Intelligent Self-Study Aid: A Revision Tool that uses Natural Language

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Abstract: - Intelligent Self-Study Aid (IS-SA) is a revision tool that communicates in natural language. Hypertext facilities are valuable in the revision process but they are not enough. They are tailored more to what teachers expect from students than to the needs of the students. IS-SA is designed as a revision tool and it is tested in the analysis and study of past exam papers. It consists of two main components: the Explanatory Environment (EE) and the Knowledge Acquisition Program (KAP). In this paper we present the structure of IS-SA, the results of our testing and we discuss its potential uses.

Key-Words: Computers and Education, Revision Tools, Natural Language Understanding, Explanations, Distance Learning

1. Introduction: Revision Tools and Natural Language

‘Revision’ is the last stage in the learning process that summarises the previous stages of the delivery and understanding of the teaching subject. In general, students are advised to revise ‘by active processes that include studying the subject using different approaches,…. doing past examination questions, rewarding their achievements and in particular using non-repetitive and thought-provoking activities that give them some pleasure.’ [8] At this stage hypertext techniques are really valuable but they are not enough. Some drawbacks of hypertext methods are the following:

- They are static and pre-defined by the teacher. Students are not allowed to ask their own questions.
- Even if different activities are used – from multiple choice questions to Web puzzles [6,8] – students are not allowed to make their own associations between the different topics.
- They do not help in the acquisition of language skills.

In this paper we present IS-SA. IS-SA has been designed as a revision tool and it has been tested in the study of past exam papers. It has the potential to be used as a teaching tool on its own.

2. Intelligent Self-Study Aid (IS-SA): a tool for students and teachers

IS-SA consists of two parts: the Explanatory Environment (EE) and the Knowledge Acquisition Program (KAP).
EE allows students to ask questions in natural language and KAP allows teachers to enter data to the system. The main characteristics of IS-SA are the following:

- It is interactive and it communicates in natural language.
- It constructs all the possible interpretations of student’s question and it generates all the possible answers.
- It stimulates the user by providing alternative interpretations of the input question.
- It is subject-based tool.

The following figure shows the structure of IS-SA:

![Figure 1: the structure of IS-SA](image)

Teachers can insert data to the system via the KAP. The data are saved in a database. The structure of the database is designed in order to work well with the EE. Students use the EE to ask their questions. A question goes to the ‘syntactic parser’ that produces the syntactic structure of the input question. The syntactic structure is the input to the semantic parser that produces all the logical representations of the question. The semantic parser makes use of the ‘semantic grammar for explanations’. (part of this grammar has been published in [2]) We have called the logical representations of the input question ‘explanation objects’. Each explanation object is transfer to the explanation generator that communicates with the database produced by KAP and it generates the ‘structure of the answer’. Finally, the ‘answer generator’ produces the actual answer in natural language. The answer is presented in the EE. (for a detailed description see [3]).

3. The Explanatory Environment

EE aims to provide students with all the necessary information that will help them to understand the answer. Apart from the main answer, it offers information about the model used to construct this answer and the type of knowledge this model provides; the possible interpretations of the input question as well as the terms that are included in the answer and they can be explained further. The types of questions that the EE can answer fall within the following categories:

- Semantic explanations. Under this category we have included all those questions that ask for pieces of information.

- Explanations. Under this category we have included questions that can be answered by any one of the explanation models. In some cases, different explanation models can produce answers for the same explanation object. These answers are categorized as more or less advanced explanations. The explanation models used to explain X and the different types of knowledge that each model provides are:
  - the necessary and sufficient conditions that make X necessary (Deductive-Nomological model)
  - the statistical conditions that make X possible (Inductive-Statistical model)
• how X is fitted into a frame (Schematic model)
• the cause of X (Causal model)
• analogical events for X (Analogical model)
• the possible interpretations of X (Linguistic model)

The above models have been defined and they are used by psychologists, philosophers, cognitive scientists and computer scientists [4, 7].

