A Web-Based Multi-User Error Correction, Analysis, and Feedback System

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Abstract: - Taking C programming language learning as an example, this paper describes the development of a Web-based multi-user error correction, analysis, and feedback system. This system reinvented traditional paper-based error feedback and error correction in the form of interactive error analysis and error feedback, which is a new type of computer corpus annotation for learning. In this system, users can create error corrections (annotations) in the same way as the traditional paper-based correction approach. In addition, this system can provide users the annotation marks subject to different query contitions so that the problem of cognitive overload can be avoided. For error analysis purposes, this system can access the database and analyzes students' errors and displays the results as requested. Four error analysis options are included: single document for an individual student, all documents for an individual student, single document for all students, and all documents for a group of students. With the multi-user correction component, this proposed system has the capability of peer assessment; and with correction analysis, this proposed system can feedback correct answers and teachers' comments to students.

Key-Words: - error correction, error feedback, error analysis, peer assessment, online annotation

1 Introduction

Error correction and error feedback are important tasks for teachers and students in many contexts. It is generally agreed that students themselves want and expect feedback on their written errors from their teachers [10]. Therefore, for many teachers, their most immediate concern in the classroom is not so much "to correct" or "not to correct", but rather "what to correct" and "how to correct" [3]. However, error feedback and analysis of students' work is an extremely time consuming task. Considering the time required for correction, the most effective way to correct errors is worth investigating. For error correction, researches have been conducted on effective correction methods, but there is no agreement among researchers on the most effective method [10]. Specifically, when teachers mark student errors, do they need to indicate the type of error the student has made, or is it adequate for the teacher to simply underline or circle an erroneous form, leaving it to the student to diagnose and correct the problem? It seems that traditional paper-based error feedback mechanism has its limitations. Researchers have suggested a more constructivist approach to designing open-ended learning environments for error feedback. Peterson [8] has reminded that online technologies can offer new ways of gathering that information from students. Lee [3] indicated that a crucial variable in error correction is recognizing the existence of errors.

In fact, traditional error analysis and feedback can be reinvented in the form of computer-aided error analysis, which is a new type of computer corpus annotation [12]. In other words, the limitations of traditional paper-and-pencil error feedback and analysis highlight a new direction. One possible direction is using the online annotation systems for error analysis and feedback [12]. Such application is grounded in the fast growing fields of distance education and computer learner corpus research.

Annotations are the notes a reader makes to himself/herself, such as students make when studying texts or researchers create when noting references they plan to pursue [11]. Since annotations involve four major functions: remembering, thinking, clarifying, and sharing [7], annotation systems can take advantage of networked technologies to allow communities of readers to comment on the same virtual copy of a text. Compared to paper-based annotations shared merely through printed technology, online annotations provide readers with more opportunities for dialogue and learning through conversations [11]. Practically, online annotations can be quite useful, in which students could share their annotations to discuss reactions to a text, or they could use annotations as a type of reading journal to share with the instructor [4]. Basically, it is agreed that online annotations can provide a good way for readers to share knowledge and allow extended conversations to take place in the context of a common text.

Online annotations can help readers navigate documents, functioning much as user-created hyperlinks that allow readers to look up information, pursue citations, or return to earlier sections of a document [2]. By facilitating such easy movement between texts, annotation tools can emphasize the intertextual nature of reading. Tools for manipulating and rearranging annotations can scaffold different note-taking and information strategies that help students learn to move from reading to writing. With annotations, users are no longer limited to viewing content passively on the Web, but are free to add and share commentary and links, thus transforming the Web into an interactive medium.

Peer assessment, assessment of students by other students, has many potential benefits to learning. Peers are students with similar educational qualifications or knowledge, who grades or offers suggestions concerning another student's work [9]. Peer assessment can help self-assessment, too. By assessing the work of others, students gain insight into their own performance. It gives students feedback and opportunities to improve, hence encourages student autonomy and higher order thinking skills. Its weaknesses can be avoided with anonymity, multiple assessors, and tutor moderation. With large numbers of students the management of peer assessment can be assisted by Internet technology [1].

However, in spite of the advantages mentioned above, the questions of how annotations may help correct, analysis, and feedback students' errors and enhance peer assessment have not been sufficiently addressed. To this end, this study develops a Web-based multi-user annotation system which can provide error correction, analysis, and feedback, and can be applied to error management. The objectives of the system are (1) providing multiple annotation functionality; (2) providing error feedback and error analysis; and (3) realizing knowledge sharing and collaborative learning in peer.

2 System Overview

The Web-based multi-user error correction, analysis, and feedback system is developed for C programming language learning. It is based on the client/server architecture as illustrated in Fig. 1.

2.1 Program Editor

It is a text editor for students to input their program codes. As the program code is edited, the system will convert it into the HTML format and save it in the document database so that it can be displayed with general Web page browsers for error correction marking.

