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Procedia - Social and Behavioral Sciences 73 (2013) 438 – 443

Procedia
Social and Behavioral Sciences

The 2nd International Conference on Integrated Information

Framework for representing Semantic Link Network with Adjacency Relation System

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Abstract

In this paper we propose a framework of operations for representing semantic information with adjacency relation systems (ARS). The framework consists of the following elements: (1) construction of domain-specific semantic network (SN), (2) the refinement of semantic network into semantic link network (SLN) and (3) the conversion of semantic link network into adjacency relation system (ARS). The proposed framework combines effectively semantic data structures with traditional data structure. In this paper the proposed framework is used to modeling the statistical accident information reports.

Keywords: Adajecency Relation System; Semantic link Network; Knowledge representation

1. Key concepts and framework

Semantic network (SN) provides representations for concepts and their relations within a domain [1] [2] [3]. Statistical accident information reports provide the case data (domain) for this study [4]. At the first step domain concepts and their relationships were mapped and SN was formed. At the second step relationships were analyzed and Semantic link network (SLN) was formed by attaching semantic properties to each relationship.

1.1. Semantic Linked Network

Semantic link network (SLN) is a directed graph which consists of nodes and links between nodes. A node can be for example text or a concept. Link between nodes is a labeled pointer. The label contains semantic properties

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doi:10.1016/j.sbspro.2013.02.073

which are derived from the domain [5]. Any semantic relationship between nodes is described by a property or by a combination of properties [5]. According to Zhuge [6] the use of SLN can be justified as follows:

- It supports intelligent applications by assigning semantic indicators and rules to links and enabling relational, analogical, inductive, and complex reasoning.
- It explores the laws of semantic linking. It pursues diversity and user experience of linking and exploring rather than the correctness.
- It provides a light-weight semantic networking approach for peer-to-peer knowledge sharing.

According to Zhuge [5] [7] SLN provides the following semantic link primitives (Table 1.) which increase the networks power of expression and as well reasoning capabilities.

Table 1. Semantic link primitives

Link type	Characteristics
Cause-effect	Transitive link that indicates causality between two items.
Implication	Transitive link which means that the semantics of predecessor implies to its successor.
Subtype	Transitive link indicates that successor is part of its predecessor.
Similar-to	Intransitive link that describes similarity in semantics between successor and predecessor.
Instance	Link showing that successor is an instance of the predecessor.
Sequential	Transitive link which indicates that the content of item A is a successor of the content of item B. Also links can be connected in a sequential chain.
Reference	Transitive link which means that item A is an explanation of item B.
Equal-to	Link showing that two items are identical in meaning.
Empty	Link showing that two items are irrelevant to each other.
Null or unknown	Link that indicates unknown or uncertain relation between two items.
Non-α relation	Link that shows that there is no semantic relationship between two items.
Reverse relation operation	If there exists semantic relation from A to B, then there exists also relation from B to A.

1.2. Adjacency relation systems

Adjacency relation systems (ARS) is a structure by which graphs can be used to illustrate the adjacency of elements belonging to sets, which represent different entity types [9]. ARS is a pair (A, R), where $A = \{A_1, A_2, \cdots, A_n\}$, $n \geq 1$, is a set containing pairwise disjoint finite nonempty sets and $R = \{R_{ij} \mid i, j \in \{1,2,\cdots,n\}\}$ is a set of relations, where each R_{ij} is a relation on $A_i \times A_j$. If $(x, y_1), (x, y_2), \ldots, (x, y_m) \in R_{ij}$ are all the pairs of relation R_{ij} having x as the first component, then each element y_k $(k = 1,2,\ldots,m)$ is *adjacent* to the element x [10].

The procedure for converting SLN to ARS is quite straightforward. In ARS the nodes and links of the SLN are represented as sets. Obviously, each node and link is a member of certain set of entity types.

Example 1. We have SLN (Figure 1) that contains nodes x_i and y_j that are connected by link α_k, denoted as $x_i \xrightarrow{\alpha_k} y_j$ (formal notation of SLN see for example [7]). The example ARS (Figure 2) is a pair *(A, R)* where $A = \{A_1, A_2, A_3\}$ and $A_1 = \{x_i\}, A_2 = \{y_j\}, A_3 = \{\alpha_k\}$. And *R* consists of relations: $R_{13} = \{(x_i, \alpha_k)\}, R_{31} = \{(\alpha_k, x_i)\}, R_{23} = \{(y_j, \alpha_k)\}$ and $R_{32} = \{(\alpha_k, y_j)\}$.

