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Using of Ontologies for Building Databases and Knowledge Bases for Consequences Management of Emergency

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ABSTRACT

The modeling of decision support for emergency consequences management is investigated. The presentation of information of injuries or illnesses of the victim when first examined by a rescuer or doctor is used to establish a diagnosis of the symptoms of the disease or to identify the consequences of the injuries. This approach is used to represent ontological data. The precedent technology for describing emergency response scenarios is presented in this article.

Key words: Emergency, Ontology, Precedent, Elimination, Automated Decision Support Systems.

1. INTRODUCTION

The emergency conditions change significantly and have unexpected consequences, so the additional elements of uncertainty and of the representation of textual descriptions need to take into account in models. The study further developed modeling methods and technologies that use both quantitative and qualitative indicators, databases and knowledge, and generalize them.

The special attention is paved on the creation of the new common tools of emergency information space development, system analysis and modeling of situations, technology of reuse of similar management decisions, adaptive to be used by automated decision support systems.

2. MODELING PROBLEM STATEMENT FOR THE DOMAIN AREA RESEARCH

We have the task of creating a knowledge base for decision support on emergency management [1]-[3]. The source for knowledge discovery could be the rescuer knowledge and information on the Internet. An ambulance rescuer or doctor usually interviews the victim or has a personal understanding of the victim's injuries, communicates with witnesses, or can access the Internet to find a description of such a situation and make a conclusion regarding the previous diagnosis of the victim's condition [4]. This could be a basis for decision-making using the ontological data of the pathology of the victim and the precedent for decision-making or the scenario of primary care or evacuation of the victim.

Let $D = \{d_1, d_2, \ldots, d_i\}$, where $i = \overline{1, N}$, $N-$ the set of all possible diagnoses for the victim condition, which are determined after the pre-treatment with him. The health characteristics of the victim have a categorical form defined by the function:

$$Kat(val, d_{n,r}, age, sex): I \times R \times D \times Sex \to C_j, \ j \in N,$$

where $Sex = \{m, f\}$ – the set of possible values of the characteristic «victim gender»,

$C = \{low, normal, high\}$ – the set of possible category values of victim health characteristics.

The functions C and Kat are given in relational form by an expert (rescuer or doctor) in domain knowledge, it means emergency.

It is necessary to define a binary representation of signs of injury or a condition of the person (1 – the presence of a symptom or a sign and 0 – the opposite) for classification in the protocol of the examination of the victim with categorical features.

$$X = \bigcup_{\forall i \in N} i \times C,$$

where X – space of binary signs, k_i – the space of categorical features.

And should be considered as a single and complex symptoms and signs that are selected from the knowledge base (KB) ontologies and precedents [4]-[6]. This approach, based on preliminary systematic analysis of existing case or ontological data, can be compiled into a relational database (DB), which is built by searching for additional verbal information on the Internet, its systematic analysis, application of Data Mining algorithms, introducing simplification of the size of the search set of possible values, parameters of the patient's condition, and the concept of "micro-situation" [5], [6].

In order to diagnose the victim, the doctor has to take into account, a number of features: symptoms and syndromes of its nosological forms, ethnology, ethology, pathogenesis, clinical manifestations taking into account personal manifestations and others. Clearly, not every doctor will be able to remember everything or really accumulate in relation to many parameters of the patient's condition. It should be noted that new medical knowledge is emerging, and there is not enough time to analyze the whole wealth of knowledge. As a result, there are many unfortunate medical errors in diagnosing the condition of the victim. According to some sources, more than 30 percent of them are found in medical practice.

In Figure 1 ([4], [5]) the model of knowledge representation in a KB is presented. It's oriented on combined knowledge representation tool.