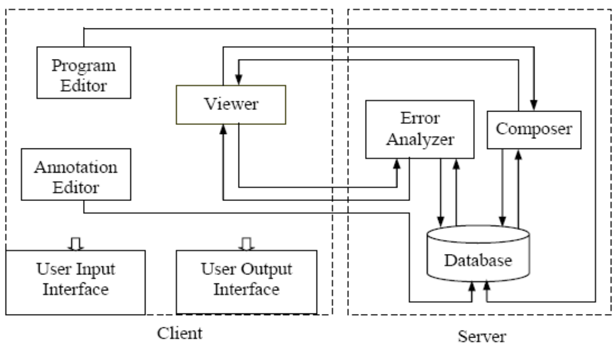

Fig. 1: System architecture

2.2 Annotation Editor

Fig. 2 illustrates the interface of Annotation Editor. To create a correction and comment, the assessor first highlights the code to which he or she wants to annotate, which is named as “annotation keywords” hereafter. Then he or she clicks on one of the annotation tools to activate the corresponding function to place the error correction mark into the code. The annotation tools include “DELETE”, “INSERT BEFORE”, “INSERT AFTER”, “HIGHLIGHT”, and “REPLACE”. A pop-up window is also available for entering additional explanations for each error. The system uses JavaScript to automatically insert the <SPAN> tag of XHTML arount the highlighted code.

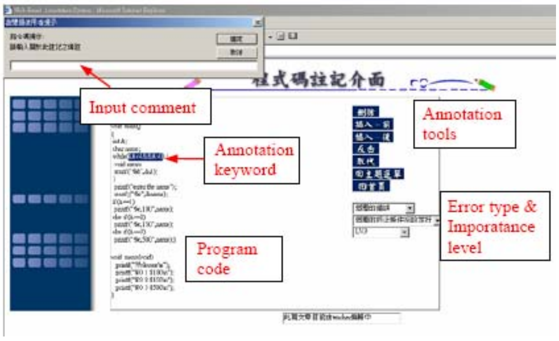

Fig. 2: Screen shot of Annotation Editor

Example of the code to use <SPAN> for inserting annotation

```
<div align="left" id="MainTextDiv"
class="MainText">
 #in<SPAN class=Delete
id=2382030179
onclick=Show(2382030179)>clud</SP
AN>e&lt;stdio.h&gt;<BR> int
a,1,2,3;<BR>int
main(void)<BR>{<BR> pri<SP
AN class=Insert id=9350308642
style="DISPLAY: inline"
onclick=Show(9350308642)>插入前
</SPAN>
</div>
```

The CLASS feature within the <SPAN> tag indicates the used annotation tool, such as “DELETE”, “INSERT BEFORE”, etc. The CLASS feature also determines the CSS template to be applied to the annotation keywords within the <SPAN> tag. Fig. 3 illustrates the annotation effect of “HIGHTLIGHT” and “DELETE”. The ID feature within the <SPAN> tag plays the role of annotation identification code. It can make dynamic control to the annotation keywords, e.g., displaying annotation marks subject to different query conditions of users, by regarding each annotation as an object stored in the annotation database. As an annotation is being created, related information, such as user ID, annotation type, error type, importance level, annotation identification code (ID), additional explanations for each error, is recorded in the database whose primary key is the annotation identification code (ID). The annotation database offers the information for error analysis (manipulated by Error Analyer) and annotation query (manipulated by Composer). In Annotation Editor, users can make correction marks and comments only, i.e., it is under a “read-only” status in that the content of the original program code cannot be changed.

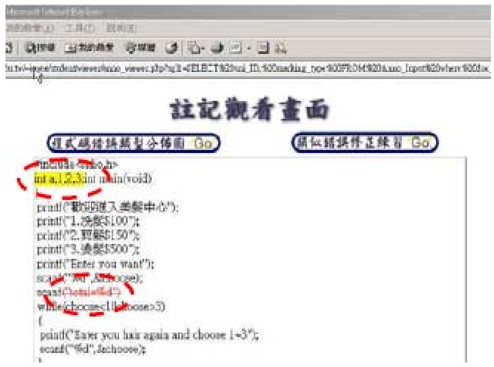

Fig. 3: The annotation effect of “HIGHTLIGHT” and “DELETE” (Document Viewer)

For each annotation, the assessor assigns an error code using the three pull-down menus to indicate its error type and importance level. Under each error type, there are different numbers of error subtypes. In this system, six major error types and thirty-four error subtypes, in total, are included. For each error, three importance levels can be assigned to indicate the importance of the error. The higher the importance level, the more severe the error is. Level 1 errors are those that need to be polished, however, if not corrected, will not affect the execution of program. Level 2 errors are slight errors caused by minor misconceptions or mistyping of students and the students have better to correct them. Level 3 errors are severe errors that must be corrected [5].

