A Novel Approach for Text Steganography: Generating Text Summary using Reflection Symmetry

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Abstract

Steganography is the art and science of covered or hidden writing. The purpose of steganography is covert communication to hide the existence of a message from the prying eyes. Digital Steganography algorithms have been developed by using texts, images and audio as the cover media. However, using text as the target medium is relatively difficult as compared to the other target media, because of the lack of available redundant information in a text file. This paper presents an approach for text steganography through a technique that uses reflection symmetry of the English alphabets. To hide secret data bits, the proposed method checks the vertical and horizontal reflection symmetry properties of the characters present in each sentence of the text and, if followed, it selects the sentence to generate a summary of the text, known as cover text or stego-text. Similarly at the extraction end, the receiver checks for the reflection symmetry properties followed by the characters present in the sentences of the stego-text and places the corresponding bits to get the secret message from the summary generated by the hiding process. The proposed method exhibits a satisfactory experimental result with the cover text chosen from different daily newspapers.

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1. Introduction

Steganography means covered or hidden writing. The principle of steganography is secret communication to hide a
message from an intermediary. This differs from cryptography, the art of secret writing, which is intended to make a message indecipherable by an unintended receiver but does not hide the existence of the secret communication. Although steganography and cryptography are different and distinct, these two can be treated as twin sisters of secret communications. As the application of computer in real life is increasing day by day, the need to secure data is becoming more and more essential and challenging part of message or data transfer and hence the hidden exchange of information has attracted more attention to the researchers.

Steganography is the art and science of hiding information such that its presence cannot be detected [1]. In steganography, the secret message is encoded in such a way that information’s existence kept hidden from the unintended receivers. The aim of steganography is to establish a secured communication in an absolutely unnoticeable manner [2] and to avoid drawing suspicion to the transmission of a hidden data [3].

The steganography is not to keep others from knowing the hidden information, but it is to keep others from drawing suspicion that the information even exists. If a steganography method causes someone to suspect that there is secret information in a carrier medium, then the method has failed [4].

The first written evidence about steganography being used to send messages is the Herodotous [5] story about slaves and their shaved heads. The modern representation of Steganography can be given in terms of the prisoner’s problem [6]. Specifically in the general model for Steganography, illustrated in Fig.1, let Alice wishing to send a secret message $S$ to Bob. In order to do so, Alice embeds $S$ into a cover-object $C$ to obtain the stego-object $\hat{C}$. The stego-object $\hat{C}$ is then sent through the public channel. In a pure Steganography framework, the technique for embedding the message is unknown to Wendy and shared as a secret between Alice and Bob. However, it is generally not considered as good practice to rely on the secrecy of the algorithm itself. In private key Steganography Alice and Bob share a secret key which is used to embed the message.

A number of steganography methods have been introduced on different cover media such as images [2, 4, 7], video files [8, 9] and audio files [10]. Due lack of large scale redundancy of information in a text file, in compared to others, text steganography seems to be most difficult kind of steganography [11].

This paper presents a novel approach for text steganography by generating the summery of a text file that contains English language text. The proposed method takes as input a publicly available text and the secret message. The secret message is hidden in the summery by following the reflection symmetry properties of the characters of English alphabets along the axis of reflection. As a output of the system, a summary is generated from the chosen input text and that summary is our cover text, to be sent to the receiving end. At the receiving end depending on the same properties of the English alphabets, respective secret bits from the cover text are extracted to get back the original message.
2. Related Work on Text Steganography

2.1. Syntactical Steganography

Considering the syntactic structures of a text, the syntactical steganography approach builds syntactically correct sentences by using Context Free Grammars (CFG). CFG based Mimicry [12], NICETEXT [13] comes under this category. NICETEXT uses the cover text as a source of syntactic patterns and by running the cover text through a part-of-speech tagger, this algorithm obtains a set of "sentence frames," e.g. [(noun) (verb) (prep) (det) (noun)] for ‘I saw in the Hall’. Then by using the dictionary, a large list of (type, word) pairs where the type may be based on the part-of-speech tagger or its synonyms, the system randomly generate sequence of words to form a sentence. Though, NICETEXT produces syntactically correct sentences, the output text is almost always set of ungrammatical and semantically anomalous sentences. Using this disadvantage of NICETEXT steganalysis algorithms [14] have been developed to detect the presence of hidden information in the cover file generated by NICETEXT.

2.2. Lexical Steganography

In lexical Steganography, lexical units of natural language text such as words are used to hide secret bits. In this approach a word could be replaced by its synonym and the choice of word to be chosen from the list of synonyms would depend upon secret bits. For example consider a sentence – Diana is a good lady. If good represent 00 then according to the input bits 01, 10, 11 we can replace the word good by nice, pleasant and kind respectively to hide the bits.

2.3. Ontological Technique

In this method, to embed information, instead of implicitly leaving semantics intact by replacing only synonymous words an explicit model for the meaning is used to evaluate equivalence between texts. This method is also having the same disadvantage like NICETEXT that sometimes it may produce semantically incorrect texts.

2.4. Other Steganography Approaches

In Text Steganography by Hiding Information in Specific Character of Words [15] approach, specific characters from some particular words are selected to hide the information. For example, the first character of every alternative word hides the secret message.

Text Steganography by Line Shifting method [16, 17] is another useful approach where lines are shifted vertically to some degree. For example, lines are shifted vertically to degree say $\alpha$ or $-\alpha$. For $\alpha$, the information is 1 and for $-\alpha$, the information is 0. This method is appropriate for printed text.

Information can be hidden by Creating Spam Texts [18] in an HTML file. This approach uses the flexibility of HTML regarding case-sensitiveness.

