A method of text watermarking using presuppositions

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ABSTRACT

We propose a method for watermarking texts of arbitrary length using natural-language semantic structures. For the key of our approach we use the linguistic semantic phenomenon of presuppositions. Presupposition is the implicit information considered as well-known or which readers of the text are supposed to treat as well-known; this information is a semantic component of certain linguistic expressions (lexical items and syntactical constructions called presupposition triggers). The same sentence can be used with or without presupposition, or with a different presupposition trigger, provided that all the relations between subjects, objects and other discourse referents are preserved - such transformations will not change the meaning of the sentence. We define the distinct rules for presupposition identification for each trigger and regular transformation rules for using/non-using the presupposition in a given sentence (one bit per sentence in this case). Isolated sentences can carry the proposed watermarks. However, the longer is the text, the more efficient is the watermark. The proposed approach is resilient to main types of random transformations, like passivization, topicalization, extraposition, preposing, etc. The web of resolved presupposed information in the text will hold the watermark of the text (e.g. integrity watermark, or prove of ownership), introducing "secret ordering" into the text structure to make it resilient to "data loss" attacks and "data altering" attacks.

Keywords: Text watermarking, natural language processing, semantic structures, presuppositions

1. INTRODUCTION

The idea of attempting semantic-level text analysis for the purpose of watermarking has been attractive for several years since 2000 when the research based on lexical substitution in synonyms sets was first proposed (see [Topkara et al. 2006] for more details). Later [Atallah et al., 2001, 2002] proposed algorithms to embed information in the tree structure of the text. The watermark was not directly embedded in the text, but in the parsed representation of sentences. Automatic discourse semantic analysis is still not a well developed field, but we are trying to use its best recent advances and propose a new approach for embedding watermarks with the help of semantic representations of single sentences and of the whole text.

When thinking about possible ways of transforming a text for the purposes of watermarking we should keep in mind the factors defined in [Topkara et. al, 2006] which must remain untapped and not be influenced by the transformations:

- meaning – it should be preserved through watermarking in order not to disturb the communication.
- fluency - is required to represent the meaning of the text in a clear and readable way.
- grammaticality - the embedding process should comply to the grammar rules of the language, in order to preserve the readability of the text.
- style - preserving the style of the author is very important in some domains such as literature writing or news channels.

We will be speaking here about text, meaning the result of the verbal activity of this text producer (a speaker or a writer), and about discourse, meaning the verbal activity process, i.e. - the text together with all the pragmatic,

psychological, cultural and other factors influencing this text generation. Such discrimination between text and discourse is important to make clearer the later discussion in Section 2.3 that includes mechanisms of context update and dynamic semantics.

From our point of view, the text, i.e. the result of the discourse generation, is not an aggregate of separate sentences considered in isolation, the meaning of the whole text cannot always be perceived compositionally, but text is an integer entity holding all its intersentential links provided by certain linguistic means, such as anaphoric links, presuppositions, ellipsis, coreference, etc. Each sentence is considered as a new contribution to the whole discourse, information is accumulated with every new step and consistently integrated into the previous discourse. This property of integrity and underlying semantic relationships within a text allow us to think about new robust methods of text watermarking based on efficient semantic representations of the text.

2. Semantic structures for text watermarking

2.1. What is a presupposition?

For the key of our watermarking approach we propose to use a linguistic semantic phenomenon called presupposition. Presupposition is a sort of implicit information which is considered well-known or which readers of the text are supposed to treat as well-known; this information is a semantic component of certain linguistic expressions (lexical items and syntactical constructions). These linguistic expressions generating presuppositions are called presupposition triggers.