2.3 Composer

Since a program code can be annotated by multiple users with different annotation tools, error types, and importance levels, students might be confused due to too much information. With annotation database and the annotation identification code, through Composer, the system can provide the student the annotation marks subject to different query contitions so that the problem of cognitive overload can be avoided. In our system, a user can query the annotations based on (1) the user making annotations, (2) the annotation type, (3) the error type, and (4) the importance level of errors (Fig. 4). For those annotation identification code fulfilling the query conditions, the system will display the corresponding CSS templates within the <SPAN> tag by using JavaScript so that those annotation marks will be shown in Document Viewer accordingly (Fig. 3).

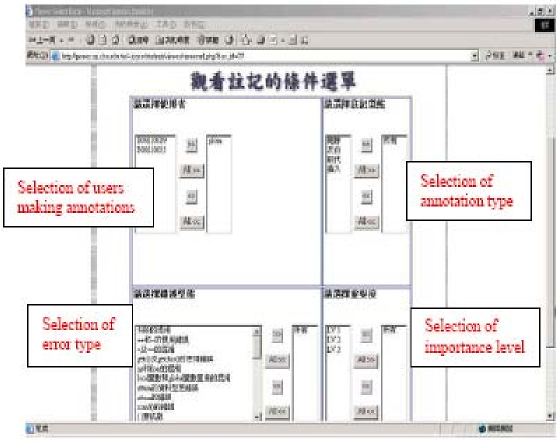

Fig. 4: Screen shot of annotation query

In many cases, multiple users, teachers or peers, make different corrections in the same correction point. This system uses the confidence degree, which is adopted the work of Ogata et al. [6], to determine the annotation marks to be displayed if no query conditions are requested by the user. Annotations with the highest confidence degrees will be set to be the errors and displayed.

All annotations in the correction point created by teachers

$$CD_z = \left(1 - \sqrt{\left(w_z - \overline{w}\right)^2}\right)\frac{o_i}{t} \qquad (1)$$

CD_z : the confidence degree of correction mark z

w_z : the weight of importance level of correction mark (annotation) z (weights for levels 1, 2, and 3 are assigned as 1/3, 2/3, and 1, respectively.)

$\overline{w}$: the averaged importance level of correction marks in the correction point

o_i : the number of correction marks of error type i in the correction point (error type i is the error type that correction mark z belongs to)

t : the number of teachers making correction marks in the correction point

All annotations in the correction point created by students (peer assessment).

$$CD_z = \left(\left(1 - \sqrt{\left(w_z - \overline{w}\right)^2}\right)\left(1 - \frac{E_{ij}}{\sum_{j=1}^{n_i} E_{ij}}\right)\right)\frac{o_i}{s} \qquad (2)$$

$E_{ij} = \left(\sum_{p=1}^{m_j} E_{pij}\right) / m_j$: the ratio of error type i that student j has made in all program codes (student j is the one who creates correction mark z)

E_{pij} : the number of errors of error type i that student j has made in document p

m_j : the number of program codes that student j has written

$\sum_{j=1}^{n_i} E_{ij}$: the cumulative ratio of error type i for all students that have made error type i in all program codes

n_i : the number of students that have made error type i before

s : the number of students making correction marks in the correction point

If no students have ever made error type i before ($n_i = 0$), equation (3) will be used:

$$CD_z = \left(1 - \sqrt{\left(w_z - \overline{w}\right)^2}\right)\frac{o_i}{s} \qquad (3)$$

Annotations in the correction point created by teachers and students. In this case, only the correction marks created by teachers are considered. That is equation (1) is used.

2.4 Annotation Analyzer

For error analysis purposes, the Annotation Analyzer accesses the database and analyzes students' errors and displays the results in bar charts through Analyzed Result Viewer as requested. Four error analysis options are included: single document for an individual student, all documents for an individual student, single document for all students, and all documents for a group of students.

Analysis of single document for an individual student. Fig. 5 illustrates the analysis result, E_{pij}/E_{pj}, of single document p for an individual student j. E_{pij} is the number of errors of error type i that student j has made in document p and E_{pj} is the total number of errors that student has made in document p. If multiple correction marks are created in a correction point, the one with the highest confidence degree (obtained in Section 2.3) will be used.

