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ABSTRACT

Computer assisted language learning (CALL) packages offer the majority of students who are learning English as a foreign language the opportunity for individual instruction. To meet the needs of an individual student, an adaptive CALL environment must have a dynamic model of student performance, a means of varying the difficulty of the learning task, and a mapping between student competence and task complexity. There are two main types of user-adaptive interfaces for language learning: discrete-step interfaces and continuously variable interfaces. Before designers can build CALL systems that "understand" their users, they must be able to analyze the interactions between the user and the computer in the language learning task. Language learning skills may be divided into the categories of lexical skills, syntactical skills and discourse skills. The first task in recording and measuring student performance is to devise a user profile; the second task is to ensure a continuum of exercises. Once the student has decided what linguistic skill to work on, there are four stages to the exercise generation process: (1) determining a suitable source; (2) choosing suitable passages; (3) selecting from these passages examples most suited to user needs; and (4) generating the electronic version of the exercise. The format of the exercise used in this study was found to be generally effective; however it is unclear to what degree there is a correlation between readability grade and exercise difficulty. (AEF)

A User-Adaptive Interface for Computer Assisted Language Learning

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Abstract: To meet the needs of an individual student an adaptive CALL package must have a dynamic model of student performance, a means of varying the difficulty of the learning task, and a mapping between student competence and task complexity. This paper analyses how these components can be implemented for lexical, syntactical and discourse skills using domain knowledge from the Oxford Advanced Learner's Dictionary and the Susanne Corpus, a fully tagged subset of the Brown Corpus.

Rationale for Computer Assisted Language Learning

Students who are learning English as a Foreign Language in an English-speaking country form a multi-cultural group with disparate motivations and goals, whose diversity cannot be adequately accommodated in a traditional classroom. There is no rate of imparting information nor sequence of instruction that will meet the needs of every student. Teachers can only construct in their mind a model of the 'average' student and have as their goal the adequate progress of this hypothetical student; frequently they are guiltily aware that the more able will be bored while the less able will be lost. Today computerised language learning packages offer the majority of students their only realistic opportunity for individual tuition. Even with the most mundane of CALL packages, each student can essay an answer to every question, repeat lessons not fully comprehended or skip lessons that merely rehearse previously acquired skills. A CALL package which permits a student to make this sort of choice is sometimes referred to as a *user-tailored* system.

Self-directed learning of this kind has been shown to benefit *mature learners*, that is, experienced students of proven academic competence (Kearsley & Hillelsohn, 1982), who are capable of determining their own educational needs. However, less experienced or less able students may not be able to make an accurate assessment of their own shortcomings or to devise for themselves a coherent and comprehensive study plan. For these students, a CALL package can be immeasurably improved by a user-adaptive interface i.e. an interface where adaptations in the order and pace of learning are made by the system, not by the student.

User-Adaptive Interfaces

A *user-adaptive interface* is one which can change its behaviour automatically in response to its experience of user performance, that is, it changes to suit the skills and knowledge of an individual student. The system designer or language teacher no longer tries to construct an interface for a stereotypical average user, to which no real learner conforms. Instead, the designer accepts that no single learning theory pattern is suitable for all students – or even for one student over a range of skills or a period of time – and realises that the teaching package must adapt to the student's varying abilities in different skills by providing information and exercises at a level which matches the student's current needs. To this end an adaptive learning package must have three components:

- a means of recording and measuring individual student performance. This could also be described as a dynamic model of the user's past performance and current capability. This dimension of capability is inevitably continuous rather than discrete.

• a means of adjusting the learning task so as to change its difficulty. In the context of language learning this might simply be the ability to offer appropriate help and linguistic explanations to students of various levels of ability and to set for each student exercises commensurate with the student's expected performance.

• mappings of help level onto student capability and of student capability on to degree of difficulty. How these mappings are achieved determines the type of user-adaptive interface.

Types of User-Adaptive Interfaces

There are two main types of user-adaptive interfaces for language learning: discrete-step interfaces and continuously variable interfaces.

