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EXPLOITING CONCEPT MAPS FOR THE REPRESENTATION OF COMPUTER SCIENCE TEXTS BASED ON A TEXT COMPREHENSION MODEL

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Abstract. The basic objective of this work is the knowledge representation of the content of Computer Science texts on the basis of a text comprehension model, by using concept maps. According to this model, a reader of a text constructs microstructure and macrostructure of its knowledge content. Microstructure is considered as the relational structure, which describes the static relations among the entities involved in the content, as well as the transformational structure, which describes the events that cause the change of the relational structure over the time. Macrostructure is considered the construction of the microstructure, as well as the teleological structure, which describes the goals of functions performed by the microstructure.

1 Introduction

Text Comprehension is a key research field of Cognitive Science; its basic objectives are the study of knowledge construction during reading and the text comprehension models. Some of the most well known theories and models on the human process of understanding texts are the Contruction-Integration Model (Kintsch, 1992) and the Latent Semantic Analysis Theory (Landauer & Dumais, 1997). In this work, concept maps are used as a key tool for the representation of the conceptual content of Computer Science texts and the Baudet & Denhière Text Comprehension Model (Figure 1), which analyzes in a better and more efficient way technical systems usually described within Computer Science texts, has been used as a reference model (Baudet & Denhière, 1992).

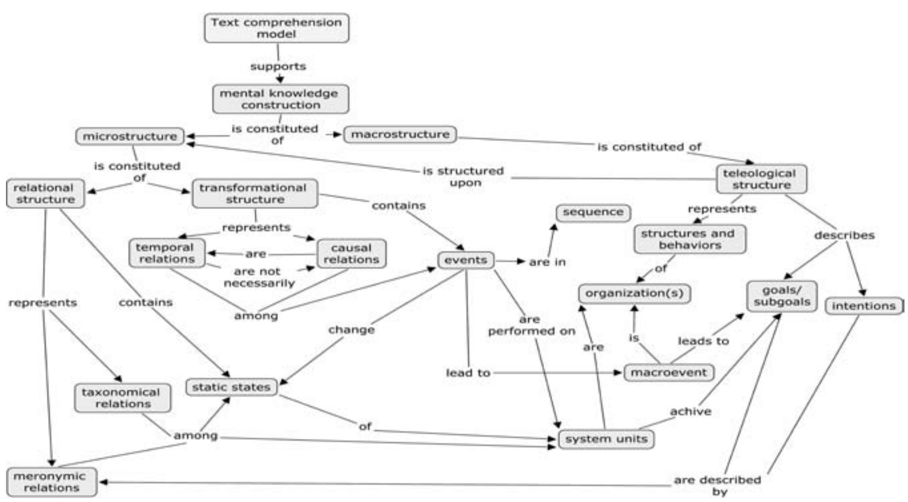

Figure 1. A diagrammatic representation of the text comprehension model

According to this model, the person reading a text builds gradually its micro- and macrostructure. The microstructure is a hierarchical structure of states and events related to the atoms described in the text and contains causal or/and temporal relations among the events. In details, an *Atom* is each individual entity that plays a role in text understanding, a *State* is a static situation of a system and reports no change over time and an *Event* describes an activity that causes changes over time but is not human-oriented. The event may be random or caused by a non-human activity, for example by a machine. The reader of a text is trying to organize and establish the meaning of what he/she reads, in order to build a representation of the "natural course of things" where every new fact is causally explained by the events that have already occurred. The entities of atoms, states and events are combined into complex hierarchical structures, creating the micro- and macrostructure. A system described in a *technical text* contains a set of interrelated units, organized into a tree-like goals/subgoals hierarchy called *Operating System*. A text allowing an accurate description of a *technical system* facilitates the reader in constructing the macrostructure and provides descriptions including the relational, transformational and teleological structure.

2 Concept Mapping upon the Content of Computer Architecture Texts

Scientific texts on Computer Architecture subject matter (Brookshear, 2005; Forouzan, 2003) were used for the text analysis and the construction of the corresponding concept maps according to the semantic relations (Snow et al, 2004) described below: (1) *Hyponymic/Hypernymic Relations*, where "A is a kind of B" or "B has kind A", i.e. "An ambulance is a kind of a car" or "A car has kind an ambulance", (2) *Meronymic Relations, where* "A is part of B" or "B is constituted of A", i.e. "A bicycle is constituted of aluminum", (3) *Attribute Relations*, which link an object with its characteristics, i.e. "The towers are tall". Especially for meronyms, a number of studies have been conducted to conclude with the different types of these relations. In Table 1, the six main types of meronymic relations (Winston, Chaffin & Herrmann, 1987) are shown. The distinction among these types follows three criteria: (1) *Function*, when parts of an object has a specific temporal/spatial position in relation to the other parts and/or to the whole, i.e. "a car wheel can be used in one particular position in relation to the other parts and the whole car", (2) *Homoeomeria*, when parts of an object are the same kind of each other and of the whole, i.e. "a grain of salt is the same kind of another grain and of a larger amount", (3) *Separability,* when set members can be separated naturally from the ensemble, i.e. "the wheel can be separated from the car".

