Research Article

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A review of annotation classification tools in the educational domain

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Abstract: An annotation consists of a portion of information that is associated with a piece of content in order to explain something about the content or to add more information. The use of annotations as a tool in the educational field has positive effects on the learning process. The usual way to use this instrument is to provide students with contents, usually textual, with which they must associate annotations. In most cases this task is performed in groups of students who work collaboratively. This process encourages analysis and understanding of the contents since they have to understand them in order to annotate them, and also encourages teamwork. To facilitate its use, computer applications have been developed in recent decades that implement the annotation process and offer a set of additional functionalities. One of these functionalities is the classification of the annotations made. This functionality can be exploited in various ways in the learning process, such as guiding the students in the annotation process, providing information to the student about how the annotation process is done and to the teacher about how the students write and how they understand the content, as well as implementing other innovative educational processes. In this sense, the classification of annotations plays a critical role in the application of the annotation in the educational field. There are many studies of annotations, but most of them consider the classification aspect marginally only. This paper presents an exploratory study of the classification mechanisms used in the annotation tools, identifying four types of cases: absence of classification mechanisms, classification based on controlled vocabularies, classification based on folksonomies, and classification based on ontologies.

Keywords: annotation tool, annotation classification mechanisms, controlled vocabulary, folksonomy, ontology, exploratory study

1 Introduction

Annotations make it possible to enrich content with additional information that facilitates understanding. Traditionally, this process has been carried out by hand [1]. However, the introduction of computer science in this field has transformed the annotation process in several ways. First of all, the type of content that is annotated is digital [2, 3]. Second, it facilitates collaborative processes [4– 10, so that a team of people can work at the same time on the annotation of the same contents. This encourages higher annotation quality, as annotations are the result of different points of view [11]. And thirdly, tools of this type offer services that facilitate the annotator's work, such as the possibility of using different types of annotations, classifying the annotations made, analysing the annotation process performed on a content, and analysing annotation styles.

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Annotation has been used in different educational areas as an auxiliary tool in the learning process. The most common way to use annotations is to set up group annotation tasks under the supervision of a teacher who gives students instructions on how to perform the annotation process [12]. From the point of view of learning, annotations have positive effects as they strengthen and promote certain skills such as teamwork, reflective ability, and communication skills.

From the educational point of view, analysing the annotations made by students provides information about content comprehension [13], annotation styles, and intellectual maturity. In this sense, many annotation tools provide services oriented to exploit the annotations. The results of this exploitation are usually models that show how annotation types are related to each other, as well as other types of relationships that may exist among the annotations themselves [14]. This information can be useful for creating annotation recommenders or for finding patterns

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in annotations. In this sense, a requirement to be able to exploit the annotations is the possibility of classifying the annotations.

This paper provides a review of the mechanisms that are used in annotation tools to classify the annotations made. The study has been limited to document annotations, since it is the most usual type of content. In addition, and according to the critera introduced in [15], the study has been limited to tools that enable cognitive annotation (i.e., annotation processed and manipulated by humans, students in this setting, and which requires a cognitive and intelectual effort to be interpreted) instead of computational annotation (i.e., annotations as metadata). To carry out the study, an exhaustive bibliographic search in several current reviews of this topic was conducted, as well as searches in repositories of academic papers. Concerning the reviews, we examined the reported in [12, 14–16] in order to extract references to significant annotation tools. Concerning the repositories we considered the following ones: ScienceDirect, ACM Digital Library, IEEE xplore, and Google Scholar. As search string we used "document annotation tool", with no additional search filters. In each case, we screen the first 200 results, by looking in the abstracts for interesting works. For those works appearing as promising, we went into the content to identify the classification mechanisms used. As a result of the search, 34 different tools have been considered. Based on them, a classification of 4 types of tools has been defined, taking shared features as a grouping criterion: 1) Tools with no classification mechanisms, 2) Tools that use controlled vocabularies to classify, 3) Tools that use folksonomies to classify, and 4) Tools that use ontologies.