Discrete-step interfaces

A *discrete step interface* is an interface which identifies the user as a member of a particular ability group and sets the interface to correspond with the skill level for the group. This, while more satisfactory than a general user interface, does not allow for continuous variation in student capability but assumes discrete ability levels. In language learning it is a practical solution for the organisation of *expert procedural knowledge*, which is the distillation of the rules that govern the lexical, syntactical, and discourse structures of the language. The traditional presentation format for this knowledge has been textbooks and reference books. Such books might be aimed at a specific category of language learner e.g. *novice*, *intermediate*, *expert*, or might be an exhaustive exposition of all facets of a language for scholars of comparative linguistics and languages. Knowledge of this kind has never formed a continuum: each text represents the independent view of one teacher or expert on the information needed by an *average* learner at a *typical* stage in the learning process. The order in which the information is presented may be said to represent the author's strategy for how best to accomplish the learning task. Computerised learning packages, particularly those implemented in hypertext, allow us to separate monolithic texts into fragments and to convert these fragments into many different virtual structures. This is useful for accommodating students whose ability over different linguistic skills varies widely: in one skill a student may be given a simple explanation from first principles while in another the same student may be given only a brief hint or reminder because past performance indicates a consistently high level of ability. In a skill where the student's ability is intermediate, extra information and/or explanation of more abstruse points may be provided. But, however skilful the dissection of the information and however varied the virtual knowledge structures in which it can be stored, it is not possible for the computer, to re-write or even re-phrase the expert knowledge to cater uniquely for the needs of an individual student as a human teacher might be able to do. Thus, the interface for expert procedural knowledge remains a discrete-step interface.

Continuously variable interface

Although levels of procedural knowledge are discrete the domain knowledge in any natural language is, of course, a continuum. *Domain knowledge* consists of the accumulated oral and written records that are accepted by the native speakers of this language. While the documents that comprise these sources may in themselves be as discrete as the expositions of procedural knowledge, together they form a continuum that represents every aspect of language use in every sphere of human activity. That this is so, is recognised by the accumulation of corpora – collections of texts from different genre assembled to enable language scholars to investigate the evolution and current state of a language. The remainder of this paper will discuss how corpora may be used to build an interface which uniquely adapts to the linguistic needs of an individual student in the generation of exercises to improve the student's linguistic skills. As a first step, it will look at ways of recording and measuring student performance.

Recording and Measuring Student Performance

Before designers can build CALL systems that 'understand' their users, they must be able to analyse the interactions between the user and the computer in the language learning task. This means that they must be able to specify the skills that make up the learning task and must have ways of measuring student performance in individual skills. Language learning skills may be divided into three major skills categories:

Lexical skills appertain to words:
Syntactical skills are the skills needed to produce grammatically correct phrases or sentences.
Discourse skills are the skills needed to write coherent and cohesive text.

Obviously, all these skills overlap but nevertheless they provide the parameters for creating a student performance model. The parameters are given values which indicate the student's past performance in the relevant skill. The student's attainment can be assessed simply by measuring the student success in linguistic exercises to assess and improve the skill. In this way, student competence can be viewed as a continuum. The student exercises should, of course, be set at a level which is appropriate to the student's current attainment so that every student is stretched to the limit of current ability: competent students should not be bored, weaker students should not be intimidated.

An initial user profile

The first task is to devise an initial user profile. This can be done simply by using a standard model for novice, intermediate, or expert. This model will rapidly self-adjust to give a more accurate assessment of proficiency in each skill as the student uses the package. A further refinement is to incorporate into the student model some element that reflects the average performance in a particular skill of students from different language groups.

Ensuring a Continuum of Exercises

The second task is to ensure a continuum of exercises. This is only possible if the CALL package has the ability to assign to an exercise a parameter which gives a measure of its expected difficulty. How this can be done depends upon the form of the domain knowledge on which the exercise is based. There are two main forms: continuous text and pre-selected passages, sentences or phrases that have been chosen by experts to illustrate precise linguistic features.

- Continuous text

A simple way to assign a coefficient of difficulty to continuous text is to use one (or more) of the methods that have been developed to assess readability grades; the more difficult a passage is to read, the more demanding should be any exercise based on it. Two common measures of readability are: Gunning Fog Index (Gunning, 1952) and Information Density (Wainwright, 1984)

Figure 1 shows Fog Indices and Information Densities for texts in the Susanne Corpus, (Sampson, 1992). The coefficients obtained from these two methods do not always correlate and other factors must also be taken into account when selecting material. However, either method gives a continuous scale of difficulty which can be correlated against student proficiency.

