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Modeling and Implementation of Context based Annotation for XML Documents

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ABSTRACT

This paper proposed context based annotation model and annotation ambiguity correction methods. The proposed model provides various annotation types, semantic models, and pen-based free drawing interface. Annotation correction method that is specifically based on the context which includes various textual and structure information between free-form marking and annotation. Also, interface for XML environment using the proposed model and correction methods is proposed and possibilities of application is looked at. The results from the implementation of the proposed method show that the annotated areas included in the free-form marking information are more accurate, achieving more accurate exchange results amongst multiple users in a heterogeneous document environment

Key words: Annotation, Free-form Annotation, XML, Context-based Annotation, eBook

1. INTRODUCTION

Normally, annotation is a sentence or a text that is added for the purpose of explaining, describing and emphasizing the subject or the content of a document[10,11]. Annotation in paper document is used for summarizing, abstracting, understanding, and recording the content of a document and especially, underline, symbol and note are used[13]. Meanwhile, because annotation in electronic document is not one-time information but important information that can be reused or shared, related software provides it as a necessity[16].

Due to changes in the Web service paradigm, annotation technique is being recognized as an important element in not only desktop environment, but also in the hand-held environment[5]. Generally, pen-based hand-held devices, or reading hardware[15], support free-form annotation (marking)[15] for the creation of annotation.

However, for hand-held devices or next-generation web environment, more comfortable GUI than the results of existing studies, related to various annotation style types and behaviors[3] as shown in Table 1. And also, various existing annotation systems related to free-form marking do not yet support analysis and resolution of annotation ambiguity[15,19] that can cause conflicts with free-form marking in a XML-based annotation environment.

Thus, in this study, context-based annotation model that provides various types of annotation and semantics for sharing of annotation, annotation positioning in structured document and correction of annotation ambiguity in pen-based environment is proposed.

Also, interface for XML based document or device environment using the proposed model is

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Table 1. Annotation creation method and characteristics depending on interface

Interface	Annotation Creation Method	Characteristics	Limitations
Chat-boarding annotation interface [4,16]	Thread-based BBS	Use a separate note, message or icon to illustrate annotation	Does not provide inline annotation type, which is created directly on the original document
Line-based Interface[6,8,9], [14,20]	WIMP	Provide inline based Highlighting, UnderLine, and Note	Does not provide symbol typed annotation and multi-step menu selection process is needed
Symbol-based Interface [1,3,7]	WIMP(Window, Icon, Menu, Pull-down)	Provide inline highlighting, symbol, free-form marking	The result of free form Marking is processed as a simple image.
Paper-like Interface [2,5,12,15]	Pen based free-form marking and dragging selection	Provide pen-based free-form marking, Highlighting and Note. Guarantees minimum cognitive overhead for selecting a menu	Does not provide ambiguity analysis and correction methods

proposed and possibilities of application is looked at.

As a result, annotation model proposed in this paper can be applied to various platforms and domains and especially can be appropriately implemented in desktop or hand-held environments. And this paper presents a method for accurate creation of annotation with free-form marking, achieving more accurate exchange results in a XML-based annotation environment.

This paper is organized as follows. Section 2 proposes context-based annotation model and in section 3, annotation interface and technique that use proposed annotation model and correction method are described. Section 4 evaluates the accuracy of the proposed method and the conclusions and future works are summarized in Section 5.

2. ANNOTATION MODEL

Depending on the objective, annotation can be defined and classified into different forms and also because it can include various types, semantics and structure. In this paper, the proposed annotation model contains detailed information for various annotation types and semantic, and recognition and correction information for XML documents. Structure based annotation information can be useful when exchanging and reusing. Detailed explanation of the proposed annotation model is as follows.

2.1 Context based Annotation Modeling

Annotation in this study contains semantic relation between annotation type of original document and anchor and the content is as described in Definition 1.

Definition 1

Annotation Model is composed of the following three basic components and contents for each component are as follows.

T : Basic type that composes annotation.

C : Context that is annotated, namely anchor text.