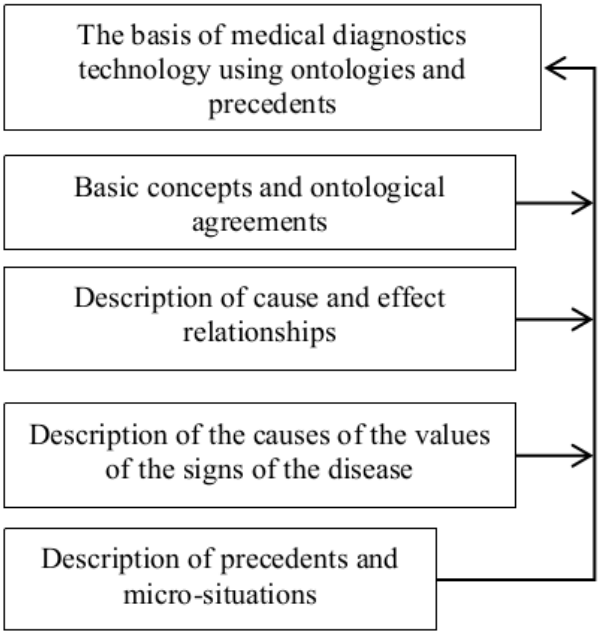

Figure 1: Combined means of knowledge representation.

3. MAIN CHARACTERISTICS OF ONTOLOGY AND THEIR USAGE IN THE DIAGNOSIS OF THE VICTIM CONDITION

Using the ontological knowledge [7], [8], it is possible to include the structure of the medical information description more accrual, its rules of interpretation regarding the diagnosis of diseases. With the advent of Protégé [8], ontologies became more and more often represented as a hierarchy of classes of concepts and properties of these concepts. Also promising for knowledge representation – is ontology based semantic approach, which makes it possible to explicitly represent an ontology as a semantic network of concepts with a root node, loops [4], [6].

The following analysis of the possibilities of using ontologies for decision support regarding the conditions of the emergency and the condition of the victim is made using medical diagnosis made using modern experience [4], [6] and combining with the use of precedents [5] and research of authors on the use of Data Mining methods, clustering, classification, application of search technologies with ontologies, precedents and micro-situations [4], [6] for decision-making in the choice of treatment strategy.

Description of the ontology (and its models) of the domain area of the so-called "medical diagnostics" takes into account the interaction of cause and effect relationships of different types. This ontology is close to the real representations of medicine in our country and describes the combined and complicated pathology, the dynamics of pathological processes in time, as well as the impact of therapeutic

measures and other events on the manifestations of the consequences of emergency.

The mathematical model of the ontology of medical diagnostics is presented as an unenriched system of logical relations with parameters in the applied logic language, and includes the definition of terms of the knowledge model (parameters), the definition of terms of the model of reality (unknown), as well as the limitation of the integrity of unknowns and parameters and the relationship between them.

According to the conceptual, complex solution of the problem, the first part of the ontology model describes the basic concepts and ontological agreements of the domain knowledge and reality. The basic knowledge terms include signs, events, features, observations, multiple values, conditions, necessary conditions of the disease, periods of dynamics, interval of disease development. The basic reality terms include moments that were observed in the features, performance, diagnosis, development, intervals of development of the trait.

The modeling of the patient questioning could be represented as a communication of next objects. Object (Doctor or Rescuer) − Q_1 asks questions or shows the victim questions and answers on the smartphone or any gadget. In the case of a satisfactory condition for the affected response, the transmission goes to the automated decision support system (ADSS) to eliminate the effects of the emergency of the object Q_2, otherwise the control goes to T_1 which shows an explanation for the decision. After all the questions have been answered, control is transmitted to the R_1 object – which reflects the final result – the diagnosis or scenario of assistance to the victim.

The object ($Clasms_1$) «the testing of the main symptom for the pathology» passes to the ADSS the question about the search of the option during the first metical questioning of the victim.

Si1 = Question
{
Question:
"The search of the main pathology symptom"
}

// We have the next answers in the knowledge base:

Option 1: "difficulty in nasal breathing"
Option 2: "headache"
Option 3: "nasal discharge"

Correct: Option1

// If the answer is correct, the control is transferred

// goes to the Si2 object, otherwise the control goes to the explanation

// T1 = Tip

{
//Text: "Sudden onset of two or more symptoms, one of which is one of the most important symptoms of a victim's life";
ifnocondition
call Q2;
}

After all the questions have been answered, control is passed to object R1 – to show the final result.