The paper is structured as follows. Sections 2, 3, 4, and 5 present each type of tool. Their general features are shown, and examples are given. In section 6, their use in the field of education is discussed. Finally, section 7 presents some conclusions and lines for future work. A preliminary version of this study can be found in [17]. While in [17] the analysis was fundamentally narrative, in the current paper we adopt a more structured, feature-oriented, approach. In addition, we refine the classification approach formerly adopted in [17], as well as the set of tools selected to ground the analysis.

2 Tools without classification mechanisms

There is a considerable number of tools that lack explicit mechanisms to classify the annotations made or for later exploitation of the information obtained from the annotation process. In this sense, they are designed exclusively to make annotations and offer services to perform this process such as collaborative annotation or the possibility of using digital ink.

Some examples of this category are the following. Regarding the use of digital ink, we have WriteOn [18] or PaperCP [19], which supports annotations in digital ink of presentations in the classroom using tablets. Some examples of the ability to annotate collaboratively, and sharing content and annotations are Digital Reading Desk [20], which enables collaborative annotation of ebooks based on a virtual desktop, Livenotes [21] which enables collaborative annotation of presentations in PowerPoint, and u-Annotate [22], which supports annotation of web pages by hand. Table 1 shows the main characteristics of these tools.

Table 1: Tools without classification mechanisms

Tool	Mechanisms	Content
WriteOn	Digital ink	Classroom presentations
		using tablet PCs
PaperCP	Digital ink	Classroom presentations
		using tablet PCs
Digital	Collaborative	E-books
Reading	annotation	
Desk		
Livenotes	Collaborative annotation	PowerPoint presentations
u-Annotate	Handwritten	Web pages
	annotation	

3 Tools that use controlled vocabularies

These tools are characterised by having a set of tags that constitute a controlled vocabulary with no structure, used to label the annotations. In general, extending the vocabularies, or using tags different from the pre-established ones is not possible. There are two types of tools according to the aspect to be tagged: Firstly, there are the tools that tag the way in which content is annotated, putting the focus of interest on the style of annotation. Thus, these tools highlight aspects such as the using of underlining, bold type, emphasis and other elements related to the presentation

Table 2: Tools that uses style tags

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Tool	Style tags	Content	Other features
Adobe	Different types of notes such as highlighted,	PDF	_
Reader PDF	inserted or erased text, sticky notes	documents	
Annotator			
Diigo	Highlight text fragments and add sticky notes	Web page	_
CASE tool	Adding images, links, pop-ups and text notes	Web page	Collaborative annotation
CON2ANNO	Highlight / underline text and add text notes, as well as to add summaries based on existing notes to form integrated essays.	Web page	_
VPen	Highlight and underline text, and add text and voice	Web page	Recommendation mechanism based on ranking users by the quantity of the notes provided
IIAF	DiDifferent annotation modes (e.g., underlining, enclosure or commenting)	Web page	Automatic detection of the user's intention in order to automatically identify the intended annotation mode.

of contents. Notice, that, although presentation-oriented, these typographic tags can be understood as a particular type of controlled vocabulary, which involves terms such as underlining, highlighting, etc. (although it is typically hidden by the WYSIWYG features of the tool); this is the reason why these types of tools are considered in this section. Secondly, there are other types of tools that use tag vocabularies in which more attention is paid to the semantics of the annotated content, so that it is possible to determine whether the content is a discussion, an argument, etc. Section 3.1 describes the tools that use style tags and section 3.2 describes the tools that use semantic tags.

3.1 Tools that use style tags

These tools offer a set of predefined tags to make annotations based on the ways of annotating the documents and the presentation attributes used, such as underlining, highlighting, explicit text, etc. Thus, they do not take into account the semantics of the annotation, but the presentational attributes of the contents.

