

KNOWLEDGE STRUCTURE DEFINITION FOR AN EXPERT SYSTEM  
IN PRIMARY MEDICAL CARE

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ABSTRACT

This paper presents an outline of the program KSDS (Knowledge Structure Definition System) designed for the definition of the structure of a medical knowledge base. KSDS defines type and structure of the elements of a conceptual net. KSDS generates the internal structure and format of the knowledge base. Nodes and relations of this net are structured in a uniform fashion, consisting of four parts: identification, description of attributes, relations to concepts, and explanations. For each attribute there exists a list of primitives which restricts its type and possible values. The relation part is constructed referencing already defined relations of the structure base. If the structure is changed, KSDS takes care of the re-formatting of the knowledge base. The system is currently being used for the definition and maintenance of the knowledge base of an expert system in primary medical care.

INTRODUCTION

In the primary medical care sector, an expert consultation system for diagnosis and treatment recommendation has to face a specific situation: in the initial consultation the patient presents a very unappecific collection of subjective findings, the availability of diagnostic procedures is very limited, the physician concludes a 'suspected diagnosis' usually, but he has to decide about correct therapy, including the decisions 'wait and do nothing', 'send patient to hospital immediately', and 'send patient for special examination'. The system must manage follow-up visits, follow the course of disease(s), and control the therapeutic effects and side-effects, perhaps revise the initial diagnosis in the light of new manifestations and therapeutic outcomes.

The first task in primary care is to detect 'preventable dangerous courses of diseases'. Therefore the possible courses of a disease, together with appropriate medical actions at each stage, and expectations about the future course have to be represented in the system. This has been accomplished for the restricted area of glaucoma (CASNET [8]), but an expert system in primary medical care will often face an unknown or not well known pathophysiology.

KNOWLEDGE STRUCTURE DEFINITION

The representation of the medical knowledge should serve as a basis for the consultation system performing its task under the requirements mentioned above. Compared to the clinical area, it is hardly possible to include all facets of primary care a priori in an expert system. Decisions will be based e.g. on nosological, etiological, topographical, pathogenetic knowledge. We will discover that some of the necessary facets are not represented after the construction of the knowledge base and after the consultation system has been completed. This fact led us to build the Knowledge Structure Definition System KSDS for easy modification and supplement of knowledge. This idea of developing systems for constructing consultation systems is also stressed by Weiss and Kulikowski [9].

One possibility would be to represent knowledge in rules like MYCIN [7]. However, defining explicit hierarchies for the topography of diseases and for abnormal function of physiological systems is extremely difficult. Additionally, Reggia [6] reported the inadequacy of the rule-based approach for his neurological localization problem.

We designed our knowledge base as a net structure, bearing in mind the design principles of CASNET [8], INTERNIST [4,5], PIP [3], ABEL [2], and CENTAUR [1],

Medical knowledge is represented in a conceptual net. We have defined four different concepts up to now:

- manifestations,
- diseases,
- diagnostic procedures, and
- therapeutic procedures.

KSDS represents concepts as nodes connected by relations. Nodes and relations are represented in the same format (compare figs. 1 and 2). Their description in KSDS consists of four parts:

1. The definition part (first two lines of figs.1 and 2) contains
  - an unambiguous identification of the node or relation {1},
  - the name of the defined entry {2}, and
  - if it is a relation: the type of the nodes connected (3,4).

2. The descriptive part declares the attributes of the node or relation ('DESCRIPTORS' in figs.1 and 2). It is similar to the notion of slots in the frame terminology. The descriptive part for a relation contains values associated with this relation, e.g. strength, preference, consequences, expectations using the relation. Thus, figure 1 shows of the relation 'perform therapeutic procedure', connecting a 'Disease'-with a 'Therapeutic procedure'-node.

Besides the name and a classification code (ICD, SNOMED), the descriptive part of a node contains items like risk, duration, frequency. Figure 2 shows the complete definition of the node 'Therapeutic procedure'. The information for each of the descriptors consists of the name of the descriptor {1}, its abbreviation {2}, value (3) and default value {4}. Additionally, information about the internal structure created by KSDS is displayed (length, position). The value determines a group from a list of allowed primitives (Fig.3: primitives of the group 'types of therapeutic procedures (T.TYPE)', defined prior to the definition of the concept. The default value will be used, if the expert will not

GR	EL	ABBREV	NAME
12		T.TYPE	types of therapeutic procedures
12	1	ADVICE	advice/psycho-sozial therapy
12		MEDIC	medication
12		PHYSIO	physiotherapy
12		RADIO	radiotherapy
12		NURSE	nursing care
12		FUNCT	substitution of function
12		INTENS	intensive care
12	8	SURG	surgical care

Figure 3: List of primitives.

supply a value filling the concept. The usage of primitive-lists allows the checking of plausible values as well as the definition of attributes in natural language.