	Meronymic Relation	Example	Function	Homoeomeria	Separability
1	Component- integral object	pedal - bicycle	Yes	No	Yes
2	Member-collection	Member - committee	No	No	Yes
3	Portion-mass	slice - pie	No	No	Yes
4	Stuff-object	flour - cake	No	No	No
5	Feature-activity	swallowing - eating	Yes	No	No
6	Place-area	oasis - desert	No	Yes	No

Table 1. Different types of meronymic relations

Based on the cognitive model structures described above, the expert's knowledge structure is presented in the following Figures, using concept maps as a representation tool. In particular, in Figure 2, an example of expert's relational structure is shown, which describes part of the ontology of the concept "Computer Memory and Storage Units". Because each technical document contains implicit knowledge, which is not mentioned explicitly in the text, it is necessary to add entities and relations among them implied, where there is a lack of continuity in the ontology created. On the map depicted in Figure 2, the numbers, shown next to the meronyms, identify the type of each meronymy according to the Table1. Some examples of different types of meronymic relations (indicated with bold blank lines in Figure 2) are: Magnetic disk is constituted of (4) {Stuff-object type meronymy} Magnetic material, Computer Memory is constituted of (1) {Component-integral object type meronymy} Main Memory, and CPU is constituted of (6) {Place-area} CPU registers. In Figure 3, an example of expert's transformational structure of the macroevent of reading from the DRAM memory is shown, where the following relations are used: (1) Has event: This kind of relation is a meronymic relation of Feature-Activity type (Table 1). It is used to indicate the events, which a macroevent is constituted of. Each event has a purpose, which must be achieved, in order for the system to change from a state to another, and reach the final one. The purpose of the event has met in the final state alone. (2) Causes: There is a causal relation between two events, when the one causes the other, (3) Follows: This relation indicates that one event follows another. That is, in order to execute an instruction, the system must first pass by another event without the first one causes the second. In particular, it appears that at the initial state of the system the processor is idle, while at the final state - after the execution of the events of the macroevent, the register R contains the content of MDR. The temporal relations (having the label "follows") are used for the events that run sequentially while the causal relations (having the label "causes") are used for the events that cause the others through the automatic management of the CPU control unit that generates control signals. In Figure 4, an example of expert's teleological structure is shown, where the following relations are used: (1) Has goal or has subgoal/presupposes: This relation is used to state the purpose of a particular entity/unit of the system. Relations of this type are located on the upper levels of the hierarchy of the technical system. (2) Is implemented by: The relation of this type is actually the link connecting the teleological structure with the transformational structure. Figure 4 highlights the system macroevents through which its goals/ subgoals are getting fulfilled, e.g. the "dynamic reading" is implemented by the macroevent "DRAM-read Operation". Figure 3 depicts the transformational structure of this macroevent.

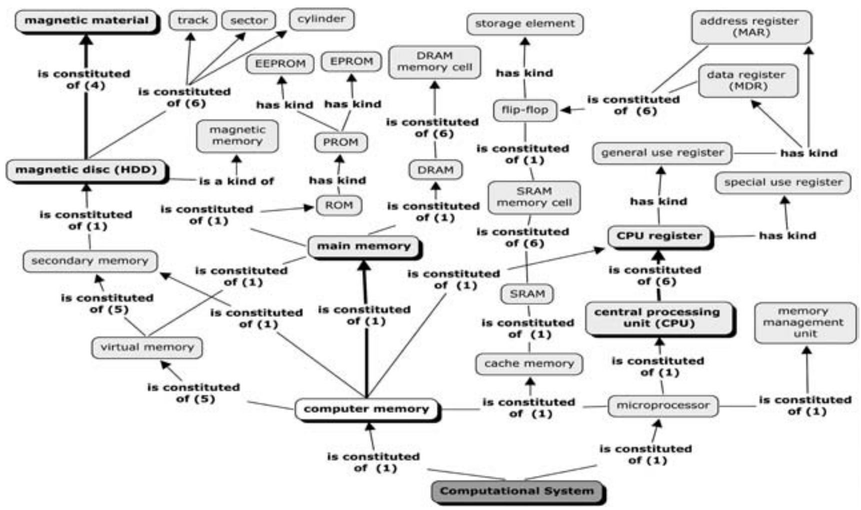

Figure 2. An example of concept map describing hypo/hypernymy and the different kinds of meronymy