Some examples of this approach are Adobe Reader and PDF Annotator [23], which allow for different types of notes such as highlighted, inserted, and deleted text, as well as sticky notes on pdf documents; Diigo [24, 25], which allows users to highlight text fragments and add sticky notes; CASE [26] which allows users to add images, links, pop-ups and text notes; and CON2ANNO [27], which lets users highlight / underline text and add text notes, as well as add summaries based on existing notes to form

integrated essays. Finally, other tools benefit from information about the annotation activity to allow for more sophisticated uses, like VPen [5], which allows annotators to highlight and underline text, as well as add text and voice; and IIAF [28], which supports different annotation modes (underline, enclose or comment). Table 2 summarises the main characteristics of these tools.

3.2 Tools that use semantic tags

These tools offer a set of predefined tags to classify the annotations based on their meaning / semantics. In this sense each tag represents a different semantic concept.

Some examples of this approach are Highlight [29], which uses two different semantic types (important and confusing) to make annotations, PAMS 2.0 [10], which uses four predefined semantic types (definitions, comments, questions, and associations), MyNote [30], which includes four semantic categories (normal, question, answer, and discussion), Tafannote [31] that includes nine predefined semantic categories (comment, reference, positive and negative judgment, correction, question, example, confirm and refute), WCRAS-TQAFM [11] that uses five types of predefined semantic annotations (importance, quizzing, query, example, and summary) or the MADCOW tool [32] that offers a set of nine predefined types of semantic annotations (explanation, comment, question, integration, example, summary, solution, announcement, and memorandum). Finally, CRAS-RAID [4] provides two separate sets of semantic tags, one for tagging annotations (reasoning,

Table 3: Tools that use semantic tags

Tool	Semantic tags	Other features
Highlight	important and confusing	_
MyNote	normal, question, answer, and discussion	It can be integrated in an LMS
		for annotating learning objects
		as well as external documents
PAMS 2.0	definitions, comments, questions, associations	-
Tafannote	comment, reference, positive and negative judgment, correction, question, example, confirm and refute	Collaborative annotation
WCRAS-	importance, quizzing, query, example, and summary	Support for the automatic
TQAFM		assessment of the quality of the annotations
MADCOW	explanation, comment, question, integration, example, summary, solution, announcement and memorandum	Annotation of multimedia documents
CRAS-RAID	tagging notes (reasoning, discrimination, linking, summary, quizzing, explanation, and other) and tagging discussion entries (reasoning, discrimination, quizzing, clarification, debugging, and other)	Collaborative annotation

discrimination, linking, summary, quizzing, explanation, and other) and another for tagging entries in discussion forums (reasoning, discrimination, quizzing, clarifications, debugging, and other). Table 3 shows the main characteristics of these tools.

4 Tools that use folksonomies

Although these tools also have a set of tags that constitute a vocabulary without a structure, which is used to tag the annotations, the main difference with respect to the previous ones is that they are not controlled vocabularies, but rather they are built and extended using new tags created by the annotators themselves. That is why these tools have in common the fact that annotations are made collaboratively. These vocabularies are usually called folk-sonomies [33]. One of the advantages with respect to the previous vocabularies is that they are usually better suited to the annotation needs when they are created by the annotation experts and in a specific way for each annotation process.

Some examples of these tools are HyLighter [34], which allows for the use of tags defined by the user; Annotation Studio [35], which makes it possible to use sets of tags introduced by teachers in order to be used by students; A.nnotate [36, 37], which makes it possible to classify free-text notes using tags or to create annotations whose content consists only of tags created by the users

themselves; Note-taking [38], which uses tag clouds created by the students to classify the annotations made on electronic books; OATS [39, 40], which facilitates searches in collections of documents in terms of the associated annotations using folksonomies; SpreadCrumbs [1, 41], which enables the annotation of documents with discussion trails and their classification into user-defined topics; and Tsaap-Notes [42], which uses a classification scheme based on user-defined hashtags. Table 4 shows the main characteristics of these tools.