R : Relation between added annotation and document, and includes Semantic information of annotation

Depending on the style type, annotation type(T) is divided into Closed(T_c), Open(T_o), Symbol, and Note type(Definition 2), and simultaneously, depending on the relation with context, it can be divided into Tightly Coupled(T_t) type and Loosely Coupled(T_l) type(Definition 3). Tightly Coupled type is when annotation region is directly influenced by structural information, word, phrase and sentence, and Loosely Coupled type is when the amount of influence is less.

Definition 2

T = (T_c, T_o, *Symbol, Note, Highlight*)

T_c = {*Circle, Rectangle*}

T_o = {*Line, Bracket*}

Symbol = {*Check, Star, CrossOut*}

Definition 3

$T = \{T_t, T_l\}$

$T_t \cap T_l = \emptyset$

$T_t = T_c \cup$ {*Line, Highlight*}

T_l = {*Bracket, Symbol, Note*}

Context(C) is an anchor region for annotation or surrounding text and especially, it can be classified into Non-Structural Context(C_n) and Structural Context(C_s)(Definition 4). Non-structural Context is composed of basic components of document such as word, phrase, sentence, and each component is assumed to be a series of continuous form. Structural Context(S_t) is composed of components of Non-Structural Context and structural feature information that includes starting(E_s) and ending(E_e) element.

Definition 4

$C = \{C_n, C_s\}$

$W = \{a,b,...,z,A,B,..,Z,0,1,..9\}$

$C_n = W^+$

$S_t = \{E_s, E_e\}$

$C_n = S_t \cup C_n$

This paper provides interface for recognition and correction of annotation, and for this, annotation correction(A_c) is divided into style correction and region correction. Each correction is classified into Tightly(TA_c) or Loosely Coupled(LA_c) correction depending on whether the annotation type is Tighly or Loosely Coupled Type(Definition 5).

Also, during correction process, when annotation is Tightly Couple Type, top, down, left and right information of context is considered first. And for Loosely Coupled Type, top and down information of context is considered first.

Definition 5

$A_c = (TA_c, LA_c)$

$f = T_t\ (t,\ b,\ r,\ l) \rightarrow TA_c$

$\delta = T_l\ (t,\ b) \rightarrow LA_c$

Relation(R) is for the semantic of annotation and describes the intention of annotation. In the study, this annotation function is divided as defined in (Definition 6).

Definition 6

R = {*placeholder, reading_assistant, self_thinking*}

Placeholder = {*remind, mark*}

Reading_assistant = {*interpretive, mark*}

Self_thinking = {*idea, criticism*}

Also, Relation has the following relation for annotation Type and Context.

$REL : (T,\ C) \xrightarrow{R} A$

2.2. Structural Context Annotation Markup Language

In this section, we describe Structural Context annotation Markup Language (SCAML) in detail, which is an annotation language for considering various annotation style types, semantic information and annotation recognition and correction

SCAML expresses annotation type, semantic information, structural and physical offset for annotation created on original document, and when printing annotation, SCAML document and original document are integrated to reflect annotation in our browser. Overall structure and content of SCAML is as described in fig. 1, fig. 2. It is possible to repeat annotation elements below the AnnotationList, a root element, and for each annotation, there are Type, Context and Relation elements.