Let us illustrate these theoretical statements on simple examples:

(1) `Jane likes her white Toyota.`

(2) `Jane regrets that John is stupid.`

If we want to accept these sentences as normal contributions in the discourse, we have to take for granted that (1) Jane has a white Toyota and (2) John is stupid. Otherwise we have:

(1') `Jane has no car? Jane likes her white Toyota.` (unacceptable)

(2') `John is clever? Jane regrets that John is stupid.` (unacceptable)

Thus, some information is conveyed in implicit form using certain linguistic tools. This kind of information even survives altered context conditions, for instance:

(1'') `Jane does not like her white Toyota.` (negation)

`If John is in town, then Jane likes her white Toyota.` (conditional)

Presupposition: `Jane has a white Toyota.`

(2'') `Jane does not regret that John is stupid.` (negation)

`If Nancy is a boxer, then Jane regrets that John is stupid.` (conditional)

Presupposition: `John is stupid.`

As we can easily infer, the same sentence can be used with or without presupposition, provided that all the relations between subjects, objects and other discourse referents are preserved, then such transformations will not change the meaning of the sentence. Linguistic transformations can be based on presupposition triggers. For our purposes we classify the following presupposition triggers: definite NPs; possessives; interrogative words; factive predicative constructions; implicative verbs; aspectual verbs and modifiers; it-clefts and wh-clefts. We define the distinct rules for presupposition identification for each trigger and consequently regular transformation rules for using/non-using the presupposition in a given sentence.

For example:

(3) Jane likes her white Toyota. = Jane has a white Toyota and she likes it.

(4) Jane regrets that John is stupid. = John is stupid and Jane regrets it.

(5) It was a new jacket that he bought = He bought a new jacket.

(6) He began to smoke at the age of 16. = He did not smoke before the age of 16.

(7) He stopped smoking at the age of 16. = He does not smoke from the age of 16.

(8) The fact that my friend is ill, makes me sad. = My friend is ill (and) it makes me sad.

(9) What people do you know here? = You know some people here, don't you?

Presuppositions build the semantic basis of discourse, provide its coherence, consistency and are important for creation of the common ground between the author of the text and the readers. Presuppositions are a pervasive feature of human language and they are a valuable linguistic instrument – it is an effective way of sharing information.

2.2. Transformation rules for the presupposition triggers

For all presupposition triggers suitable for the purpose of text watermarking we define the rules for sentence transformations, keeping in mind the necessity to keep untapped all the relations between subjects, objects and other discourse referents within a single sentence, and hence within the whole discourse. We describe here only generic rules, without detailed consideration of all the sophisticated peculiarities associated with each linguistic entry, that could be a subject of an extended separate paper. We illustrate the possible transformations on real-life examples of sentences from different sources collected for the experiment described in Section 3 below and interview texts originally collected for presupposition analysis in discourse by [Vybornova, 2002]:

2.2.1. Definite NPs

Identification: these triggers expressed by noun phrases with definite article *the*, as well as with demonstrative pronouns *this, that, these, those* generate presuppositions of existence of the subject or the object mentioned in the sentence.

Possibilities for transformations: if we want to remove a presupposition from a sentence, we have to get rid of the presuppositions trigger and to paraphrase the sentence so that it does not contain the trigger. For that the determiner can be removed at all in some cases, or an indefinite article can be used instead. Another possible transformation is to keep the presupposition, but to replace one trigger with another, for example, interchange between *the, this, that* is possible, and *these* and *those* can be replaced with *the.*

Example:

Original sentence: It seems pretty clear to me that *the* great majority among the Revolutionary generation wanted a national Union... // John Ferling, http://www.theamericanrevolution.org/hvpts.asp

Transformed sentence: It seems pretty clear to me that *a* great majority among the Revolutionary generation wanted a national Union...

2.2.2. Possessives

Identification: these are possessive pronouns *his her its my our their your* as well as nouns and proper names in possessive case, say *country's, John's*, etc. They also generate presuppositions of existence.

Possibilities for transformations: the form of a transformation depends on the right context neighborhood of the possessive. Depending on the noun used with the possessive in a given sentence, there can be *Subject has/have/had* <*the noun*> or *Subject makes/make/made* <*the noun*>, etc.