5 Tools that use ontologies

These tools provide sets of predefined tags to make annotations. Their main characteristic is that the tags used are related to each other according to an ontology, *i.e.*, a collection of tags in which relationships have been defined that represent properties that can be expressed through triplets of the subject-predicate-object type [43]. Thus, these tools make it possible to select the ontology that best adapts to the semantic particularities of the annotated content. It is also the type of tool with the greatest semantic richness, as, by associating concepts to a content, all the relationships maintained are also inherited from these concepts.

Some tools that follow this paradigm are loomp [44, 45], which makes it possible to select relevant text fragments and annotate them with concepts taken from various ontologies so that the annotations become instances

Table 4: Tools that use folksonomies

Tool	Annotation features	Other features
HyLighter	User-defined tags	_
Annotation	User-defined tags and repertories of tags	-
Studio	introduced by instructors	
A.nnotate	User-defined tags and annotations whose content consists only of tags	_
Note-taking	Tag clouds to classify their notes on e-books	Specifically oriented to the annotation of e-books
OATS	User-defined tags in order to browse in collections of digital documents	_
SpreadCrumbs	Classification using user-defined topics	Promotes the annotation of documents with discussion trails.
Tsaap-Notes	Classification schema based on user-defined hashtags.	Adopts a micro-blogging paradigm for supporting annotation

of the selected concepts; WebAnnot [46], which uses an ontology of domain annotation objectives and an ontology of document annotation objectives; DLNotes [47], which allows for the annotation of text fragments with concept examples instead of the concepts themselves; MemoNote [48], which allows users to incorporate three different types of ontologies (the ontology of pedagogical annotation objectives to make a specific pedagogical feature of the content explicit, the ontology of domain annotation objectives to annotate a certain aspect of the learning domain, and the ontology of annotation objectives of the document to record aspects related to the document itself); AeroDAML [49], which maps proper nouns and common relationships onto classes and properties in DAML ontologies; AKTiveMedia [50, 51], which allows users to annotate with ontology-based and free-text annotations; KIM [52-54], which uses an ontology, a knowledge base, and an automatic Semantic Annotation, indexing, and a retrieval server; and @note [13, 55-57], which makes it possible to coherently combine free-text and semantic, ontologybased, annotations. Table 5 shows the main characteristics of these tools.

6 Discussion

Figure 1 shows a summary of the tools analysed, which shows that 14.71% do not use any annotation classification system, 41.18% use some type of controlled vocabulary, whether it is constituted of semantic tags or style tags, 20.59% use extensible vocabularies built by the annotators themselves, and finally 23.53% use ontologies to classify

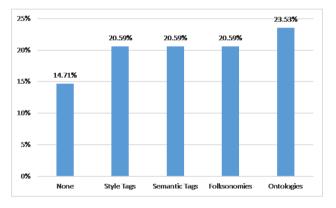


Figure 1: Distribution of analysed annotation tools

the annotations. Therefore, in absolute terms, 85.29% use some system to organise annotations in order to classify them and to enable the exploitation of this information.

From the educational point of view [16], the tools that do not allow the classification of annotations are reduced to a simple simulation of an activity that was previously done by hand. Consequently, the possibility of exploiting the information that can be obtained from the annotation process is lost. In this sense, aspects such as the annotation styles or the annotation models, which could emerge from the analysis of the annotations, are lost, so that neither students nor teachers can benefit from this information.