File	Snts	Wrds	Lwrds	Nouns	Adjs	Fog	ID
A01	88	1939	712	97	88	10.75	41.72
G01	86	2069	465	181	76	11.81	31.22
J01	65	1908	629	161	91	15.45	41.40
N01	156	2065	391	65	85	5.66	22.08

Figure 1. Gunning's Fog Index and Information Density coefficients for texts in the Susanne Corpus

- Pre-selected passages

A general text database is not always a suitable source for language exercises, particularly for advanced lexical exercises, e.g. differentiating frequently confused words such as *early, soon*. There are two reasons:

- there is no guarantee that the word has been correctly used;
- the database may not contain enough usage examples to create a worthwhile exercise.

A more appropriate source for lexical exercises is a dictionary. Here the usage coverage for every word is exhaustive and the quality of the examples is assured. However, because the examples consist almost entirely of single sentences or phrases, it is not possible to use Gunning's Fog Index or Information Density to assess difficulty. For exercises where there is an abundance of material (e.g. verb particles) other methods can be used to choose appropriate examples. One of these is based on word frequency counts, e.g. use only verbs that are in the most frequently used 1000 words, 1500 words, 2000 words and so on. The word counts may be determined either from general literature or from texts relating to the student's primary discipline: the latter will increase student motivation. (Sometimes, even in a dictionary, usage examples may be inadequate.)

Hence, the type of exercise and the preferred source for an exercise of that type both influence implementation algorithms.

Implementation of the Exercise Generation Package

Exercise generation is dynamic. Once the student has decided what linguistic skill to work on, there are four stages to the generation process:

Determine a suitable source text
Retrieve passages which illustrate the required linguistic feature
Sieve the retrieved examples to leave those examples most suited to the needs of the current user.
Generate the electronic version of the exercises.

Determining a suitable source

Initially, only two text sources, or knowledge domains, were readily available to this project, – the Oxford Advanced Learner's Dictionary (OALD) (Oxford, 1974) and the Susanne Corpus (Sampson, 1992). Consequently, it was decided simply to have a two-column table of skill against source to determine the more appropriate knowledge domain. If the source assigned is the Susanne Corpus (i.e. a continuous text source), the program uses the parameter for student competence in that skill to compute a commensurate readability grade and then selects the Susanne text that matches that grade most closely. As the number of sources available to the project increases, a more complex algorithm may be needed. A project priority is to investigate automatic parsing so that texts directly related to a student's prime discipline can be used by the exercise generator. This should increase student motivation by making exercises more directly relevant to student need.

Choosing suitable passages

Once a source has been selected, there are two main methods of retrieving appropriate examples: direct lexical search and searching for tags.

- **Direct lexical search**

This is the more straightforward search and needs little explanation. The program searches the selected source texts for occurrences of a precise string of letters, usually a word, occasionally a word-stem. The technique can be used with tagged or untagged sources. An indexed text affords a considerable crease in speed of retrieval.

- **Searching for tags**

Complicating use of tagged sources is that every major database uses a different tagging system. Hence, the linguistic parameters for retrieval and even the retrieval algorithm vary with source. Consequently, rather than explain algorithms in detail, it might be more generally useful to compare the two main tagging systems encountered in this project and highlight features of each that are particularly valuable in exercise selection.

- Susanne Corpus

The Susanne Corpus is a 128,000 word subset of the Brown Corpus (Francis, 1989) comprising 64 files, each of more than 2000 words from four Brown genres:

A	press reportage	J	learned (mainly scientific and technical writing)
G	Belle lettres, biography, memoirs	N	adventure and Western fiction

The texts in Susanne have been manually analysed and annotated in a way that gives access to both surface and logical structure. Figure 2 shows a portion of text from Susanne. The most valuable fields in Susanne for exercise extraction are the *word* and *lemma* fields for finding examples for lexical exercises; the *wordtag* field for finding occurrences of syntactical features and for finding discourse frameworks and, occasionally, the *word* field for lexical queries. The *parse* field has not yet proved useful for selecting discourse passages, but structural complexity may give another measure of degree of difficulty of a text.