Example:

Original sentence: *Her* previous visit was in 2003, when the tournament was still played in Los Angeles where she was also crowned the year end №1 player. // http://www.henin-hardenne.be/bin/shownews.asp?Lang=en&id=2817

Transformed sentence: She *made* a previous visit in 2003, when the tournament was still played in Los Angeles where she was also crowned the year end №1 player.

In the case of possessives we would like to point out an interesting problem. If a possessive triggers a presupposition related not to context-dependent entities introducing referents in a given discourse, but to general world knowledge, then transformations based on such a trigger will hardly be possible, otherwise they are too noticeable. For instance, phrases like their lives, his arm, his body presume common knowledge about human beings and generate presuppositions that the subjects are alive, that the subject has an arm, the subject has a body, correspondingly. If we try to transform such phrases in the above mentioned form, the modification might seem too obvious and hence inadmissible.

2.2.3. Interrogative words

Identification: the interrogative words *who? what? when? why? where? which? how?* are presupposition triggers only in questions. Along with the presuppositions that hold for the corresponding affirmative proposition, interrogative forms presuppose the appropriateness of the information under the question.

Possibilities for transformations: an interesting peculiarity of this trigger processing is that we cannot make transformations within a single sentence containing it. To make a proper transformation satisfying the requirements of consistency and well-formedness we have to consider also the answer to the question invoked by the interrogative word, if this answer follows the interrogative sentence. The strategy here is to remove the interrogative word, generate an affirmative sentence and start the sentence with the part following the interrogative word, change the word order for affirmative, coordinate the number and tense and then combine it with the answer to the question from the next sentence. For each interrogative word the transformation rules are different. For instance, *who?* has to be replaced with the subject from the next sentence, *what?* – with the object. The simplest one is the word why – to transform the sentences we remove the *why?*, keep the rest of the sentence, add *because* and combine it with the next sentence.

Example:

Original sentence: How can I make the paper look better? I read a lot.

Transformed sentence: To make the paper look better I read a lot. = I read a lot to make the paper look better.

2.2.4. Factives

Identification: predicates like *know that; realize that; regret that; matter that; count on; make sense that; find out that; discover that; see that; notice that; be sorry that, be proud that, be indifferent that, be glad that, be sad that, the fact that, significant that, important that, odd that, tragic that, exciting that, relevant that, glad that, proud that, lucky that, though, although, due to the fact that/smth* – presuppose the fact, the truth of the information in the subordinate clause, unlike the non-factive predicates, like *believe, think, suppose*, etc.

Possibilities for transformations: to remove the presupposition we can replace the factive construction in a sentence with a non-factive. Another possibility is to rearrange the construction, preserving the key word, but getting rid of the presupposition, like in (4). An example illustrating replacement of a factive with a non-factive:

Original sentence: Many Americans do not *realize* that George Washington crossed and re-crossed the Delaware River a total of four times in the waning days of 1776. // John Ferling, http://www.theamericanrevolution.org/hvpts.asp

Transformed sentence: Many Americans do not *believe* that George Washington crossed and crossed again the Delaware River a total of four times in the waning days of 1776.

2.2.5. Implicative verbs

Identification: verbs like *manage, forget, happen, avoid,* etc. are semantically rich. Let's consider the following schema to illustrate the presupposed information that they trigger:

`X managed to V.` <p> = "X tried to V". The result is that X did V.

`X forgot to V.` <p> = "X ought to have Ved, or intended to V". The result is that X did not V.

`X happened to V.` <p> = "X didn't plan or intend to V". The result is that X did V.

`X avoided V-ing.` <p> = "X was expected to, or usually did, or ought to V". The result is that X did not V.

Possibility for transformations: as we can see from the given schema, the main point to care about during the transformation is to preserve the "result" introduced by the implicative verb, and the implicative verb itself can be removed:

Original sentence: `Somehow I managed to wrench myself out of the dream, but not into a state of waking; it was like the screen went blank.` // Neil Gaiman and Dave Mckean interview, Los Angeles, December 1994, originally broadcast on KUCI, 88.9FM.

