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An Interactive Tool for English Reading Comprehension by Providing Questions and Hints to Student during Reading and Parsing

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Abstract: We developed a tool that helps EFL (English as a foreign language) students to explicitly represent a sentence as a parsing tree. Firstly, the tool generates a sequence of questions from a partial-parsed parsing tree of a sentence, and secondly a software agent provides these questions sequentially to students during the process of reading. By correctly answering to these questions, step-by-step, the students are able to learn how to separate the words, word groups, and phrases of the sentence and organize them into a tree structure.

Keywords: Reading, partial parsing, chink-down, chunk-up, parsing tree, question guided reading

Introduction

Reading a sentence is a process of parsing in which the readers use their linguistic knowledge to transform the linear sequence of words of the sentence into a tree structure of chunks (meaningful group of words) [1], implicitly in their minds or explicitly by representing the tree structure visually. We developed a tool that help students to explicitly represent a sentence as a parsing tree by firstly generating a sequence of questions from a partial-parsed parsing tree of a sentence, and secondly providing these question sequentially to the students during the process of reading and parsing. By correctly answering to these questions, step-by-step, the students will learn how to separate the words, word groups, and phrases of the sentence and organize them into a tree structure.

1. Motivations

1.1 Problem happened in reading for EFL student in Taiwan

Researchers had found that college students in Taiwan who learn English as a Foreign Language (EFL) experienced difficulties in English reading comprehension [2]. Several kinds of knowledge are needed in reading comprehension including vocabulary knowledge and structural knowledge [3]. These knowledge are implicitly learned by comprehensive students, but are sometimes difficult for other students. Thus, an explicit

representation of these knowledge is needed to explicitly measure the reading ability of students.

1.2 Reading as a Process of Parsing

Reading a sentence is a process of parsing the sentence into a tree structure of chunks. Previous works on sentence parsing in traditional natural language processing are performing full parsing through prescribed grammars, such as context free grammar (CFG) [4]. However, it is difficult for students to apply these grammars to fully parse sentences. There is a different approach of parsing, called partial parsing [5] [6], which is used to easily and robustly parse sentence into chunks (noun phrase, verb group, preposition phrase, simple clause, etc). There are two paradigms of partial parsing. The first one is called "chunking", which retrieves chunks from a sentence by searching the word sequences that matching the regular expressions of noun phrases, verb groups, and preposition phrases. The second one is called "chinking", which transform a sentence into several segments by eliminating the functional words in the sentence. By applying partial parsing and organizing these chunks into a tree structure, the reading of a sentence is explicitly represented.

1.3 Providing Hints and Questions in the Process of Parsing

The process of parsing a sentence into a tree structure of chunks can be guided step-by-step by providing appropriate questions about (a) which word in the sentence should be separated to rationally divide the sentence into parts and (b) which word in the current part should be separated to rationally divide the current part into more parts. This process can be performed recursively under a depth-first procedure until each part, as a node of the parsing tree, is exactly representing a chunk. By answering to these parsing questions, the students can show that they are able to make correct decisions during the process of reading, and the ability to make a correct decision is measured from recording the sequence that the students answering to these questions.

2. Problem Descriptions

2.1 The Functional Words and the Structure of English Sentences

According to Longman Dictionary of Contemporary English [7], the part-of-speech (POS) of English words are classified into 15 classes, including noun, verb, adjective, adverb, pronoun, modal verb, interjection, preposition, conjunction, pre-determiner, determiner, number, indefinite article, definite article, and auxiliary verb. The first four classes are call "content words" and the others are called "functional words".

The structures of English sentences are classified as four kinds, simple sentence, compound sentence, complex sentence, and compound-complex sentence. A simple sentence is composed of a subject and a verb group, following by a complement, or an object, or an object and a complement, or two objects (indirect and direct objects). Each of these compartments can be modified by adjective phrases or adverb phrases. A compound sentence is composed of two or more simple sentences, as clauses, which are linked by conjunctions. A complex sentence is composed of two simple sentences, the main clause and the subordinating clause, which are linked by a relative pronoun. A compound-

complex sentence is composed of both compound and complex sentence. By linking several clauses, the length of a sentence increases. The longer a sentence is, the more difficult for students to read.

2.2 Partial Parsing by Chink-Down and Chunk-Up

2.2.1 Chink-Down

Since a long sentence gains its length by linking clauses and phrases by conjunctions, relative pronouns, and prepositions, which are a subset of the functional words of English. On the contrary, we can decompose a sentence into simple parts by separating it at these functional words, and result in a list of parts which are usually noun phrases, verb groups, adjective or adverb phrases. This partial parsing method is called "chinking", in respect to the other method of "chunking". We call this process as "chink-down". The chink-down rules are shown in Figure 1(a).