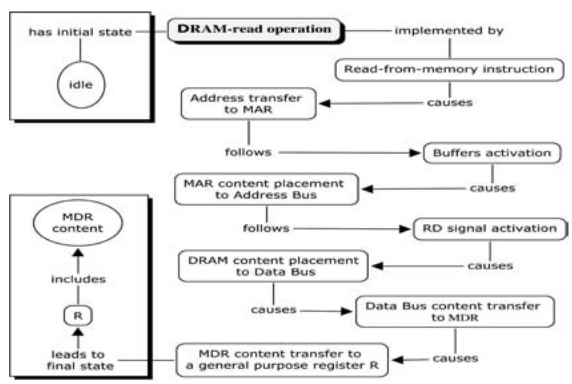

Figure 3. An example of the transformational structure describing "DRAM-read" operation

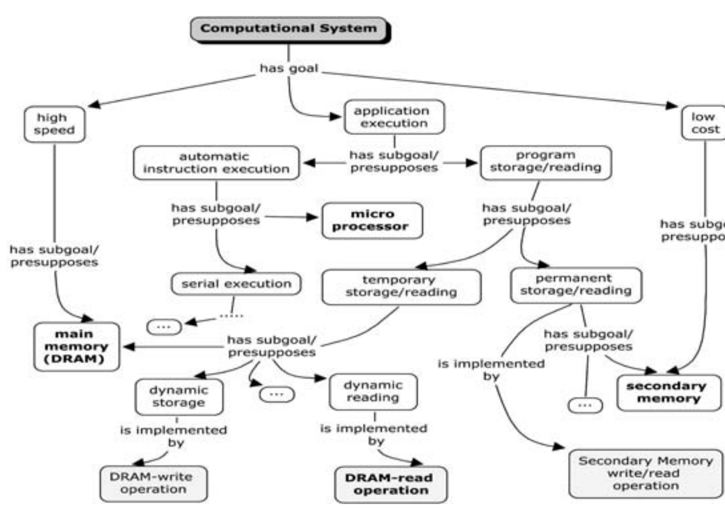

Figure 4. An example of the teleological structure describing "Application Execution" by a Computer

3 Discussion

In Section 2, the representation of expert's knowledge structures on the central concept of "Computational System" using concept maps and based on the Baudet & Denhière model is discussed. In particular, starting conversely, the teleological structure describes how a computational system is organized to achieve the goals and leads to the transformational structure - macroevents – describing the events to be performed, in order for the system to meet its goals/subgoals, and the causal and/or temporal relations among them. Finally, the relational structure describes the entities – and their attributes - involved in the macroevents of the computer's memory system depicted in the transformational structure in order to achieve the goals depicted in the teleological structure.

The results of a study revealed that students acted as readers of a Computer Science text can construct concept maps associated with the relational structure, since in most cases readers come into a direct contact with the explicit knowledge related to this structure (Blitsas, Papadopoulos & Grigoriadou, 2009). The transformational and the teleological structures of a technical system are not specifically mentioned in the texts and therefore should be drawn from the readers. Moreover, the results revealed that (i) students who have a superficial understanding of the basic concepts and represent sufficiently the relations among concepts in microstructure faced problems in representing the teleological structure, and (ii) students who have deeper concept knowledge perform well even in teleology. In this context, concept maps constructed for representing expert's relational, transformational and teleological structure can guide the design of concept mapping activities, asking students for example to (i) extend a given relational structure map with transformational/teleological structures and/or (ii) complete a given map by filling in the appropriate events and/or states. Moreover, the maps designed according to the cognitive model and extracted in XML/TXT format, could also be used by the Semandix tool, which is a discipline-independent tool, developed in the context of implementing a system for evaluating free text responses (Blitsas, Grigoriadou & Mitsis, 2009). It allows enrichment of its database with semantic content from different sources on the basis of the abovementioned model. In particular, it allows the enrichment of its database with semantic content from concept maps and computational dictionaries databases (WordNet), and gives the possibility of searching any terms based on the text comprehension model. Our future goals include a new Semandix feasibility of adding free text responses and of exploring automatically alternative conceptions appearing within them with respect to the knowledge structure represented on the criterion-reference map (expert's map).

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