<p> = `"I tried to wrench myself out of the dream"` triggered by the implicative verb `manage`

Transformed sentence: `Somehow I wrenched myself out of the dream, but not into a state of waking; it was like the screen went blank.`

2.2.6. Aspectual verbs and modifiers

Identification: verbs and adverbs denoting the beginning, end or continuation of an action, such as *begin, start, commence, stop, finish, quit, cease, leave off, give up, continue, carry on, go on, keep, still,* etc. usually presume that there is a prerequisite for this action. An interesting semantic feature of the aspectual verbs and modifiers is that their presuppositions describe the situation that took place at the time preceding the reference time of the sentence. Depending on the aspect of action described by the modifier – beginning, end or continuation, we distinguish several groups according to the presuppositions they trigger:

a) For verbs denoting beginning of action:

`Subject (X) + start, begin VERB-ing / VERB – infinitive + Adv. modifier`

Let t denote the reference time of the utterance. Then the presupposition triggered by action beginning verbs will be:

<p> = "X didn't VERB at time before t"

b) For verbs denoting continuation of action:

`Subject (X) + continue + VERB-ing / VERB – infinitive; go on, carry on, keep + VERB-ing + Adv.modifier`

and

c) For verbs denoting end of action:

`Subject (X) + finish, stop, leave off, give up + VERB-ing + Adv.modifier`

and

d) For adverb *still*:

`Subject (X) + to be + still + (VERB-ing) + Adv.modifier`

Let t denote the reference time of the utterance. Then the presuppositions triggered by action continuation and end verbs and by adverb still (b-d) will be:

<p> = `"X VERB-ed at time before t"`

Possibilities for transformations: the sentences containing these triggers can be transformed by means of removing the aspectual modifier, but introducing the information presupposed by it. For example:

Original sentence: `Because most nonprofit mental health service providers don't provide medication and don't accept Medicaid patients, Thur said, demand for the Community Services Board's assistance will` *`continue`* `to grow.` // Bill Turque, Washington Post, November 19, 2006.

Transformed sentence: `Because most nonprofit mental health service providers don't provide medication and don't accept Medicaid patients, Thur said, demand for assistance of the Community Services Board will grow as before.`

2.2.7. It-clefts and wh-clefts

Identification: it-clefts and wh-clefts presume the truth of the information contained in their subordinate clause:

a) It is/was NP/PP/ADV which/whom/who/in which/for whom/when/where/that S

<p> = "Someone/somewhere/somehow/something S"

b) what + NP/PP/VP + VERB/ADJ + is/was/are/were S.

<p> = "Someone/something + VERB/ADJ [Spenader, 2002]

Possibilities for transformations: it-clefts and wh-clefts can be transformed by simply removing the corresponding constructions, but keeping their presupposed information, for example:

Original sentence: *`What`* `we can learn from Olmsted` *`is`* `the importance of planning; one of the ways to make suburban growth better is, in fact, to plan it.` // A conversation with Witold Rybczynski, July 14. 1999.

Transformed sentence: `We can learn from Olmsted the importance of planning; one of the ways to make suburban growth better is, in fact, to plan it.`

A few concluding remarks for this section: we have described the possibilities of text transformation by means of removal of presuppositions and converting sentences (or their corresponding fragments) into non-presupposed forms. However, the inverse process is possible – using the same techniques, but applying them the other way round, we can introduce presuppositions into (parts of) sentences where there were originally none.

2.3. Presupposition resolution within Discourse Representation Structures

To the best of our knowledge, the most efficient and elegant way of representing the behavior of presuppositions in a discourse is to treat them as anaphoric expressions [Van der Sandt, 1992]. Presupposition triggers can be processed in the same way as anaphoric pronouns and other anaphoric expressions. There are two ways of interpreting presupposed information in discourse: it can be bound or accommodated.