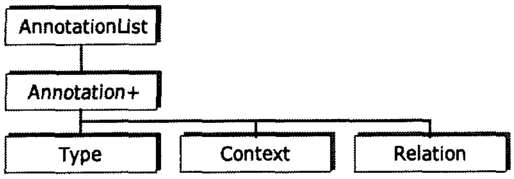


Fig. 1. Overall structure of SCAML

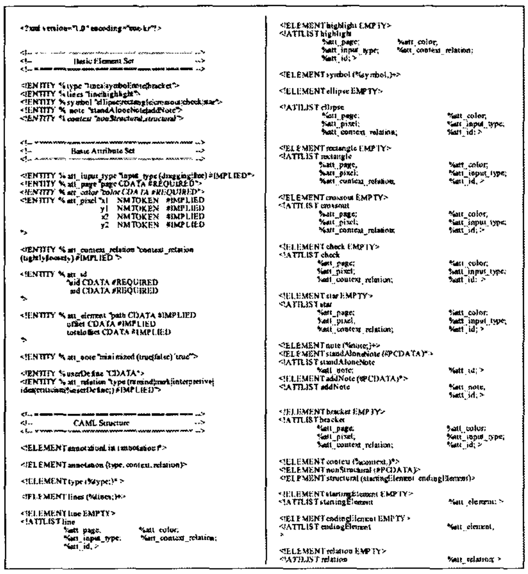


Fig. 2. Content of SCAML DTD

Annotation type is either Tightly or Loosely Coupled type depending on context in-formation and depending on the style form, it is defined as either Closed or Open set. Annotation context is classified into Nonstructural or Structural and Nonstructural includes annotated information such as full anchor text. And Structural element includes structure and offset information of original document that are included in anchor text. The process for the creation of this information is explained in detail in section 3. As explained in the previous section, annotation Relation provides various annotation Semantics that are categorized as placeholder, readingAssistant and selfThinking. Overall content of SCAML that includes the content mentioned above is as described in the fig. 2.

3. SYSTEM OVERVIEW

In this section, annotation system using annotation model discussed so far is explained in detail The target of the system is XML based eBook[18]. And processes for input, output, creation, recognition and correction of annotation using the proposed annotation model are performed. Detailed description is as follows.

3.1 Interface Design

For effective creation of annotation, pen based device is considered in this paper. And to appropriately implement it in desktop or hand-held device, various annotation types and recognition/correction techniques are provided. Also, the interface and the system is for XML based structured documents and to do this, process such as shown in fig. 3 is included. Each element of the system is explained in detail in the next.

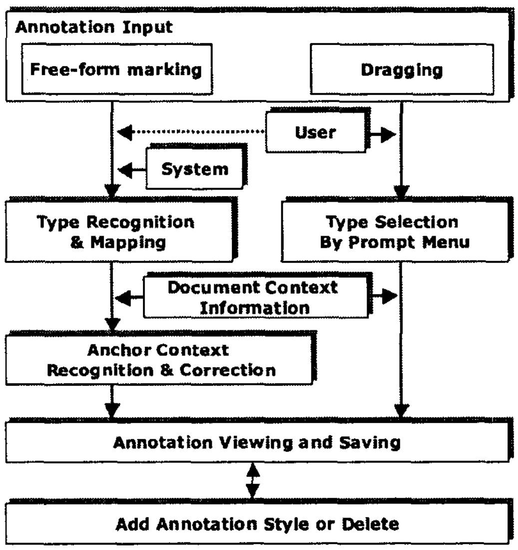


Fig. 3. Overall structure of the system and the interface

3.2 Annotation Type Recognition and Structural Context Feature Extraction

For the recognition of annotation type, pixel information drawn from pen device is analyzed to recognize the style type of annotation as defined in this paper and, during recognition process[17] for the logical information of annotation, location of annotation anchor context, offset, and structural relations which are in a form defined by SCAML are extracted to be sent to correction interface.

To do this, first, logical tree of the original document based on XML is created and route to leaf node of logical tree and offset information are all extracted to be stored separately and are sent to correction module. This process is as shown in fig. 4 and location information[14] for leaf nodes is expressed using each depth of logical structure tree, sequential number in depth, path to leaf nodes and offset of the text of leaf node. Fig. 5 is an example.

Location information that progresses from the left to the right in fig. 5, describes, labels for each node, depth order, media type of leaf node described by "[ ]" and content and offset information of leaf node. Also, the last number means total offset

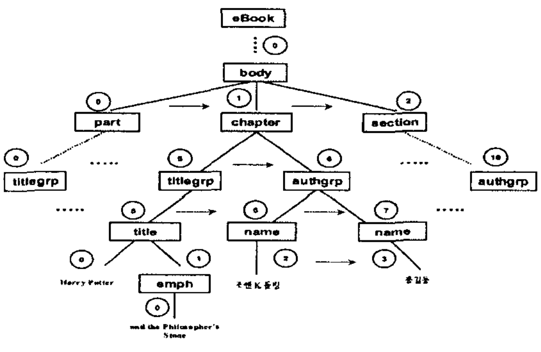


Fig. 4. Creation process for logical-structured tree

eBook/0 body/1 chapter/5 titlegrp/5 title/0 [text] harry porter/12/512

eBook/0 body/1 chapter/5 titlegrp /5 title/1 emph /0 [text] and the Phillosopher's Stone/28/530

eBook/0 body/1 chapter/6 authgrp/6 name/2 [text] 조앤 K. 롤링/8/538

eBook/0 body/1 chapter/6 authgrp/7 name/3 [text] 홍길동/3/541

Fig. 5. An example of extraction of context information following the creation of logical tree

information from the first text to the text of the corresponding leaf node and it is used for smooth processing of annotation viewing in browser.

