Using Cognitive Categories for an Interactive Diagnostic Learner Model of Historical Text Comprehension

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Abstract:
In this contribution we present a Learner Model (LM) of Historical Text Comprehension (HTC), which infers the cognitive profile of learner's global comprehension concerning the recognition or not of the three fundamental cognitive categories: action, state and event. Moreover the LM infers the profile descriptor, which displays the learner's learning difficulties. The diagnostic module of the LM, which has been presented in our previous work, imitates human diagnosis using Fuzzy logic and Case-Based Reasoning techniques of artificial intelligence. Based on the diagnostic results the model activates the learner in an interactive diagnostic dialogue. The LM is externally explicit and open to discussion and helps learners to become conscious of the quality of their answers, reflect back to claims about their reasoning and some times change their reasoning.

Keywords:
cognitive categories, historical text comprehension and learner model.

1. Introduction

Traditional computer diagnostic systems infer the reasons for the student's behaviour without directly involving the student. Recently, there is a growing interest in opening the student model to the learner, encouraging him to reflect on his beliefs and on the learning process, [9]. Thus, diagnosis is considered as a process, which depends on the diagnosee's involvement and the diagnoser's ability to encourage this involvement [6]. Diagnostic dialogue between the learner and the system about learner's own beliefs and the beliefs of the system about the learner makes a LM externally explicit and open.

On the other hand, a method for improving learning through promoting reflection is to have the learner defend his views to the system by discussing and arguing the system's assessment of his knowledge and beliefs [2]. This is achieved through discussion between the learner and the system about learner's own beliefs and the assessment of the system about the learner. Recently, approaches that involve learners in diagnosis have been proposed [11][9][3]. Systems are being built to give the learner greater responsibility and control over learning. Interactive open learner modeling involves human learners in diagnostic dialogues and extracts a picture of the learners' cognition in terms of his beliefs and his reasoning.

In the domain of comprehension of historical text, the computational diagnostic process imitates a human expert's ability to estimate how the learners comprehend the historical text and what are their learning difficulties. In our previous work a diagnostic student model of historical text comprehension using fuzzy case- based reasoning techniques has been presented [13]. In the present work we demonstrate an open to discussion LM, which infers the learner's cognitive profile and profile descriptor of HTC and moreover involves the learner in diagnostic dialogue. In section 2 we concentrate on the LM of HTC. In Section 3, we the briefly highlight the Fuzzy- Case Based (F-CBR) approach. In section 4, the diagnostic interaction between the learner and the system is discussed. In section 5, we conclude and give short-term perspectives.

2. The Learner Model of HTC

Models of HTC

Comprehension of historical text is a special kind of the complex and interactive cognitive process of comprehension. The reader utilises certain fundamental cognitive categories for establishing and organising the meaning of the text [1]. Comprehension is viewed as attribution of meaning to causal connections between events in the historical text [5]. Historical narration is considered as an argumentative discourse, as an unbreakable system with a start and an end. Historical narration is defined as a causal transformational system: a) it is characterised transformational because it describes the representation of a complex historical event that is a historical transformation, which has happened in a particular place and time. b) It is characterised causal because it describes an historical event, which is interpreted by a series of causal links. Historical narration is based upon causal connections.
In the level of comprehension as a cognitive task, the representation of the historical text the learner composes, is a system, which contains the cognitive categories: *event*, *state* and *action*. Comprehension of historical narration is associated with causal connections and arguments made by the reader. The arguments are based on the three cognitive categories. For the interpretation of learners' cognitive actions we analyse their discourse tracing the recognition or not of the three cognitive categories. Historical actions constitute the core of the historical discourse. According to relevant research, the recognition of the cognitive category *action* is more important than that of *state* [5]. The recognition of the cognitive category *event* is less important than that of the *state.*

