A Natural Language Watermarking Based on Chinese Syntax ⋆

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Abstract. A novel text watermarking algorithm is presented. It combines natural language watermarking and Chinese syntax based on BP neural networks. Since the watermarking signals are embedded into some Chinese syntactic structure rather than the appearance of text elements, the algorithm is totally based on the content that can prove to be very resilient. It will play an important role in protecting the security of Chinese documents over Internet.

1 Introduction

With the development of digitalization technology, it is indispensable to protect the copyright over the text documents. Although there are many text watermarking algorithms in recent years, but it is easy to remove it[1]. A better text watermarking approach is to use natural language watermarking [2–4] that Atallah et al. proposed. This paper describes a natural language watermarking based on Chinese syntax.

The organization of the paper is as follows: In Sect. 2, we will present a kind of natural language processing techniques of Chinese syntax based on Backpropagation (BP for short) neural networks [5]. A natural language (NL for short) watermarking based on Chinese syntax will be depicted in Sect. 3.The finally is the conclusions.

2 NLP Technique of Chinese Syntax

Natural Language Processing (NLP for short) aims to design algorithms that will analyze and understand natural language text automatically, such as machine translation, information retrieval and so on. In this section, we describe a Chinese syntax analysis system based on BP neural networks(see Fig. 1.)

Database adopts production rules to express the knowledge, which is standardized into binary rules and is coded to be stored in the neural networks. In general, the form of production rules is as follows:

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$$\text{If } a_1 \wedge a_2 \cdots \wedge a_n \text{ then } b_1 \wedge b_2 \cdots \wedge b_n$$

Standardize the above form to become binary form:

$$\text{If } a \text{ then } b_1 \wedge b_2 \text{ or If } a \text{ then } b_1 \wedge b_2$$

We uses 106 pieces of Chinese language knowledge so that they will be represented with seven bits, for instance:

noun <u>encoded</u>:0000001, verb <u>encoded</u>:000 0010, Sub <u>encoded</u>:0011110
Pre <u>encoded</u>:0011111, Sub_Pre <u>encoded</u>:0100100, No_Sub_Pre <u>encoded</u>:0100101

Chinese syntax rules can be described as follows:

$$S \rightarrow Sub\_Pre \vee No\_Sub\_Pre\ \underline{encoded} : 0000000 \rightarrow (0100100) \vee (0100101)$$
$$Sub\_Pre \rightarrow Sub \wedge Pre\ \underline{encoded} : 0100100 \rightarrow (0011110) \vee (0011111)$$

Inference machine makes inference based on neural networks, which are BP neural networks grounded on Leverberg-Marquard algorithm. The learning algorithm of BP networks can depict in the following way:

$$\begin{cases} f(p^{k+1}) = \min_\alpha f(p^{(k)} + \alpha^{(k)} p(x^{(k)})) \\ p^{(k+1)} = p^{(x)} + \alpha^{(x)} s(p^{(k)}) \end{cases} \tag{1}$$

Where $p^{(k)}$ is a vector, which contains all the values of weights and thresholds; $s(p^{(k)})$ is the search direction of the vector space, which is composed by each p's weight; $\alpha^{(k)}$ is the teeny length of the pace of $f(p^{(k+1)})$ in the $s(p^{(k)})$ direction. For example, if the sentence is "罗雪娟最终获得金牌。", the input would be: "n adv v n". The syntax inference tree is left out. Taking out the empty node, the syntax analysis tree will be as shown by Fig. 2.

3 A NL Watermarking based on Chinese Syntax

3.1 Principle

In Chinese, a sentence might have several ways to describe without changing the meaning. So, our scheme is to embed the watermark by transforming the syntactic structure. In this mechanism, we intend to select all the sentences except the topic sentences to carry the watermark bits. To describe the principle clearly, some definitions and backgrounds should be presented formally at first.

$A = \{C \cup N \mid C$ is the set of all the topic sentences, and N is the set of all the non-topic sentences$\}$, i.e., A is the set of all the sentences in the text.

p denotes the secret key and it is a large prime. w denotes watermark bits, its length is λ. β denotes the number of watermark bits in each sentence. T_i denotes a corresponding tree that represents s_i syntactically. $B_i = D(T_i)$ denotes the corresponding binary string to each T_i. $B'_i = H(B_i)$, where H denotes a one-way hash function. d_i denotes the number of 0's in the bitwise XOR of B'_i and $H(p)$. S is the set of sentences to be watermarked, that is a list of the $s_i(i = 0, 1, \ldots, n-1)$ sorted according to their d_i values, r denotes s_i's rank in S.

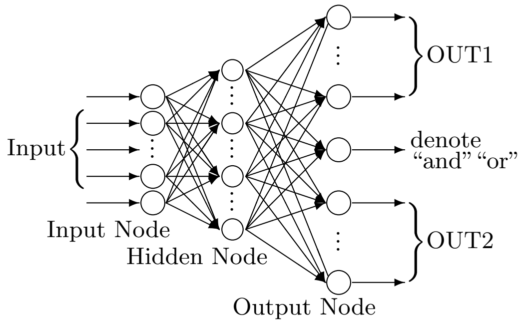

Fig. 1. Model of the BP

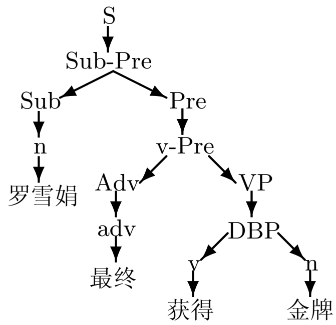

Fig. 2. Syntax Analysis Tree

Definition 1. *Syntactic transformation is meaning-preserving and near-meaning preserving text substitutions for NL watermarking. Three common syntactic transformations are as follows:*
1) Adjunct Movement, where an adjunct is like a prepositional phrase or adverbial phrase.
2) Passivization: Any sentence with a transitive verb can be passivized.
3) Insertion "transitional" phrases that has empty meaning, such as "众所周知···", "值得一提的是···", and so forth.

3.2 Algorithms

Embedding Algorithm :

```
program Embedding(A, w)
   begin
      get S from A, then generate B from S with D(Ti)
      select β value according to the comparison of n and λ
      sort the sentences of S
      for each sentence ∈ S do
         if it is able to be transformed, then
            the indicator bit is 1, embed the watermark by syntactic
transformation
         else
            the indicator bit is 0, and that sentence are ignored during
the watermark detecting time
         end-if
      end-for
   end
```

The technique to select β value according to the comparison of n and λ is very important for the robustness of the algorithm. There are two circumstances for it, which are as follows:

if $n \geq \lambda$ then $\beta = 2$(the first bit is an indicator bit)
else $\beta = \frac{\lambda}{n}$ or repeating the watermark $\frac{\lambda}{n}$ times.

As for generating B from N with $D(T_i)$, we will present the algorithm at once.

```
program Generating(N,p)
   begin
      Chinese syntax analysis to get Ti of each sentence in N
         for each Ti do
            give the nodes of Ti numbers
            replace every number i at a node by a bit: 1 if i+H(P) is
a quadratic residue modulo p, 0 otherwise
            get a listing of bits
         end-for
   end
```

This algorithm is with regard to the technique of Chinese syntax analysis, which we have discussed in Sect. 2.

Watermark Detecting Anyone with the secret prime p can generate the B_i of every sentence s_i, hence its B_i' and its rank in S. We simply read the watermark bits w out of each sentence having its indicator bit is 1.

4 Conclusions

With the development of natural language processing, the performance of which a computer can understand the meaning of a text correctly is getting better and better. Furthermore, natural language text watermarking technique will improve greatly in the future.

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