3.3 Annotation ambiguity correction

In this research, we describe the annotation ambiguity correction methods that occurs during the recognition stage of free-form annotation and the related anchored area. The ambiguity that occurs during the interpretation stage of free-form marking and context within the annotation environment needs to be resolved since it is a big obstacle when accurately selecting the anchored area to mark. To do this, this section analyzes the ambiguity that can occur in an annotation environment in the aspect of feature between annotation and context. The context-based annotation correction method proposed to resolve the ambiguity is also explained.

This process is done through the rule-based model of the proposed system in {IF CONDITION AND···AND CONDITION THEN ACTIONS} form. The rule-based system in this paper is composed of 10 annotation types and 170 rules composed of 5 steps of context analysis and correction.

As shown in Fig. 6, context information in this paper classified into non-structural context and structural context. The non-structural context has the basic features of annotation context such as word, phrase and sentence information along with

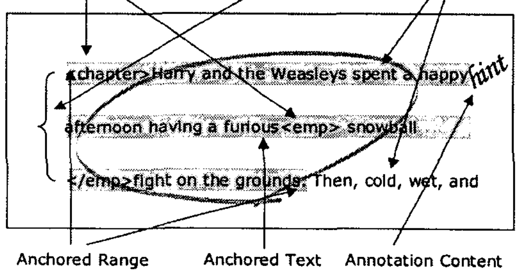


Fig. 6. Definition of context in the proposed model

anchor text. Structural context contains element information within the between annotation and anchored text in XML document. Therefore we will introduce our method for analyzing and correcting the ambiguity based on non-structure and structural feature information. To help explicate each process of the feature analysis and the correction processes of the rule model, we use an ellipse example in Fig. 7.

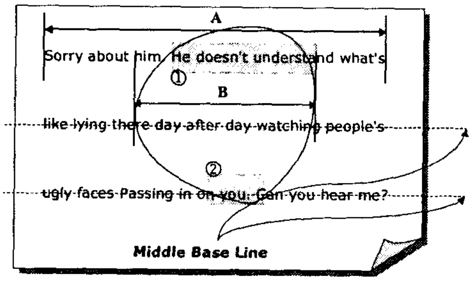


Fig. 7. An example of an ellipse created from free-form marking interface in this paper

3.3.1 Vertical feature ambiguity.

Vertical feature ambiguity occurs during the distinction process of whether the uppermost and lowermost bounding area is in contact with the anchor row or not as shown in Fig. 7. Distinguishing the relationship utilizing the method proposed in this paper would require the extraction of horizontal length of point (Fig. 7.,) and the particular area (middle base line) of original text included by the bounding row shown in Fig. 7. The information that has been extracted needs to satisfy the critical value (Threshold of Top or Bottom Row Area) in proposed rules below to say that the marking and the anchor row have met. Finally, after applying rules and others to the example in Fig. 7, only the top row is included as the top anchor row and the middle row become the new bottom anchor row as shown in Fig. 8.B.

3.3.2 Row Feature Ambiguity.

The row feature is the total number of anchor rows inside the vertical feature region and context

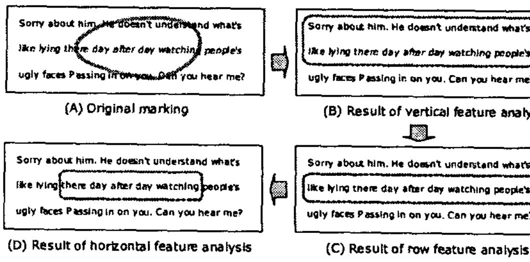


Fig. 8. Context based Correction Process on Example in Fig. 7

information such as whether there are single or multiple rows. Ambiguity that occurs during this step is called row ambiguity. The simplest way[15] to solve this kind of ambiguity is by selecting all the rows inside the boundary box of the marking as anchor rows and considering more than 2 anchor rows as multiple. However, the system should be able to distinguish the number of anchor rows and settle the question of single or multiple through analyzing context information and extracting more accurate row features. To do this, first, the total number of anchor rows is found by applying rule (41) stated below with the result selected from row feature analysis. As a result, example in Fig. 7 includes total of 2 anchor rows as shown in the Fig. 8.B.