Si 2 = Question
{
Question:
"Search for persistent symptoms of a symptom of a pathology"
}

// We have the next answers in the knowledge base:

Option 1: "decreased sense of smell"
Option 2: "stuffy ears"
Option 3: "increase in body temperature"
Option 4: "getting a nose injury"
Option 5: "cough (more typical for children)"

The traditional procedure of victim questioning by doctor is as follows: the victim tells the doctor or rescuer about their subjective symptoms, the doctor distinguishes among them the most significant ones, taking into account the proximity of the symptoms of one of the illnesses or injuries, using the basic medical knowledge and own experience, then inquires about symptoms associated with a possible illness or complications of traumatic effects on the body, and issues a diagnosis and decision to evacuate.

4. THE SEARCH IN THE CASES OF PRECEDENTS FOR THE VICTIM HELP IN EMERGENCY

To force the solutions search, we lead the concept of diagnostic or injury micro-situation, which is the result of the classification and clustering of medical data on the situation with the human condition, formed as a result of preliminary analysis of ontological and precedent knowledge. In fact, this result appears to be a problem that is being addressed as a result of the development of the element relationships complex:

«diagnosis as a result of symptom search (symptom complexes) and identification of injury condition or disease of the victim–
the scenario of treatment or further evacuation–
the health condition of the victim».

The structure of the general situation $MS = \{ms_i\}, i = \overline{1,n}$ consists of the set of diagnostic micro-situations. This could be treatment or further victim evacuation actions– ms_i, they are represented by concepts - environment elements:

$$ms_i = \langle P_i, K_P, X, L \rangle,$$

where P_i – are actions related to diagnose statement after the search analysis of the symptoms (syndromes);

L is the set of the treatment action of the further victim evacuation;

$P_i = \{cPvt_i, Pvt_i\}$ –the set of central $\{cPvt_i\}$ and secondary concepts $\{Pvt_i\}$;

the part of situations, that is defined by pair $\langle P_i, K_P \rangle$, that consists of a linguistic description of the history of injury or illness (in other words such a qualitative, semantic unit), which is necessary for a comparative search on the basis of the precedents of injury or illness for the best treatment scenario choice L, in other words – micro-situations of the central concept – $cPvt_i$.

The set of micro-situations $MS = \{ms_i\}$ is based on this concept $cPvt_i$. $X = \{x_j\}, j = \overline{1,m}$ –quantitative indicators of possible analyzes or evaluation parameters, tomograms, radiographs, etc.

The set $K_P = \{Ot_i, Pvt_i\}$ is *context* of micro-situation for the linguistic, central concept $cPvt_i$.

The context of micro-situation has the for P and L in particular, indicate the conditions of use and association with other syndromes or symptoms, or options of a better treatment scenario.

The set $K_P = \{k_{P_i}\}, i = \overline{1,m}$ has the set of relationships $\{Ot_i\}$ of the *main* concept $cPvt_k$ with the *secondary* concepts Pvt_k, that are linked with the other symptoms, or syndromes, or concepts, or diseases that relate to this micro-situation.

The relationship Ot_i – reflects some dependency of the main concept on secondary concepts Pvt_i, related to the other injuries or diseases, or symptoms. Sometimes the main concept $cPvt_i$ could be the secondary concept Pvt_i for this micro-situation of the other micro-situation (Figure 2).