3. The relation part defines all relations starting at this concept. Figure 2 shows the defined relations for the node 'Therapeutic procedure'. The length and to-node are taken from the description and definition part of the relation definition in KSDS.

RELATION {1}	Name {2}	from{3}	to{4}
TREA	perform therapeutic procedure	D	T

DESCRIPTORS:					
Name{1}	Ab{2}	Val{3}	Len	Pos	Def{4}
01 necessity of procedure	NEC	NECESS	4	1	1
02 strategy if not effective	NEFF	STNEFF	4	5	1

Figure 1: Definition of a relation.

NODE {1}	Name {2}
T	Therapeutic procedure

DESCRIPTORS:					
Name{1}	Ab{2}	Val{3}	Len	Pos	Def{4}
01 Term of procedure	NAME	C80	80	1	0
02 Classification code	CC	C10	10	81	0
03 Type of procedure	TYPE	T.TYPE	4	91	2
04 Risk	RISK	RISKS	4	95	1
05 Cost	COST	COSTS	4	99	99
06 Prescription	PRES	C80	80	103	0
07 Timelag after becoming effective	LAG	TIMLAG	4	183	99
08 Maximal number of repetitions	MAX	INT	2	187	1

RELATIONS:			
Typ	Name	Len	to-node
01 COV	is a possible therapy for disease	4	D
02 CNTR	contraindication (incl.allergy)	8	D
03 SIDE	side effect (diseases)	8	D
04 MCOV	symptomatic therapy for	4	M
05 MCNT	contraindication (manifestation)	8	M
06 MSID	side effect (manifestation)	8	M

EXPLANATIONS:  
Add in the explanation part information about prescription habits and additional information for the patient.

Figure 2: Definition of a node.

4. The explanation Part contains comments on the defined concept and detailed informations for the expert entering new knowledge. It can be used to support a natural language conversation.

#### EXAMPLE

The following example shows a 'Therapeutic procedure'-node in the knowledge base:

- 1 Term of procedure: immobilization of affected limb
- 2 Classification code: 61.2
- 3 Type of procedure: physiotherapy
- 4 Risk: minimal
- 5 Cost: low
- 6 Prescription: surgical dressing (bandages, casts), usually 2-6 weeks
- 7 Timelag after becoming effective: immediately
- 8 Maximal number of repetitions: 0

The element is connected to others by the following relations:

- 1 <is a possible therapy for disease>
  - [1] sprain and strain of supportive structures (840-848)
  - [2] dislocation of joint (830-839)
  - [3] fracture (829)
  - [4] cutaneous and subcutaneous infection (680-86)
  - [5] burn (940-949)
  - [6] superficial injury (912-917)
- 2 Contraindication (incl.allergy)>
  - [1] phlebothrombosis (451)
    - 1 STR : strong
- 6 <side effect (manifestation)>:
  - [1] hypersensitivity reaction to dressing mat.
    - 1 EXP : rarely
  - [2] pressure sore
    - 1 EXP : rarely
  - [3] disuse atrophy
    - 1 EXP : rarely

Explanations for the node "immobilization of affected limb":

The dressing should stay on site until the schedule follow-up contact. In case of pain and/ or swelling an earlier revision is indicated.

#### CONCLUDING REMARKS

The advantages of the knowledge structure definition system are:

- There exists an explicit and visible definition of the knowledge structure;
- This structure can be modified interactively;
- The internal representation is determined and controlled by the KSDS;
- Modifications in the knowledge structure can be performed easily on already existing knowledge bases. The KSDS will automatically restructure the existing knowledge base;
- The system for acquisition of knowledge from experts and consistency checking can use substructures of the net activated for a

- specific task (e.g. entering information about relations between manifestations and diseases);
- The procedural knowledge of the consultation system will be defined as operations on this knowledge structure, explicitly showing the concepts, descriptors and relations used;
- This will be of extreme importance defining executers to perform specific tasks during a consultation (e.g. activate diseases indicated by topographical relations as hypotheses, determine possible treatments, check contraindications, etc.). Only one or very few tasks will be active at one moment, corresponding to the standard procedure of a physician in primary care (try to find answers to the following questions: "What is the complaint?", "What does this refer to?", "What should be considered?", "Possible causes?", "What course is expected?", "Do's and don't's?"). Propagation in the net will be restricted by using only very few relations when performing one task. This will (hopefully) prevent combinatorial explosion of search effort;
- One criterion for our consultation system is conceptual adequacy. Presumably, the newly defined executers will perform more poorly compared to the performance of a physician. Stepwise modifications of the executers will hopefully increase performance. Since an executor shows the net structure it uses, modification can be done more easily.

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