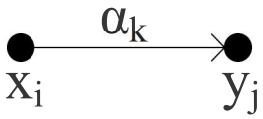

Figure 1. Example SLN

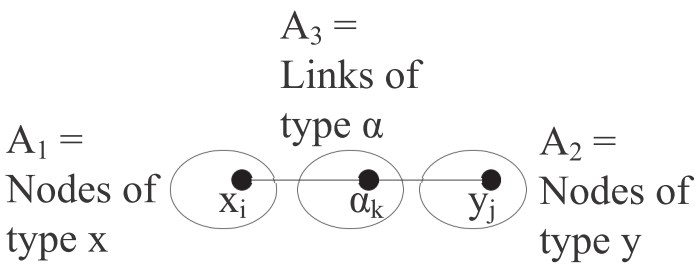

Figure 2. Example ARS

2. The case of statistical accident information reports

Statistical accident information reports are based on European Statistics on Accidents at Work methodology (ESAW-methodology) (see [4]) which is used as a domain data for this study (Figure 3).

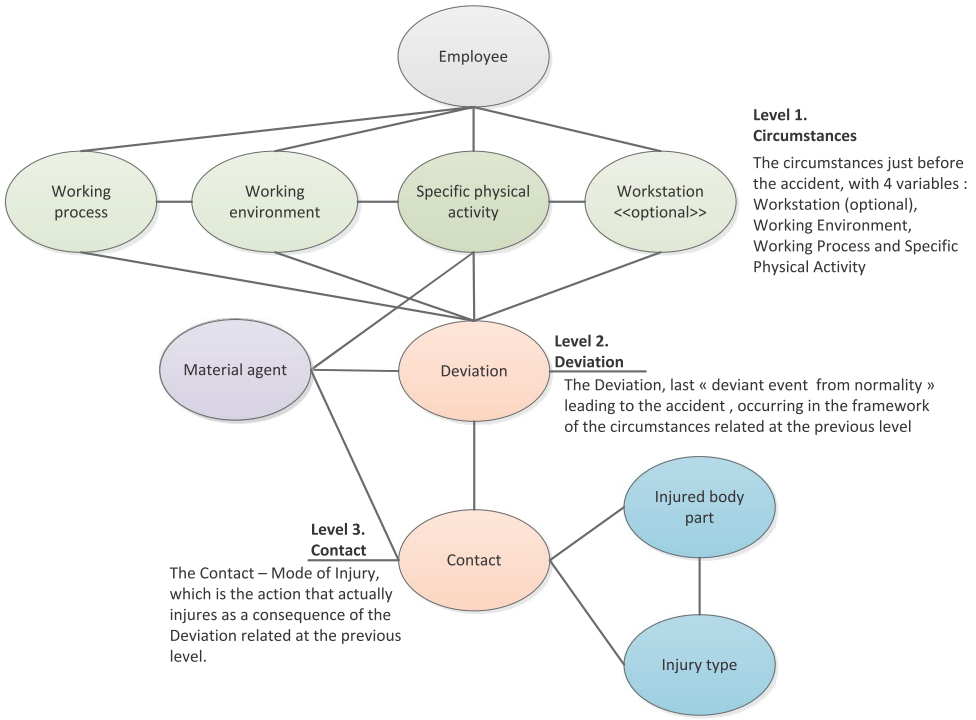

Figure 3. Concepts of Accident Record based on ESAW-methodology (see European Union)

In Appendix A is the first version of the semantic link network representation of the ESAW-based accident report. The network in Appendix A has some semantic properties attached to connecting edges. The next step is to analyze and assign links to a certain link primitives. Zhuge has defined twelve common link primitives (see Table 1.) the rest of primitives are derived if needed from the domain. The edges of the network in Appendix B

are assigned with Zhuge's link primitives. The semantic link network can then be converted into adjacency relation system. These steps should be done carefully because they effect to each other (see figure 1 and 2).

3. Conclusions

The benefits obtained by using ARS are: ARS is flexible enough to be used to represent relational and semi-structured data. ARS allows effective data querying. Proposed framework can be utilized in decision making. There is a method that converts ARS to relational database [11]. This means that semantically rich information could be reclaimed in legacy systems and could be exploited in different business intelligence systems and applications.