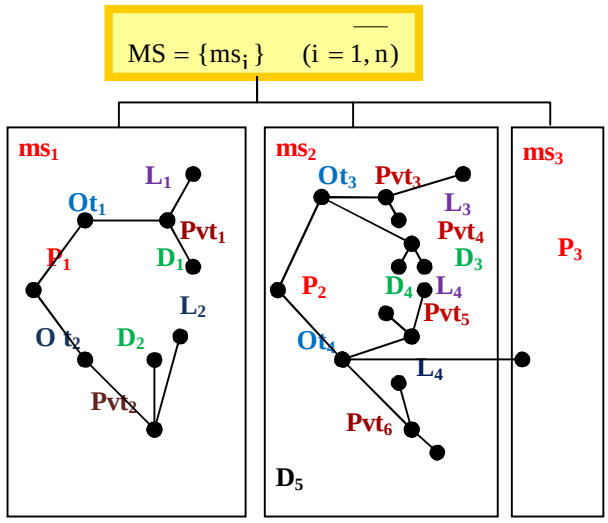

Figure 2: The example of the relationships between the micro-situations.

The central concepts cPvt and P have to be detected from the texts of diagnose description TextIMC and treatment scenarios from IMC. They could be associated with the set of micro-situations, selected on the set of the *precedents* $\{\Pi_i\}$ for the concrete disease.

The stages of the precedents set building $\{\Pi_i\}$ for the selected (standard) micro-situations:

1. The description of the current medical disease or injury diagnostic situation. It is provided in form of description in the medical history of disease or injury as a result of the traditional first interview of injured person etIMC or of further detailed examinations TextIMC.

2. The detection from the resulting description of concepts $\{P_i\}$ of the set $\{Kat\}$, that define the state of the victim after analyzing and selecting a treatment or evacuation scenario $\{L_i\}$.

3. The search of the relationships $\{Ot\}$ between these concepts.

4. The description in the language of the micro-situation representation.

The concept for this category Kat_i is obtained from the function of the concept definition execution $Pt(TextIMC)$

$$Pt(TextIMC) \to Pvt_i,$$

where $Pvt_i, i = \overline{1,n}$ – the concept definition,

$$Ms_i \Rightarrow \{cuP_i\},$$

where $\{Ms_i\}$ – micro-situation that corresponds to the set of concepts $\{cuP_i\}$, that are entities $\{Ot_i\}$ of the concepts set, which determine relationship between the other concepts.

1. Step. The identification from the set of candidates the set of central concepts or *precedents* – (nouns that are related to the sentence $TextMIC$ [9]).

$$ERp1(cuP) \to cPvt_i,$$

where $ERp1$ – the function of the candidate identification in the central concept – $cPvt_i$

2. Step. Context or relationships identification

$$OtA = cuP \Big/ \tilde{n}\, Pvt$$

for these candidates in the central concepts. The task is to identify a subset of relationships (associations) – $Ot \subset OtA$. The elements of the set of relationships Ot are main, active and additional relationships. Each element of the relationships set $OtP_1 \in Ot$ is associated with the specific central concept $cPvt_i \in cPvt$.

3. Step. The set of micro-situation is formed $ms_i = \left\langle cPvt_i, Ot_{cPvt_i} \right\rangle$ – precedents, where the set elements Ot_{cPvt_i} are the elements of the set Ot. On this step the resulted micro-situations are incomplete because the secondary concepts are not set for the elements of the set Ot.

4. Step. The search of the *secondary* concepts. Any elements of the candidate set cuP could be the secondary concept not matter did they get into the set of central concepts $cPvt$ and the set of relationships Ot or did they fall into none of them. In most cases, the secondary concepts are based on additions to the verb forms highlighted earlier. In the general case, minor terms are those that are referred to by associations.

The resulting rule could be represented in the form:

$$pravResh = \underset{i}{\wedge} Prizn_i,$$

where $Prizn_i$ – the single characteristics of the disease or injury.

In the value calculating of the decisive rule $pravResh$, each of the attributes is matched to the value of truth, if the attribute is present in the concept and falsehood otherwise.

5. CONCLUSION

The research showed that an integrated approach should be used for the ADSS creation. Bring in the ontologies, precedents and micro-situations for the technology knowledge base. Some of the results above ensure that this approach could be applied in the other areas of the rescue or medical activities. Undoubtedly, the implementation of this approach depends on a high-grade knowledge base, which can be automatically filled out by queries on the Internet search engine knowledge.

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