(a) Partial parsing by chink-down rules: 1. Cut before and after each punctuation. 2. Cut before and after each conjunction. 3. Cut before and after each relative pronoun. 4. Cut before and after each personal pronoun. 5. Cut before and after each demonstrative pronoun. 6. Cut inside each idiom. 7. Cut before and after verb group. 8. Cut before each preposition. 9. Cut before "a", "an", "the", and other determiners.
(b) Tree Construction by chunk-up rules: 1. Joint preposition + determiner. 2. Joint preposition + noun. 3. Indent before and after subordinating and correlative conjunction. 4. Indent after relative pronoun. 5. Indent the parts governed by the same verb group to the same level.

Figure 1 Rules of chink-down and chunk-up

2.2.2 Chunk-Up

After the process of chink-down, the sentence is decomposed into simple parts, then we apply the chunk-up rules, as shown in Figure 1(b), to joint particular patterns of words as chunks and make indents according to the semantic relationship between corresponding parts to construct the tree structure of the sentence, as shown in Figure 2.

2.3 The Parsing Tree Explicitly Represents the Reading of the Sentence

Through the process of chink-down and chunk-up, the sentence is transformed into its partial parsing tree which explicitly represents the reading of the sentence. Each node of the tree is a chunk, and the nodes under their parent node are also composed to a chunk of higher level of meaning. For example, in Figure 2(c), part 1 to 3 form a chunk as "There is a long-held belief", part 10 to 13 form a chunk as "eye contact we have with the person", and part 9, 10, 14, 15 form a chunk as "the more eye contact, the better". With this

(a) There is a long-held belief that when meeting someone, the more eye contact we have with the person, the better.

(b)

[01] There
[02] is
[03] a long-held belief
[04] that
[05] when
[06] meeting
[07] someone
[08] ,
[09] the more
[10] eye contact
[11] we
[12] have
[13] with
[14] the person
[15] ,
[16] the better
[17] .

(c)

[01] There
[02] is
[03] a long-held belief
[04] - that
[05] - - when
[06] - - - meeting
[07] - - - someone
[08] - - ,
[09] - - the more
[10] - - eye contact
[11] - - - we
[12] - - - have
[13] - - - with the person
[14] - - ,
[15] - - the better
[16] .

Figure 2 Representing a sentence as a tree structure. Number in squared bracket denotes the part number. (a) The original sentence. (b) The list of parts of the sentence after the process of chink-down. (c) The list of parts after the process of chunk-up. Indentation denotes the depth of the node. The example sentence is quoted from the reading comprehension test of English in college entrance examination in 2011, Taiwan.

representation, the results of reading are compared between the tree constructed by a student and the tree constructed by a teacher. If a sentence was correctly read by a student, the resulting tree should be as same as the tree constructed by a teacher.

3. Question Guided Reading and Parsing

3.1 Question Guided Parsing Process

In order to let the parsing process of a sentence for the students to be a question guided one, the sentence is pre-parsed by a teacher. In each node of the parsing tree, we identify one or more functional words which cause the bifurcation of the node from its parent node. We call these words as "parsing pivot", which, in general, are punctuations, conjunctions, relative pronouns, prepositions, verb groups, and determiners. Then we can ask students questions about these pivots like "at which word or words in the sentence should I separate the sentence to best divide the sentence into parts?" or "at which word or words in the part should I separate the current part to best divide the current part into more parts?" We call these questions as "parsing question". By tracing the parsing pivots from the root of the parsing tree through all the descendants, a sequence of parsing pivots is generated, and the corresponding questions about these pivots are generated, too. The generating method is mentioned in 3.2.

When students take a practice or a test of reading, they answer to the sequence of parsing questions from the beginning of the sequence. If the student's answer is correct for the current question, the corresponding bifurcation of the parsing pivot is performed according to the pre-parsed parsing tree, and the current part is updated, and the process continues to next question until all the questions are correctly answered. If the answer is wrong, the student is asked the same question again, until the student has made a correct answer. After all the questions are correctly answered, the result is presented.

A simple example is shown in Figure 3(a). The process begins when the teacher, as an agent, provides a sentence to a student. The first question is to find the punctuation where the sentence ends at. When the student makes a wrong answer, the agent provides a negative feedback message and a hint, and asks again. When the student makes a correct answer, a positive feedback is provided, and the result is shown. The sentence is divided into two parts and the current part is updated to part 1. In Figure 3(b), the question is asking about which conjunction in part 3 is the pivot to best divide the current part into more parts. The correct answer is "that", which divides part 3 into part 3, 4, and 5. Since part 3 and 4 are parsed already, the current part is updated to part 5.