Rule (41) ;

IF : (1) Annotation type is *ellipse*
(2) More than 2 point of contact exists on annotation and MBL of each row
(3) Row discarded from vertical feature rule exists
THEN : (1) Consider number of rows excluding rows that are thrown away from total number of anchor rows primarily extracted as anchor rows
(2) Rule to distinguish single/multiple row is performed

In the model proposed, even when the result retrieved by the rules includes more than 2 rows, the ratio of the width of annotation (Fig. 7.B) and total length of original column (Fig. 7.A) needs to satisfy certain criteria (Threshold of Single/Multiple Row) by applying the rule to be distinguished as multiple rows. Since the example in Fig. 7 only includes information on single anchor row, an appropriate single row out of the 2 anchor rows that have been extracted needs to be distinguished as the final anchor row. In the method proposed, applying separate thresholds in rule with textual context length included in each row can distinguish the middle row of the ellipse marking as the final anchor row as shown in Fig. 8.C.

3.3.3 Horizontal Feature Ambiguity

Horizontal feature ambiguity occurs during the distinguishing process of the left and right region of annotation and relates anchored range (entire region between the starting point of marking and the ending point). For more elegant distinction of the anchored range, various relationships between horizontal features and vertical features should be accurately analyzed and an appropriate range defined when a change is made. For this work, the process stated here extracts the starting and ending point of the new anchor range by applying the relevant critical value (Threshold of Select Start or End Word Area) and the rule on offset information of words or phrases included in final anchor row and marking area. For example, the left and right area of ellipse in the Fig. 7 is ambiguously adjacent to the word there and watching respectively and therefore by applying proposed rule (146) and others, a new area will be drawn as shown in Fig. 8.D.

Rule (146) ;

IF : (1) Annotation type is ellipse
(2) Includes single line attribute
(3) *Xmin* of annotation is starting point
(4) Current point is not empty(space)
(5) Above the *ThSSWA*

THEN : (1) Move in X-direction and correct starting point of anchor range with word before the space
(2) Perform following relevant rule

3.3.4 Structural Feature Ambiguity

As shown in Fig. 9, the relationship between annotation and structure information includes exclude (A), include (B) and overlap (C). This paper named each of these cases as structural features. If an annotation system plans to reflect the structural feature information to region recognition process between marking and context, whether each structural feature is appropriate for that particular recognition standard or not should be identified. Otherwise, ambiguity can occur during this step.

This method decides suitability of structural features by comparing annotation and offset of elements. If the result satisfies the proposed rule, the relevant structural feature information is considered valid criteria for an anchored range correction. As an example, in the model shown in Fig. 9.A, if the annotation and structural feature information are in an *exclude* relationship, only when the structural feature information meets certain criteria of the critical value (Threshold of Exclude Structure Correction Area) will the structural feature information be handled as correction criteria. The rule (115) shows the process.

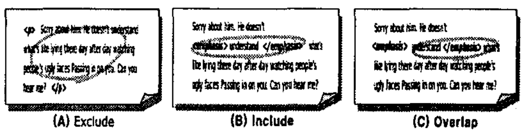


Fig. 9. Example of structural feature

Rule (115) ;

IF : (1) Annotation type is ellipse
(2) A element exists in external area corresponding to 50% of total length of generate annotation
(3) Context offset of annotation interior is over the threshold10
(4) Above *ThESCA* criteria

THEN : (1) Assign start tag as starting point and end tag as end point
(2) Perform following relevant rule

3.4 Annotation Viewing and Creating Results

Annotation interface in this study is assumed to be for a browser that provides window based eBook device, and an example of the result of implementation is as shown in fig. 10. As shown in fig. 10, it is possible to input, recognize, correct, output and create annotation type, which is based on the proposed modeling and SCAML. Menu interface is composed of three parts: page movement, selection of color and input mode.