Reference	Status	Wordtag	Word	Lemma	Parse
G04:0010i	-	CC	and	and	[S+.
G04:0010j	-	AT	the	the	[Ns:s.
G04:0010k	-	NN1n	game	game	.Ns:s]
G04:0010m	-	VVDv	ended	end	[Vd.Vd]S+]S]
G04:0010n	-	YF	+.	-	.

Figure 2. Tagged text from the Susanne Corpus

- Oxford Advanced Learner's Dictionary

In contrast with the Susanne Corpus, the example sentences and phrases in the OALD are not parsed. Thus, it is sometimes difficult to use these examples for the automatic generation of syntactical exercises. Tagging in the OALD is primarily associated with the headword for each dictionary entry, or, where a headword has several senses, with each sense. Grammatical information is detailed and includes plurals, comparatives and superlatives. Idiomatic expressions and phrasal verbs are fully enumerated and well defined. Words and expressions that fall into specialist English registers (eg accounts, aerospace, algebra, etc) are labelled. Every verb is classified by how it can be used, e.g.

[VP18A] S + vt + noun/pronoun + infinitive

I felt the house shake

Many of the verbs can take several patterns and these are listed together after the sense number: e.g.

vp = 6A, 8, 9, 10, 18A, 19A, 24.

then follows the definition and then the example sentences. Unfortunately there is not an explicit link between a verb pattern and the instantiation of that pattern. Consequently, it is difficult to extract an illustrative sentence automatically.

Sieving the retrieved examples

Retrieved sentences are sieved for two purposes:

- to remove as far as possible all sentences that may lend themselves to more than one interpretation, e.g. in an exercise on pronouns it should be quite clear from the context which pronoun to use.
- to retrieve only enough examples to create an adequate exercise. Selecting sentences at random from those retrieved ensures that students will be given a different exercise every time they rehearse that linguistic skill; however, if the exercise has not already been graded for difficulty, the use of word frequency counts is preferable.

Generating the exercises

Where appropriate the retrieved examples are re-ordered. Most exercises are generated as Cloze exercises that can be completed by the student using only a pointing device, e.g. a mouse. This has the disadvantage that it only tests recognition, not recall, but it requires little manual dexterity so the student can do it quickly. The hypertext templates used are described in (Wilson, 1992). Figures 3 shows exercises on *pronouns* generated from the Susanne Corpus; figure 4 shows a specialist vocabulary exercise for a student of architecture generated from the OALD.

Complete the following sentences by choosing the correct pronouns:

he	**him**	**himself**	**she**	**her**	**herself**
it	**it**	**itself**	**they**	**them**	**themselves**

They saw it before ___ did, even with my binoculars.
Occasionally, for no reason that I could see, ___ would suddenly alter the angle of their trot.
For ten minutes ___ ran beneath the squall, raising their arms and, for the first time, shouting and capering.
___ bent down, a black cranelike figure, and put his mouth to the ground.

Figure 3. Part of an exercise on pronouns derived from Susanne Corpus, G04, readability grade: 7.31

Select an architectural term from the column on the left.
Then, from the column on the right, select the definition that corresponds.

caryatid	*(either end of the)transverse part of a cross-shaped church*
coping	*curved edge where two vaults meet (in a roof)*
corbel	*draped statue of a female figure used as a support (eg a pillar) in a building*
Corinthian	*high, narrow, pointed arch or window*
cornice	*line of (sometimes overhanging) stonework or brickwork on top of a wall*
Doric	*column in ancient Greek architecture, with a decoration of leaves on the capital*

Figure 4. Part of a specialist vocabulary exercise on architecture from OALD

Evaluation

The format of the exercise is popular: students have no difficulty in using it and are generally enthusiastic. The feedback given to them is clear and they have no problem in monitoring their progress. What is not clear from the evaluation so far is to what degree there is a correlation between readability grade and exercise difficulty. For certain linguistic skills, such as use of articles, students' ability in the skill seems not to vary with readability grade of the text. This may not matter, but it requires further investigation. Other exercises, which were difficult to classify initially, such as differentiating word pairs, *(early, soon) (imply, infer) (constantly, continually) (anticipate, expect)* seem to be uniformly difficult even for native speakers. However, testing is incomplete; in particular, tests involving students with more widely differing levels of ability are a priority.

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