Concerning the tools that use controlled vocabularies and folksonomies, it is possible to exploit the information about the annotation process and obtain information about annotation styles. However, the flat structure of these vocabularies is limiting because it is not possible to obtain complex annotation models, since the tags used are

Table 5: Tools that use ontologies

Tool	Ontologies	Other features
loomp	It annotates using concepts taken from several	It allows grouping fragments in sets called
	ontologies.	mash-ups and semantically annotating these
		mash-ups with additional concepts and links
WebAnnot	Domain annotation objectives ontology and a document annotation objectives ontology	Excludes the <i>pedagogy annotation objectives</i> one
DLNotes	Annotation of text fragments with instances of concepts, rather than concepts themselves	Supports free text annotations classifiable by a predefined set of categories.
MemoNote	Three different types of ontologies: pedagogy annotation objectives ontology, a domain annotation objectives ontology and document annotation objectives ontology	Provides some support to semi-automatic annotation by means of annotation patterns
AeroDAML	DAML ontologies	Supports annotation with customized ontologies
AKTiveMedia	Ontology-based and free-text annotations	Annotating documents with support of text, images and HTML documents (containing both text and images)
KIM	Supports both semantic and free text annotations	Content retrieval based on semantic restrictions, and querying and modifying the underlying ontologies and knowledge bases
@note	Combines free-text and ontology-based semantic annotations	Facilitates the collaborative definition of critical annotation ontologies among various instructors

unrelated (they are plain sets of tags that are assigned to the annotations.) The most advanced type of possible exploitation would be to make clusters of terms that are used in certain contents, but it would be impossible to obtain more complex information. From the educational point of view, the use of controlled vocabularies makes it possible to analyse the adequacy for students of the limited set of concepts provided to categorize a piece of content, showing their ability to combine the terms and describe the contents. However, with folksonomies, another aspect can be measured, which is the creative and reflective capacity to find the most adequate terms to describe a content. The main problem of folksonomies is the open nature of these vocabularies, so that it can be difficult to look for annotation models if very different concepts are used, even if they are synonymous.

Finally, and concerning the tools that use ontologies, from the educational point of view, this is the most flexible option and the one that can provide teachers with most information on the way in which students annotate. Firstly, the use of ontologies makes it possible to use the most appropriate vocabulary for a specific piece of content. And secondly, due to the very structure of an ontology, it is the most effective mechanism for associating information and classifying annotations since the relationships between triplets make it possible to associate not only direct prop-

erties but properties that can be deduced from the structure of the ontology. In this sense, the use of ontologies to annotate makes it possible to show a student's reflective capacity and maturity level since he/she will have to think about how to use the complex semantic structure offered by an ontology. In addition to the use of an ontology, the teacher, through many of the tools provided, is able not only to retrieve the annotations, but he/she can profit from other systems that exploit this information such as recommenders, annotation models and even extraction of new ontologies based on the actual use of the conceptual structures (*e.g.*, considering that certain concepts are not used or that the ontology lacks other relevant concepts).

Annotation tools currently appear within other ecosystems, especially in digital book editing tools or ebooks, so they have become a component of ebooks. In this sense, annotations tend to be "content-rich" Thus, not only do they contain text but they can contain other types of content such as videos and images [58, 59], becoming one more element of the ebook. It is important to highlight the important role they play within what is called interactive fiction. In this area, the focus is placed on enhancing participation and interaction with the reader in a digital book. Thus annotations are an element widely used in this area to provide information to the reader of the book as part of their interaction (*e.g.*, an interactive fiction entry could

contain a map that illustrates information in a book that talks about a city). That is why for this type of content-rich annotations it may be necessary to use more semantic classification systems to exploit the forms of annotation used.

7 Conclusions and future work

This paper provides a review of the content annotation tools from the point of view of the way in which these tools classify annotations. The results show that most tools offer some classification system with the aim of being able to subsequently exploit the information. A classification of existing tools has been proposed according to the structure of the classification system. In this sense, the use of controlled vocabularies, folksonomies and ontologies has been identified. For these possibilities, ontologies are preferably used due to the flexibility they offer, the possibility to better adapting to the type of content to be annotated, and their semantic richness.

As lines for future work, we propose extending this study by also integrating the new content-rich annotation types, as well as considering annotations that are not made on documents.

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