Learner's Cognitive Profiles of HTC

Cognitive models, which reflect the learners' levels of historical thought, concern the recognition of the three general cognitive categories: *event*, *state* and *action* [12]. These categories are represented by their instances in the historical text. Given the historical text, question-pairs and alternative answers, the learner is asked to use the alternative answers in order to express his *position* against certain historical issues and support it selecting a *justification*. The LM composes the learner's *arguments* by combining his *positions* and *justifications*. An *argument* is considered complete if both *position* and corresponding *justification* are right. When a learner composes a *complete argument* it means that he recognizes the corresponding cognitive category. Then, taking into account the number of *complete arguments,* the model results in the formulation of the learner's cognitive model and cognitive profile for HTC.
Table 1 depicts the cognitive models and the cognitive profiles of HTC. The general categories of cognitive models considered are: *Historical Thought* (HT), *Towards Acquiring Historical Thought* (TAHTnx) and *Non-Historical Thought* (NHT). TAHTnx cognitive models are categorised in more detail according to the number n of recognised by the learner categories and to the number x of instances. TAHT1 means that the learner recognises 1 instance of a cognitive category, whereas TAHT1x means that the learner recognises x instances of a cognitive category, where x>1. The same stands for TAHT2, TAHT2x, TAHT3 and TAHT3x. The number n of recognised categories and the number x of recognised instances of every cognitive category formulate the cognitive profiles and give a first level of classification based on quantitative characteristics. The cognitive profiles determine the degree to which the learners face learning difficulties. Learners with *Very Low* profile seem to have serious difficulties in thinking historically. Learners characterised by terms like *Low, Nearly Low, Below Intermediate, Above Intermediate, Nearly High and High,* seem to encounter difficulties in thinking historically. Learners with V*ery High* profile seem to have no learning difficulties.

Table 1. Cognitive models and the corresponding cognitive profiles of LM

Cognitive models		**Number and types of recognized cognitive categories**	**Cognitive profiles**
NHT		-	Very low
	TAHT1	1 event or 1 state or 1 action	Low

TAHTnx	TAHT1x	more than 1 events or more than 1 states or more than 1 actions	Nearly Low
	TAHT2	(1 event and 1 state) or (1 event and 1 action) or (1 state and 1 action)	Below Intermediate
	TAHT2x	(more than 1 events and states) or (more than 1 states and actions) or (more than 1 events and actions)	Above Intermediate
	TAHT3	1 event and 1 state and 1 action	Nearly High
	TAHT3x	more than 1 events, states and actions	High
HT		all events, states and actions	Very High

The qualitative characteristics of the arguments are the *completeness,* which reflects the degree of recognition of a cognitive category and the *quality* of the corresponding cognitive category. Table 2 demonstrates all possible combinations of *position-justification* pairs and the corresponding argument *completeness*. Possible characterizations of position or justification are *Right*, *Mediocre* and *Wrong (R*, *M* and *W*). Possible values of the argument *completeness* are: C*omplete, Almost Complete, Intermediate, Nearly Incomplete and Incomplete (C, AC, I, NI and IC)*. For example, if the position is characterized right and the justification wrong then the argument is incomplete.

Table 2: *Argument completeness values concerning Position - justification* combinations.

position	R	R	R	M	M	M	W	W	W
justification	R	M	W	R	M	W	R	M	W
completeness	C	NI	I	AC	NI	IC	I	NI	IC

As was mentioned before, during comprehension of historical text the recognition of the cognitive category action is more important than that of state, whereas the recognition of the cognitive category event is less important than that of state. Table 3 demonstrates the cognitive category *quality* values. Possible values of the *quality* are: *superior* for the *action*, *medium* for the *state* and *inferior* for the *event*.