The number of the possible interpretations of an input question is given by the formula: \((X)^Y Z\), where X is the explanation topic, Y is the number of conditions for the explanation topic (we named them ‘compatible and incompatible associated entries’) and Z is the number of alternatives for each explanation topic and/or for each condition (we named them ‘alternative conditions’). For example, the analysis of the question ‘Why does it rain in London?’ goes as following. The explanation topic is ‘rain’. ‘London’ is a condition for ‘rain’ and it consists a ‘compatible explanation entry’. A more complicated question can be ‘why does it rain in London and not in Sahara’. In this question ‘Sahara’ is an alternative for the condition ‘London’. The grammar can analyse a question as complicated as: ‘why does it rain instead of snowing in London and not in Sahara’. In this case, the explanation topic is still ‘rain’, alternative topic is ‘snow’, condition to the topic ‘rain’ is ‘London’ and alternative condition to ‘London’ is ‘Sahara’.

4. The KAP *

KAP allows teachers to enter data to the system. It is implemented in Visual Basic and it consists of three sections: ‘Questions and Answers’, ‘Update the Dictionary’ and ‘Add Synonyms’. A major concern during development was to ensure that the two parts (EE and KAP) work well together and that all knowledge required by the EE was acquired by the KAP. This is the responsibility of the first section of KAP (Questions and Answers) where the user has to answer some simple questions that will allow the system to construct the possible explanation objects. For each exam question the teacher is asked to provide the following information: the ‘explanation topic’, ‘compatible associated entries’, ‘incompatible associated entries’ and ‘alternative conditions’. The answers are converted to text files and they are saved in a database.

The ‘update the dictionary’ section allows the teacher to add new words to the dictionary. This increases the flexibility of IS-SA. The user is asked to classify each new word that is added to the dictionary by the part of speech to which it belongs. A new word can be classified as noun, proper noun, adjective, verb, adverb or unknown. Determiners, prepositions and question words (why, when etc.) will not need to classified as they are provided by the syntactic parser of the EE.

The last section of KAP is the ‘add synonyms’. Although this section is not compulsory, it is very important for IS-SA and for the construction of a successful communication with the user. In this section, we ask the user (teacher) to provide alternative ways to phrase a question. A dictionary of synonyms is constructed.

Finally, in order to make IS-SA more flexible KAP also:
• automatically generates the different forms of verbs for regular verbs
• automatically generates the different forms of nouns for regular nouns
• automatically generates possible typing errors for all words input.

* Some sections of ‘KAP’ were designed within a research program funded by the University of Westminster (Development Fund, 1996).

5. Testing

IS-SA has been designed as a revision tool for past exam papers. It has been tested within the University of Westminster. A study of more than two hundred exam
questions from subjects within the field of computer science showed that [5]:

- There is no standard question structure
- 55% of the exam questions can be classified as ‘define questions’ (semantic explanations)
- 39% can be classified as ‘typical explanation questions’. These questions are answered by any one of the explanation models.
- 6% can be classified as ‘comparison questions’. These questions can still be treated by the system, although not in the ideal way. They are analysed to two different explanation questions and each one is answered separately.

We asked lectures and students from the Biology department of the University of Westminster to use IS-SA. We chose a totally different field in order to have users with limited computing experience. IS-SA was tested during three sequential sessions and the testing was carried out by personal interviews and a brief questionnaire. The feedback we got resulted in the implementation of a number of modifications for the interface of KAS. Most of the comments were positive for the usefulness of IS-SA as a revision tool for students. Finally, testing highlighted again the fact that the theory behind explanations is most complex and that we need good understanding of this theory in order to create a useful revision tool.

5. Potential uses of IS-SA and further research

Potential uses of IS-SA are:

- as a revision tool for questions other than examination questions. The student should be able to ask any question. This carries a lot of responsibility for the construction of the dictionary.
- as tutoring tool. In can be used on everyday basis and not only for revision.
- as a distance learning educational tool. It can be used in an asynchronous mode of distance learning study to substitute the lack of contact between the teacher and the student.

Our current research focuses on a more powerful parser that can analyse different types of input questions. To achieve this we have expanded the explanation grammar in order to accept logical connectives.

References:


