules. In SNOMED II there were 44167 medical concepts (excluding linkage terms) in 7 dimensions, while in SNOMED III there are 114111 medical concepts (again excluding

linkage and modifier terms) in 10 modules. While the original SNOMED III source database was converted to PROLOG understandable format, we have discovered several problematic areas, that would deserve discussion in a separate paper. Summing up there are problems with the hierarchic structure within and among modules. Naming of chapter and section heads and similar naming of some general concepts on high level of hierarchy might cause misunderstanding if an automated processing is aimed at. An other problem is that even increasing the number of dimensions, now called modules did not solve the problem of multiple (sometimes hidden) hierarchies within one module. These hindrances caused problems while advanced programming features as e.g. frame handling and inheritance was tried to be used. A next problem was the limited capability of SNOMED to represent time related data. While the problems were numerous, SNOMED was able to represent most of the patient related data, let it be medical history, complaint, symptom, finding or diagnosis.

The next level was the proposed data structure of medical record. The set of meta-rules describing the problem-oriented record had to be modified and extended during the development. The richness and diversity of possible patient data in medical history and complaints does not allow a simplistic approach. Representing medical history and duration of complaints emphasised the problem of time related data presentation and uncertainty. The problem oriented basic structure based on Weed's approach turned to be applicable in building a patient data base. It was observed, that starting an interview with the complaints of the patient is more easy than starting with the medical history. In the current phase of prototype building the cyclic handling of patient data was not aimed at.

The programming environment on the technical level was able to provide a usable environment for running the 3GEMR management system. Although browsing the over one hundred thousand concepts of SNOMED III build into a PROLOG hierarchic data-base initially was quite slow, with gradual development the mean response time was below two second if searching was within one module.

5. Conclusions

The original approach to build an electronic medical record management system instead of scratch from already proved tools and resources turned to be useful. Experience shows that advantages and disadvantages of using such tools and resources are balanced. In case of developing a knowledge-based application, it seems to be a good idea to use advanced software tools and the crucial point seems to be the planning of data-structure.

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