Table 3: *Quality* values of cognitive categories

cognitive category	action	state	event
quality	superior	medium	inferior

The *profile descriptor* describes the learner's cognitive profile by exploiting information carried by the *arguments' completeness* and the *quality* of the corresponding cognitive categories. For example, a *Nearly Low* cognitive profile of a learner, during comprehension of a historical text with 5 fragments and 5 corresponding question-pairs, can be accompanied by the following *profile descriptor*: "The learner gives *one complete argument of inferior category, one nearly incomplete argument of superior category, one nearly incomplete argument of superior category, one incomplete argument of superior category and one incomplete argument of medium category ".*

Figure 1 depicts a part of the historical text concerning different factors concerning the outbreak of French Revolution a question-pair and the corresponding alternative answers. It also indicates the characterizations of the answers, which are not visible to the learner. The answers a1 to a3 are alternative answers to question 3a concerning the *position,* whereas the answers b1 to b5 are alternative answers to question 3b concerning the corresponding *justification.*

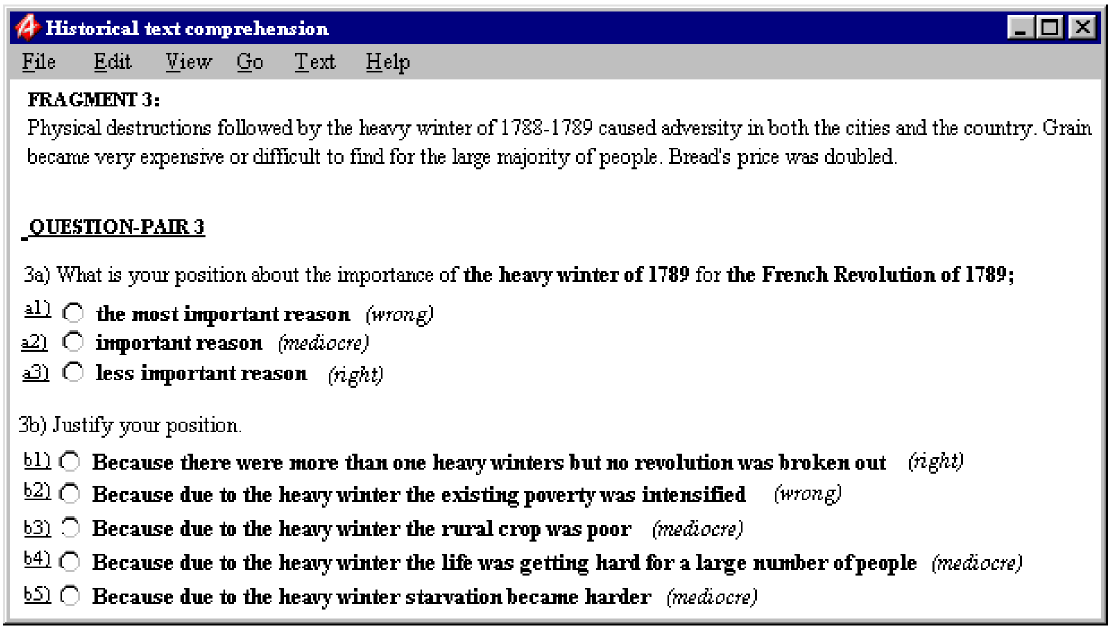

Figure 1: A screenshot depicting a fragment of the historical text concerning the cognitive category event, with a question-pair and alternative answers.

For example, if a learner selects the answers a3 and b1 this constitutes a *complete argument* of *inferior category* and indicates the recognition of one instance of the cognitive category (in this example the category *event*). If a learner selects the answers a2 and b4 this constitutes a *nearly incomplete argument* of *inferior category* and indicates no recognition of the cognitive category (event). Based on the learner's answers, which are *position- justification* pairs, the model infers the corresponding *argument* characteristics completeness and quality. Based on learner's arguments the model formulates the learner' *cognitive profile* and the *profile descriptor.*

3. The Fuzzy Case Based Reasoning Learner Model

The learner is given the historical text to read and question-pairs and alternative answers. The system involves the learner in an activity by asking him to use the alternative answers in order to express his preferences by selecting his position for certain historical issues and supporting his position by selecting a justification. The learner is encouraged to response by selecting the right answers according to his opinion. The system represents learner's observable behaviour during HTC based on his answers, position- justification pairs, which constitute the arguments. The completeness of learner's arguments and the quality of the corresponding cognitive categories reflect his learning difficulties. The diagnostic module of the system imitates human diagnosis and dynamically infers the cognitive profile of learner's global comprehension concerning the recognition or not of the three cognitive categories. Moreover it dynamically infers the learner's profile descriptor, which describes the learner's learning difficulties.