(a)

Teacher: Please read this sentence?

[1] There is a long-held belief that when meeting someone, the more eye contact we have with the person, the better.

Teacher: [Hint] Find the punctuation that ends the sentence.

Q1. Where does the sentence end at?

(1) The "," after "someone"

(2) The "." after "better"

> 1

Teacher: Oh, No! A sentence can not end at a comma! Please find a " . ", " ? ", or " ! ".

Q1. Where does the sentence end at?

(1) The "," after "someone"

(2) The "." after "better"

> 2

Teacher: That is correct! The sentence end at "."

[1] There is a long-held belief that when meeting someone, the more eye contact we have with the person, the better

[2] .

Current part : [1]

(b)

[1] There
[2] is
[3] a long-held belief that when meeting someone, the more eye contact we have with the person, the better
[4] .

Teacher: [Hint] Find the conjunction.

Q3. Which word should be separated to best divide part [3] into more parts?

(1) belief

(2) that

(3) when

> 1

Teacher: Mm... I don't think so. Please try again!

Q3. Which word should be separated to best divide part [3] into more parts?

(1) belief

(2) that

(3) when

> 2

Teacher: Good job!

[1] There
[2] is
[3] a long-held belief
[4] that
[5] when meeting someone, the more eye contact we have with the person, the better
[6] .

Current part : [5]

Figure 3 Question Guided Parsing. (a) Identify the end of the sentence. (b) Separate part [03] at the conjunction "that" into more parts.

3.2 Generating the Sequence of Parsing Questions

The sequence of parsing questions is generated by tracing the pre-parsed parsing tree from the first node through all the descendants, in a depth first search procedure. Each node has a level number. The first node is in level 1. Nodes that are at the same level of the first node are also in level 1. Child nodes of the node in level K are in level K+1. If several

nodes of the current part are in the same level, then the algorithm choose the node that contains the parsing pivot of the highest priority as the next pivot to be parsed. The priorities of parsing pivots are shown in Figure 4. The first line shows that punctuation has highest priority. The second line shows the priority of three kinds of conjunctions. The third line shows the priority of different subordinating conjunctions. The fifth line shows the priority of different pronouns.

1. Punctuation : Period, Question mark, Exclamation mark > Semicolon > Colon > Comma
2. Conjunction : Subordinating Conjunction > Correlative Conjunction > Coordinating Conjunction
3. Subordinating Conjunction : That > When, Where
4. Idiom
5. Pronoun : Relative pronoun > Demonstrative pronoun > Personal pronoun
6. Verb
7. Preposition

Figure 4 Priority of the parsing pivots, from high priority (1) to low priority (7). In each line, the detailed priorities of the sub-classes are shown, too.

For example, in Figure 2(c), the nodes of level 3 are "when", comma, "the more", "eye contact", comma, and "the better". The first comma has the highest priority. So, for part 5 "when meeting someone, the more eye contact we have with the person, the better", the next question to ask is to separate part 5 at the first comma to divide it into 3 parts: part 5 as the clause "when meeting someone", part 6 as the comma, and part 7 as the rest "the more eye contact we have with the person, the better". Since part 5 is not completed, the current part is updated to this part. In part 5, the conjunction "when" has highest priority, so the next question to ask is to separate part 5 at "when" to divide part 5 into 2 parts: part 5 as "when" and part 6 as the rest "meeting someone". The part numbers of the following parts are updated sequentially and the current part is updated to part 6.

After part 6 has been parsed as part 6 "meeting" and part 7 "someone", the current part is updated to part 9, because part 8, the comma, is parsed previously. Part 9 is now as "the more eye contact we have with the person, the better". Again the comma has highest priority, so the next question to ask is to separate part 9 at the comma and produces 3 parts: part 9 as "the more eye contact we have with the person", part 10 as the comma, and part 11 as "the better". In part 9, the idiom "the more" has higher priority than "eye contact", so the next question to ask is to separate part 9 as "the more" and "eye contact we have with the person". The process continued until all the questions are generated.

3.2.1 Types of Parsing Questions

There are three types of parsing questions. First, the pivot choosing question is to choose a word that best divides the current part into more parts. Second, the POS identification question is to identify the POS of the parsing pivot. Third, the scope marking question is to mark the beginning word and the end word that are governed by a parsing pivot. The range of words governed by a pivot is the scope of the pivot. There are three types of scope, the scope of an idiom, the scope of a conjunction, and the scope of a verb group.