After detection of a presupposition trigger in discourse, the first step in the analysis should be examination of the previous discourse context in order to try to find a suitable accessible antecedent to which the presupposition could be bound, i.e. find such a discourse referent in the previous discourse which is similar enough to the presupposed information to function as an antecedent. The presupposed information and its antecedent can be bound with the relationship of synonymy, hypo-hyperonymy, co-reference, bridging, etc. In some cases more than one potential antecedent can be accessible and then certain restrictions are needed to define the correct place for the presupposition binding so that the presupposed information is consistent, makes sense and is not redundant. If binding is successful (a suitable antecedent is found and partial match is established), then the presupposed information is considered resolved.

If the presupposed information is not given in the previous discourse context, then it is presumed that implicit usage of this information in discourse means that readers should treat this information as known. This leads to the process of adding the presupposition to the discourse – accommodation (i.e. new information presented in the presuppositional

form is added to the discourse context). The detailed algorithm of presuppositional analysis is described in [Vybornova, 2002].

In formal description of the processes of presupposition interpretation, discourse representation structures (DRSs) are used. DRS is a concept within the frameworks of Discourse Representation Theory (partly described in [Kamp, 2001]), being one of the most influential and interesting current approaches to the semantics of natural language. DRSs model semantic relationships within the discourse in general and mechanisms of presupposition interpretation in particular. DRSs are made up of two types of objects – discourse referents representing objects introduced in the discourse and conditions holding descriptive information about these referents.

More formally:

DRS R is a pair <U(R), Con(R)> where:

- U(R) is a set of reference markers

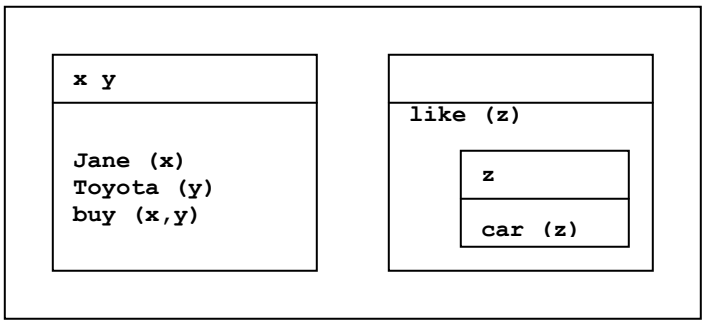
- Con(R) is a set of DRS conditions

If R and R' are DRSs, then ¬R, R∨R', R⇒R' are (complex) DRS-conditions.

DRSs are usually represented as split boxes, where the top part of the box contains the conditions that hold for the discourse referents.

If Jane buys a Toyota, she will like her car.

The obtained DRS for this sentence is the following (for illustration purposes we describe only processes related to presupposition interpretation and generalize other details):



where the embedded box represents the presupposed information to be resolved.

Linear format:

[[x, y: Jane (x), Toyota (y), buy (x,y)] ⇒[like (x,z) [α: car(z)]]]

Presuppositions have a rich semantic content, capable of introducing new DRSs within bigger ones. We incorporate presuppositional information into a larger DRS and locate it in the web of discourse referents regulated by accessibility constraints.

The resolution is performed by binding the presupposition "Jane has a car" to the antecedent ("Toyota") found in the first part of the sentence:

[[x, y: Jane (x), Toyota (y), buy (x,y)] ⇒[like (x,y)]]

If we build a DRS for the same sentence not containing the presupposition, but conveying the same meaning, we will have:

If Jane buys a Toyota, she will have a car and she will like it.

[[x, y: Jane (x), Toyota (y), buy (x,y)] ⇒[Jane (x), car (z), like (x,z)]]

In the result of anaphoric pronoun resolution and bridging the "car" to "Toyota" (using created ontology) we will obtain the same representation as for the sentence containing presupposed information:

[[x, y: Jane (x), Toyota (y), buy (x,y)] ⇒[like (x,y)]]

So, as we can see, the final semantic representations of sentences with and without presupposition are the same, since all the discourse referents and relations between them are preserved after transformation.