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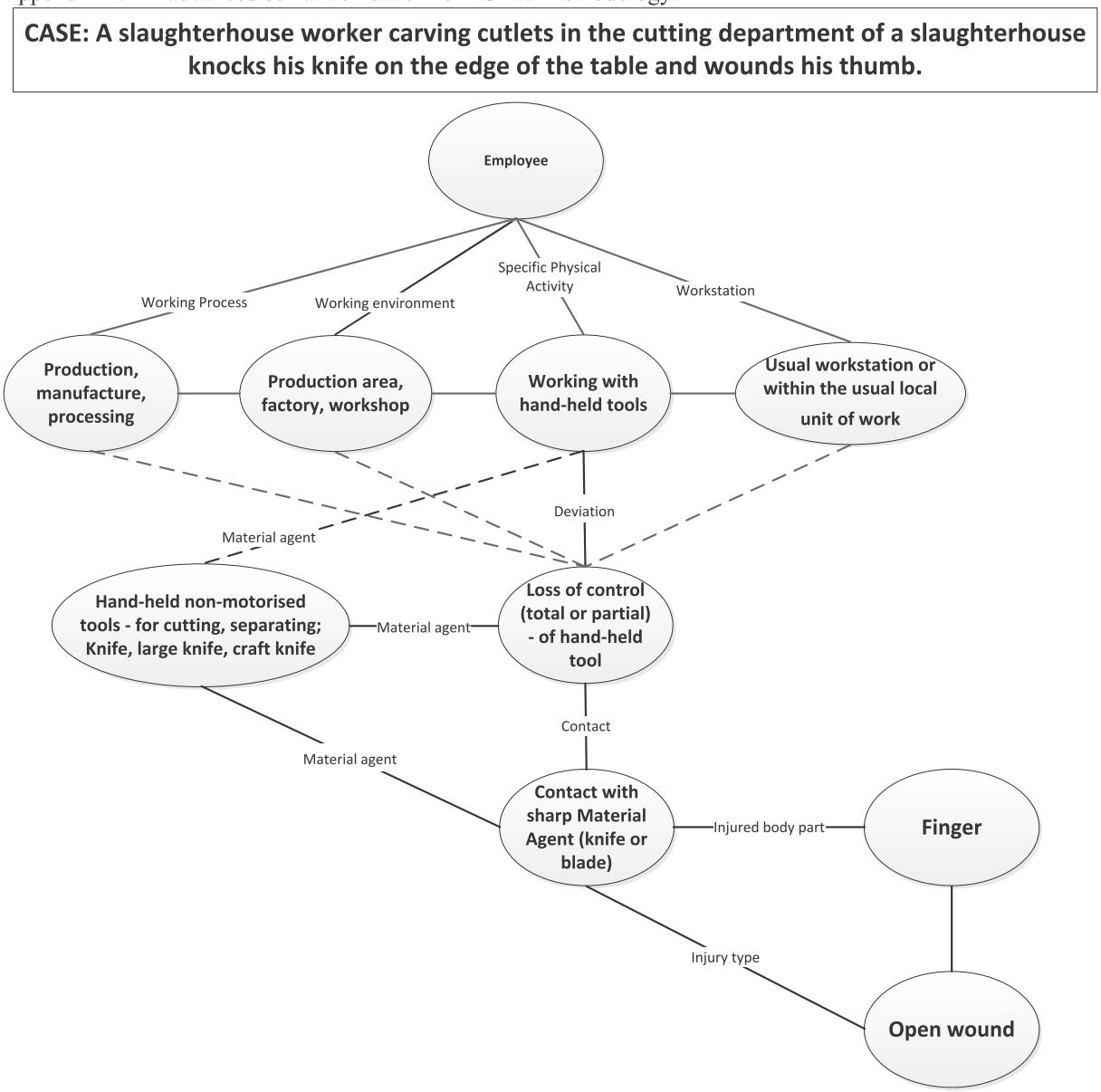
Appendix A. An advanced semantic network of ESAW-methodology.



Appendix B. Zhuges link primitives used in ESAW-methodology based network.

CASE: A slaughterhouse worker carving cutlets in the cutting department of a slaughterhouse knocks his knife on the edge of the table and wounds his thumb.

Link type	Abbreviations
Cause effect	Ce
Reference	Ref
Sequence	Seq