3.2.2 Generating the Options of the Parsing Question

For questions of type 1 and 2, the options are generated according to three principles. First, the words in the same level and POS of the parsing pivot are options. Second, if there is no word in the same POS of the parsing pivot, then the words in the same level of the parsing

pivot are options. Third, if no word is found by principle one and two, then the words before and after the parsing pivot are options. For questions of type 3, the options contain the words of correct answers and some words randomly chosen from words that belong to the current part and are before, within, or after the correct answers.

3.3 Providing Feedback and Hint

After the parsing questions are generated, they are provided to the students, as shown in Figure 3. The agent provides appropriate feedback to the student according to the answer they made. If the answer is wrong, a negative feedback, a hint and a simulated result are presented, and they are asked to answer again. If it is correct, a positive feedback is provided, and the result is presented.

4. System Design

4.1 System Architecture

The system is divided into four major blocks, as shown in Figure 5. First, the sentences of an article are pre-parsed by a teacher to produce the parsing tree of each sentence. Second, a sequence of parsing pivots is generated as the parsing sequence. Third, the sequence of parsing questions is generated from the pre-parsed parsing tree and the parsing sequence to produce a list of parsing questions. Fourth, an agent of teacher is constructed, which takes the pre-parsed parsing trees and the list of parsing questions as input and interacts with the student through a computer GUI (graphic user interface). The performance of the student is recorded for further analysis.

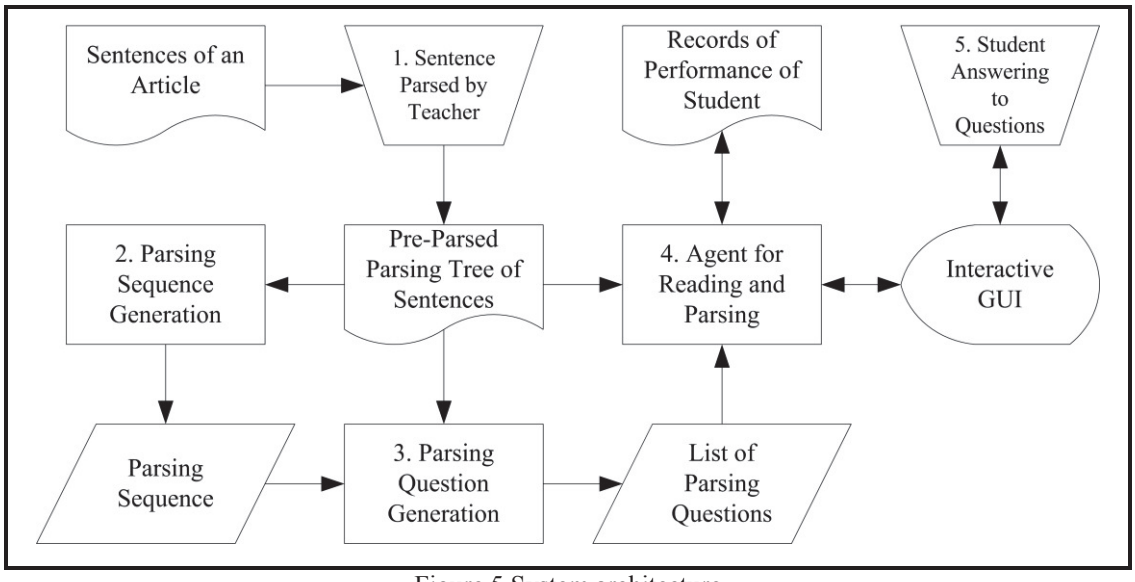

Figure 5 System architecture

4.2 Data Input and Output

The article is in plain text. The pre-parsed parsing tree is represented as four vectors. The first one is a vector of all the tokens of the sentence, including punctuations and words.

The second one is the level of the tokens. If the token is the first word of a part, then the level is encoded as it is, otherwise, the level is encoded as zero to show that the token is a following word. The third one is the POS of the tokens. The last one is the status of the tokens during the reading and parsing process. The parsing sequence is a vector of the index of the parsing pivots in the pre-parsed parsing tree. The parsing questions are represented as a list where each node of the list contains the text of question, options, correct answer, and hint. Students interact with the GUI of the system by keyboard or mouse.

4.3 The Records of Performance of the Students

The records of performance of the students are represented as a vector of an ordered pair of two numbers. The first one is the number of the question. The second one is the answer chosen by the student. These records together with the pre-parsed parsing tree and the list of parsing questions are used for further analysis of the reading ability of the students.

5. Experiments

We use the articles of reading comprehension test of English in the college entrance examination of Taiwan, 2011, as the input texts. There are four articles in this test. The experiment is still in progress.

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