Thus, the marked sentences will be those containing presupposition triggers captured by parsing (the weaker indicator) and those for which DRSs representing their semantic structure will contain (an) embedded DRS(s) with presupposed information to be resolved (the stronger indicator). During the text analysis, logically transparent semantic representations (DRSs) of single utterances are created and then these DRSs are subjected to further semantic and/or pragmatic operations which relate them to the context where the analyzed sentence is used. In case a sentence is a part of a more extended discourse the named operations should integrate the DRS into the obtained interpretation of the previous discourse which has been processed up to this moment. This is an accumulative process, where new discourse referents and conditions holding for them, are incorporated into the main DRS representing the whole discourse contents.

Formally [Kamp, 2001] shows it like this. The main strategy of discourse interpretation is of cumulative character: to interpret a discourse <φ 1,…,φ n> one should start from creation of the representation R1 of the sentence φ1, then use this representation as a context to interpret φ2, which, when matched with R1, will give the representation R2 for <φ 1, φ 2>; and so on. However further processing of the next sentence φ i+1 is not direct integration into the context representation Ri, but takes place in two stages. At first a "preliminary" representation R′i+1 for the utterance φi+1 is created where presuppositions generated in φi+1 are explicitly presented, and then this preliminary representation R′i+1 is matched to the context representation Ki. This matching includes resolution of all presuppositions represented in R′i+1. If it succeeds, the non-presuppositional part of R′i+1 is matched to Ri, and a new context representation Ri+1 is obtained. DRS are obtained fully automatically in the analysis of the sentences of a text.

3. EXPERIMENT

3.1. Prerequisites

The basis for watermarks are presuppositions in the text. In principle, every sentence is needed for carrying watermark bits. The sentences carrying presupposition triggers can be indicated with bit 1, and those not carrying presupposition triggers – with bit 0. The approach is to paraphrase presuppositional-form sentences into non-presuppositional form using the predefined regular transformation rules (as described in Section 2.2.), and vice versa – introduce presuppositional form in the sentences which do not have it originally. Here is an example of two successive sentences in a text illustrating these cases // U.S. backs diplomacy-first approach to North Korea, International Herald Tribune, The New York Times, July 9, 2006:

But in Tokyo, the Japanese foreign minister, Taro Aso, insisted that punitive UN sanctions on North Korea are the only plausible response to *North Korea's* missile launches, which rattled the region last Wednesday.

We'll replace the possessive *North Korea's* with a non-presuppositional form and obtain the transformed sentence: But in Tokyo, the Japanese foreign minister, Taro Aso, insisted that punitive UN sanctions on North Korea are the only plausible response to missile launches undertaken by North Korea, which rattled the region last Wednesday.

Next sentence in this text:

`In television appearances Sunday morning, Aso said that Japan would not yield on sanctions, despite the likelihood of a Chinese veto, and would press for a Security Council vote on Monday.`

Presupposition triggers can be introduced into a few possible positions here, for instance we can insert an aspectual verb *start*: `In television appearances Sunday morning, Aso said that Japan would not yield on sanctions, despite the likelihood of a Chinese veto, and would` *`start`* `to press for a Security Council vote on Monday.`

Even single sentences if taken isolated can carry the proposed watermarks. In those cases presupposed information will be treated like new information, it will not be bound to information in other sentences, but still all the mentioned transformations can hold. However, the longer is the text to be watermarked, the more efficient and resilient will be the watermark. The web of bound information (resolved presupposed information bound to its antecedents in the previous text) will hold the integrity of the text, introducing "secret ordering" into the text structure, in order to make it resilient to "data loss" attacks and "data altering" attacks - changing the order of sentences, removing sentences from the text or modifying them.