As described in Section 3.2, annotation input is done by either inputting annotation by free drawing method(cases of circle and line annotation in fig. 11) or dragging method(note annotation in fig. 11). For former case, automatic recognition and correction are done as soon as input is done. And for latter case, separate menu exists for selecting annotation type. As a result, user can create and delete various annotation types through one menu interface.

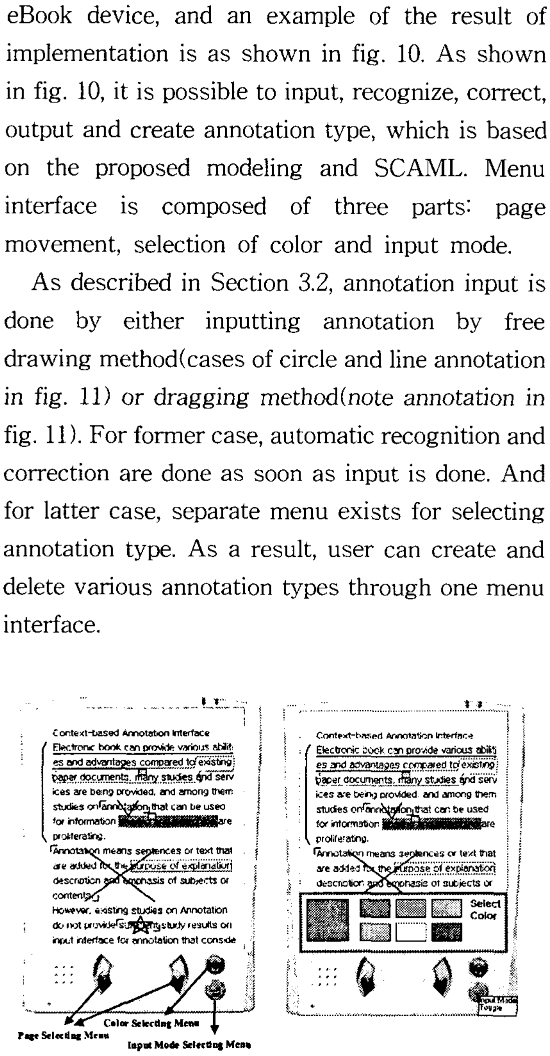


Fig. 10. Result of implementation for annotation interface

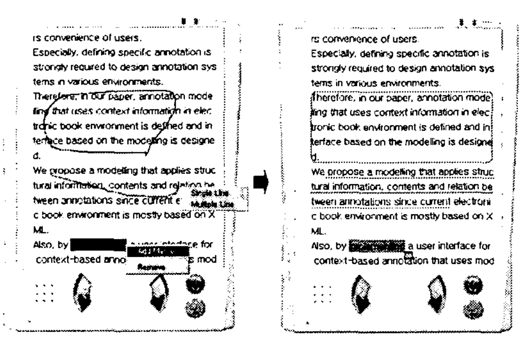


Fig. 11. An example of input, recognition and correction of annotation

4. EXPERIMENTAL EVALUATION

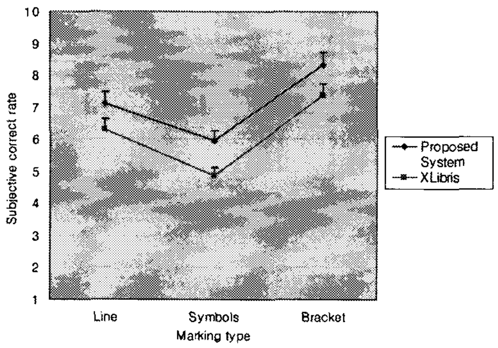
To evaluate the performance of the methods proposed in this paper, empirical user testing has been executed. Observing the accuracy of area distinction required using free-form marking made by single or multiple users, an annotation prototype applied with the technique proposed and an existing technique using Xlibris[15]. The observation on the accuracy of area distinction using computers is difficult to perform quantitatively. Instead, test subjects observed the accuracy of the anchored area that was distinguished by 2 prototypes. This experiment also includes experiments where the user decides on the accuracy of generated free-form markings on his or her own and another one where 10 users exchange generated free-form markings and decide on accuracy information.