Our system's artificial intelligence stems from the application of F-CBR techniques in the learner modeling process [4][13]. F-CBR techniques integrate the right balance between expert's knowledge described in the form of fuzzy sets and previous experience-cases. Diagnosis is based on comparisons between the learner's behaviour-case and the experience-cases of the case base [10][8][15]. Based on learner's arguments the model formulates the learner' cognitive profile and the profile descriptor by retrieving and adapting the most similar case from the case base. At the end of this process the LM reflects back to the learner the evaluation results.

4. The Diagnostic and Learning Interaction

According to the evaluation results the system adapts to the learner the appropriate dialogue. The system involves the learner in a knowledge-building activity supported by a diagnostic and learning dialogue, which aims at making him aware of the differences between him and the system. The learner can ask for explanations and justifications of the computers' opinions, can agree or disagree with the system [2]. The system can inquire, inform, challenge, suggest or disagree with the learner.
The excerpt bellow shows a fragment of the interaction between the learner and the system. Initially, the system externalizes the learner his cognitive profile and profile descriptor and asks him if he wants to be involved in a dialogue. If the learner wants the dialogue with the system, the interaction between the system and the learner occurs in the following stages: In the first stage the system assesses whether the learner is correct or not, without indicating the error. In the second stage the system indicates where the learner has errors. In the third stage the system discusses and justifies itself and argues with learner for his errors. In the fourth stage the system encourages the learner to answer again. At the end, the system can reassess the learner.

System: Your answers concerning the LIVING CONDITIONS indicate that you consider it as THE MOST IMPORTANT REASON for the French Revolution. Your argument is characterized INCOMPLETE. Do you want the system to EXPLAIN or to CONTINUE?
Learner: EXPLAIN
System: You asked the system to explain. Your answers concerning the LIVING CONDITIONS consist of your position and your justification. Your position is that the LIVING CONDITIONS was THE MOST IMPORTANT REASON for the French Revolution. This is a WRONG position. Your justification for that position is that the LIVING CONDITIONS WERE THE SAME FOR MANY YEARS. This is a RIGHT justification.
Your position about the LIVING CONDITIONS is CONTRADICTORY TO your justification. That is why your argument is characterized INCOMPLETE. What do you intent to do now?
Learner: I insist in my position that the LIVING CONDITIONS IS THE MOST IMPORTANT REASON
System: What about your justification? What do you intent to do now?
Learner: I insist in my justification that the LIVING CONDITIONS IS THE MOST IMPORTANT REASON
System: You insist in your position and in your justification. Let consider that the LIVING CONDITIONS as a reason for the French Revolution didn't exist. Do you believe that the outbreak of the French revolution would have happened?
Learner: I don't know.
System: In history exist similar cases, in which a society suffered but remained inert for many years, until some human intervention has happened.
Learner: It seems convincing, but can you explain it in more details?
System: The static system of the LIVING CONDITIONS was in a balanced situation A (before the Revolution). Some human interventions happened and disturbed this balance guiding the system to a situation B (the Revolution).
Learner: I understand
System: Try to answer again

5. Conclusions

In this work we highlighted an open to discussion LM, which infers and externalizes the learner's cognitive profile and profile descriptor of HTC. Based on the diagnostic results the model activates the learner in an interactive diagnostic and learning dialogue. The system helps learners to be aware of their reasoning, reflect back to claims about their reasoning and some times change it. The result of diagnostic interaction is eliciting a representation of the learner's cognition with the active participation of both the learner and the system. So, this system has a strong potential in advanced learning environments and is capable of tailoring to the needs of the learners and promote meta-cognitive processes. The F-CBR diagnostic model has been tested with learners and experts. In our future plans falls research concerning the application and evaluation of the diagnostic and learning interaction.

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