3.2. Experiment setup and results

We selected 16 texts for the experiment. The texts were from different sources – these were webpages of newspapers, TV- and radio-companies, of historians and sportsmen. The texts are taken both from American and British sources, and from other countries' websites, i.e. the texts are composed not only by native speakers of English, but also by non-native speakers. We decided to do so, because English is an extremely widespread language commonly used by billions of people around the world, and for most of these it is not their mother tongue. Our goal is to develop a watermarking technique that would work on non-natively composed texts also. The selected texts are not limited to any particular style or topic – these are hot political news, reviewing articles, interviews with politicians, scientists and writers, historical essays, reports on sporting events and movie trailers. The length of the texts varies from 2 to 29 sentences. They are available at the URL www.tele.ucl.ac.be/vybornova

In each text we at first marked all the possibilities for transformations (i.e. presupposition triggers), then randomly selected a few of them and modified the corresponding sentences. On average, in each text we made 2-3 transformations from a presuppositional to a non-presuppositional form and 1-2 transformations of introducing presuppositions into the sentences.

We asked 10 native speakers of English and 10 non-native speaking subjects to help in the experiment. The subjects were of different age (from 19 to 68), education and occupation (incomplete higher education and higher education in humanities and science). The instruction for the subjects was to read the texts and to tell which of the texts are originals and which are modified, according to the subject's opinion. If the subject decided that a text is transformed, he/she was asked to explain what exactly in the text makes him/her think so. Subjects had no time limits to perform the experiment, they could read the texts as long and as many times as they needed to take a decision.

No one of the subjects pointed to our transformations in the texts offered for the experiment. The subjects expressed various opinions about the origin of the texts, reasoned about their stylistic and grammatical features, noticed unusual usage of articles, prepositions or word order and made conclusions based on these observations. Native speakers were probably mislead by the texts composed by non-natives, and some of the subjects found the whole text sounding strange and hence probably transformed as they thought, whereas the text was original.

3.3. Discussion: use of the proposed text watermarking method

Our method is suited to hide at least one bit per sentence through the use of a secret key. The key indicates sentence with or without presupposition. The proposed presupposition triggers are diverse and can be randomly selected through the key. The watermark can convey a proof of ownership information, an integrity mark or a fingerprint containing the end-user id. Applications are possible in many domains, including press agencies, authenticated text, e-book protections … Our method can be implemented in a blind way but is then fragile to sentence removals. In case of a non-blind approach (using the original text for watermark retrieval), the method can be made very robust.

4. CONCLUSION and FUTURE WORK

We have considered and discussed a method of text watermarking using presuppositions. We have explained the way how the semantic representations of sentences resist against surface transformations based on presupposition triggers. For the purposes of text watermarking we have studied and described so far the behavior of seven presupposition triggers in discourse, but one of the directions of future research on this topic will be to consider the possibilities of transformations for other typical presupposition triggers – iteratives, quantitative pronouns, modal particles, constructions denoting time.

It should be explored in more detail, what would be the strategy in case more than one presuppositions are found in a sentence. Whether such a sentence should be subjected to multiple transformations from which the final meaning representation will be generated, or for instance, only the first presupposition trigger should be used to make the transformation to avoid complexity, or, another possibility is to select not the first one found, but the most appropriate trigger for the given case – this is a question of more practical testing. However, for the latter choices, if an attacker makes transformations of a sentence randomly, then it might happen that some particular triggers can be changed and thus some bits of the watermark would be destroyed. From this point of view we should better not waste triggers and hence watermark bits based on them. Though the proposed approach is resilient to main types of random transformations that might be attempted by an attacker, like passivization, topicalization, extraposition, preposing, etc. However, even if an attacker guesses the transformations based on one or two triggers, he/she will very unlikely be able to destroy all the watermarks, because the proposed presupposition triggers are diverse in their structure and in types of the presupposed information they generate.

Another possibility for watermarking a whole text is to produce an “alternative” underlying representation of the text, based only on the presupposed information obtained during the whole text analysis. This alternative underlying meaning of the text will serve as a secret key for any possible transformations.

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