Fig. 5: Screen shot of analysis result of single document for an individual student (Analyzed Result Viewer)

In addition to error analysis, from the document database, Annotation Analyzer can search for other documents, created by other students, with the most similar error distribution pattern for practice purposes. The error ratio vector of student j in document p is represented as $\left(E_{p1j}/E_{pj}, E_{p2j}/E_{pj}, \cdots, E_{p34j}/E_{pj}\right)$. (There are totally 34 error types included in the system.). If the error ratio vector of any student k in document q is $\left(E_{q1k}/E_{qk}, E_{q2k}/E_{qk}, \cdots, E_{q34k}/E_{qk}\right)$, the similarity, $S(pj,qk)$, between student j in document p and student k in document q is computed by equation (4). The larger $S(pj,qk)$ is, the more similar error distribution pattern is. Then the system can recommend document q to the student for practicing of corrections. After practicing correcting document q created by student k, the student j can check the correctness of such correction marks by comparison the original program code of document q (the upper window of Fig. 6) and the lower window displays the correction marks of document q created by teachers (the lower window of Fig. 6).

$$S(pj,qk)=\frac{\sum_{i=1}^{34}\frac{E_{pij}}{E_{pj}}\cdot\frac{E_{qik}}{E_{qk}}}{\sqrt{\sum_{i=1}^{34}\left(\frac{E_{pij}}{E_{pj}}\right)^2\sum_{i=1}^{34}\left(\frac{E_{qik}}{E_{qk}}\right)^2}}\text{, for all } q\text{'s and } k\text{'s} \qquad (4)$$

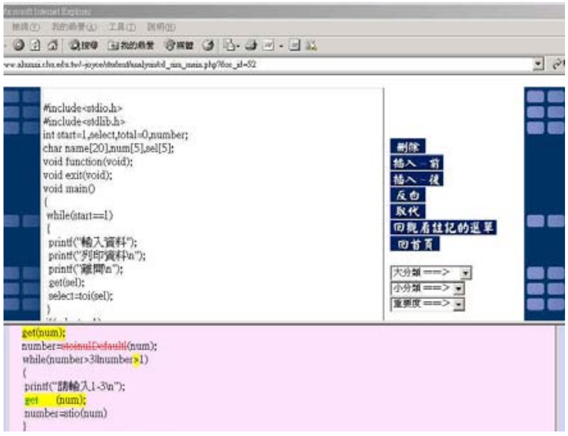

Fig. 6: Screen shot of error correction practice window.

Analysis of all documents for an individual student. The difference between analysis of all documents and single document for an individual student j is that instead of E_{pij}/E_{pj}, the error ratio that student j has made in all documents, E_{ij}, as defined in equation (2), is used. It is helpful to realize the most severe barrier the student j faces in creating program codes.

Analysis of single document for all students. The difference between analysis of single document p for an individual student and all students is that the error ratio $\left(\sum_{j=1}^{n_p}E_{pij}\right)/\left(\sum_{i=1}^{34}\sum_{j=1}^{n_p}E_{pij}\right)$ is used. It is helpful to realize the unclear concepts most students have about that program code (document p).

Analysis of all documents for all students. In this mode, the average frequency of error type i for all students, E_i, is used. It is helpful to realize the overall unclear concepts most students have.

$$E_i=\frac{\sum_{p=1}^{m}\sum_{j=1}^{n}E_{pij}}{n} \qquad (5)$$

m : the total number of program codes
n : the total number of students

2.5 Viewer

Two Viewer modes are included in the system, Document Viewer (Fig. 3) and Analyzed Result Viewer (Fig. 5). Document Viewer displays annotation marks that fulfill query conditions requested by users or have the highest confidence degrees as discussed above (see Section 2.3). In Document Viewer, users know which parts of their program codes are corrected and they can get detailed error feedback by click the annotation marks. A pop-up window will come up to display additional explanations for each error (Fig. 7). Analyzed Result Viewer displays the four error analysis options analyzed by Annotation Analyzer (see Section 2.4).

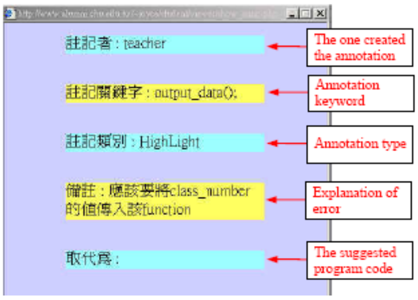

Fig. 7: Additional explanation of annotations

3. Conclusions

Correction of students' works plays an important role in instruction. Error correction and error feedback are important tasks for learning. Students have great diversities in error correction and feedback strategies, and a more constructive approach and a more interactive environment for error feedback and error correction are needed. Moreover, the effectiveness of peer assessment has been well reported. However, correction of students' works cannot be easily implemented in a Web-based learning environment as in traditional paper works. Taking C programming language learning as an example, this paper describes the development of a Web-based multi-user error correction, analysis, and feedback system. This system reinvented traditional paper-based error feedback and error correction in the form of interactive error feedback and error analysis, which is a new type of computer corpus annotation for learning. With the multi-user correction component, this proposed system has the capability of peer assessment; and with correction analysis, this proposed system can feedback correct answers and teachers' comments to students.

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