4.1 Experiment One

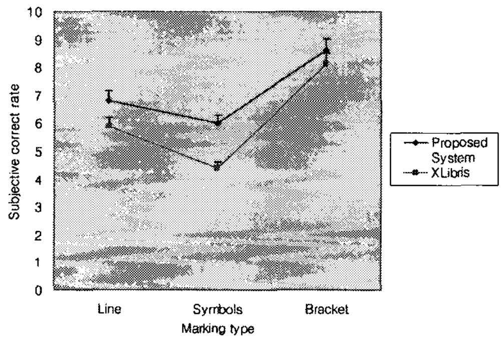
In this experiment, 20 subjects were asked to draw 5 lines, 10 symbols, and 5 brackets each in this experiment. After the tests, the area retrieved through the proposed method and existing method was given to the users and a survey was done with a questionnaire. An ANOVA (analysis of variance) with repeated measures was used to analyze performance in terms of subjective accuracy.

In fig. 12.A significant effects were seen between the three individual marking types in regards to each method ($F(1,114) = 15.8$, $P < 0.05$). Also there was a significant difference in accuracy ratings between each type (line, $F(1,38) = 9.38$, $P < 0.05$, symbols, $F(1,38) = 2.71$, $P < 0.05$).

The users were able to see through experiment one that the method proposed in this paper produce more accurate area selection from marking, using ambiguity resolving method, than existing method[15]. Marking type, symbol showed low accuracy compared to other types. The reason is that generally, ambiguity related to horizontal feature like line and bracket types occurred only. And also



(A)



(B)

Fig. 12. Subjective evaluation for the accuracy according to apply each method in experiment One(A) and Two(B) (1 = lowest accuracy, 10 = highest accuracy).

another reason for the difference on accuracy of symbol type is because various ambiguities occurred on multiple rows simultaneously and it can be seen that the method proposed in this paper has been applied effectively.

4.2 Experiment Two

In this experiment one user draws 20 free-form markings and through 2 methods mentioned in section 4.1 the area information is extracted. The result is given to 10 other users (8 male, 2 female graduate students) via exchange method of the system to evaluate accuracy. In fig. 12.B subjective accuracy evaluation of the 10 users are shown on the result retrieved by 2 methods. Significant main effects were seen between the three individual marking types with regard to apply each methods ($F(1,54) = 13.0$, $P < 0.05$). And also there was significant difference in accuracy rating between symbol types ($F(1,38) = 12.8$, $P<0.05$).

The results of this experiment display a relatively similar pattern to results in experiment one. As a result most of the users agreed that the method proposed is more accurate than the existing method. However, the overall rating ratio is lower than in experiment one. This is because in the case free-form marking, exchange within a multi-user environment forces users to interpret the thought process of other users on the area and meaning, which is much less accurate when compared to when the users are also the originators of the data. Therefore in a system environment that intends to support exchange of marking information, the ability to analyze area accurately from free-form marking and clearly exchange information should be mandatory.

5. CONCLUSIONS

This paper proposed context based annotation model and annotation correction methods that includes context feature. Context-based annotation model provides various types of annotation and semantics for sharing of annotation. For the resolution of ambiguity, rule-based annotation correction is proposed, a method that is specifically based on the context which includes various textual and structure information between free-form marking and annotation.

As a result, annotation model proposed in this paper can be applied to various platforms and domains and especially can be appropriately implemented in desktop or hand-held environments. Free-form marking information generated with the proposed method in this study supply more accurate anchored area information when compared to existing methods[15] and guarantees clear exchange results in a multi-user environment.

In addition, the application of this study to online text editing or proofreading based on the structural document and hypertext environments (eBook, Cyber-Class, Interactive Electronic Technical Manual) should be effective.

Hereafter we are planning to continue with studies related to the repositioning[14] and tracing of free-form marking information following XML structure changes.

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