By Word Shifting method [16, 19], information is hidden in the text by shifting words horizontally and by changing the distance between the words.

Feature Coding method [20, 21] changes the feature or structure of the text to hide data. For example, elonging or shortening end portion of some characters, or by vertical displacement of points of characters like ‘i’, ‘j’ etc. In this method a large volume of data can be hidden in the text.

By adding Open Spaces method [22], the information can be hidden by adding extra white spaces in the text.

Besides all these, some algorithms for text steganography through Indian Languages have been proposed by using feature coding method [23] and dynamic programming method [24]. Some more approaches in text steganography area has also been developed, that scans the letters in English alphabets and analyses their shapes for hiding secret data [25, 26]. Some approaches are also there that checks the properties of sentences and depending on that hides secret data in it[27].
3. Proposed Work

In most of the text steganography algorithms the secret message is hidden by changing the structure of the cover file, hence there is a chance of either suspicion or loss of data in case of retyping. To avoid this and hence claiming more security, in this proposed method, instead of hiding the secret bits by changing the structure of the text file, we hide the secret message by generating summery of a given text collected from newspaper or any public media. The process of generating the summary is dependent on the reflection symmetry property of English alphabets and according to that, they are grouped into different sets, where each set represents a pair of bits.

To do this let us first analyze the reflection symmetry properties followed by the English alphabets and classify them to represent the binary bits. The properties and the corresponding bit representations are as follows:

3.1. Classification of English Alphabets following Reflection Symmetry Property

For classification of the English Alphabets following reflection symmetry property, first we select the horizontal axis as the axis of symmetry and divide the English letters into two groups based on the horizontal bisection of the letters i.e. whether a character is equal or not on both side of the axis after bisection of it e.g. characters like ‘A’, ‘C’ are not same on both side of axis if bisected horizontally, whereas the letters ‘B’, ‘H’ etc. are just the reverse i.e. same on both side of axis after horizontal bisection.

The entire classification based on this logic is as shown in Table 1.

| Group ID | Group name               | Letters in Group | Bit to be hidden |
|----------|--------------------------|------------------|------------------|
| 1        | Reflection Property not followed | A, C, F, G, J, L, M, N, P, Q, R, T, U, V, W, Y, Z | 0                |
| 2        | Reflection Property followed | B, D, E, H, I, K, O, S, X | 1                |

Next we select the vertical axis as the axis of symmetry and classify the English letters into two groups based on the vertical bisection of the letters i.e. whether a character is equal or not on both side of the axis after bisection of it e.g. characters like ‘B’, ‘C’ are not same on both side of axis if bisected vertically, whereas the letters ‘A’, ‘H’ etc. are just the reverse i.e. same on both side of axis after vertical bisection.

The entire classification based on this logic is as shown in Table 2.

| Group ID | Group name               | Letters in Group | Bit to be hidden |
|----------|--------------------------|------------------|------------------|
| 1        | Reflection Property not followed | B, C, D, E, F, G, J, K, L, N, P, Q, R, S, Z | 0                |
| 2        | Reflection Property followed | A, H, I, M, O, T, U, V, W, X, Y | 1                |

Combining both the two concepts as described respectively in Table 1 and Table 2, we now finally classify the English letters into four groups based on both the horizontal and vertical bisection of the letters i.e. whether a character is equal or not on both side of the axis after bisection of it e.g. characters like ‘C’, ‘F’ etc. are not same on both side of axis in any of the cases if bisected both horizontally and vertically, whereas the letters like ‘B’, ‘D’ etc. are just the same on both side of axis after horizontal bisection. Similarly the letters like ‘A’, ‘M’ etc. are also the same on both side of axis after vertical bisection and the letters like ‘H’, ‘I’ etc. are same on both side of the axis in
both cases of horizontal and vertical bisection.

The entire classification based on this logic is as shown in Table 3. We can represent this classification of alphabets using a Venn diagram, as shown in Fig. 2. In the diagram, N represents the set of alphabets those do not follow the reflection property along any of the axis of symmetry. H represents the set of alphabets those follow the reflection property only along horizontal axis. V represents the set of alphabets those follow the reflection property only along vertical axis and B represents the set of alphabets those follow the reflection property along both horizontal and vertical axis.

### Table 3: Groups based on Bisection of the letters along both Horizontal and Vertical Axis of Symmetry

| Group ID | Group name                  | Letters in Group | Bits to be hidden |
|----------|-----------------------------|------------------|------------------|
| 1        | Reflection Property         | C, F, G, J, L, N, P, Q, R, Z | 00               |
|          | followed along Horizontal Axis |                  |                  |
| 2        | Reflection Property         | B, D, E, K, S    | 01               |
|          | followed along Vertical Axis |                  |                  |
| 3        | Reflection Property         | A, M, T, U, V, W, Y | 10              |
|          | followed along both Axis    |                  |                  |
| 4        | Reflection Property         | H, I, O, X       | 11               |

Fig.2. Venn Diagram representing Table 3

### 3.2. Text Steganography based on Reflection Property of English Alphabets

Following the classification of English alphabets as shown in Table 3, the method for generation of summary of any text is to take a sentence and use the first letter of first word from every sentence provided the word is not an article. Subsequently, for hiding a ‘0’ bit in the input text file, we check the first letter in the sentence. If the first letter of sentence is from first group then we can hide a ‘0’ bit and if first letter of sentence is from other group then we can hide ‘1’ bit. For example if we want to hide the message having bits say “1100” and we select a text that is viz. “Ostrich is a bird. Ostrich can fly. So many types of birds are there. Peacock is our national bird.” Now, to hide the bits ‘11’, we can scan the first letter of the first word i.e. ‘O’ which appropriately is the member of group 4. Next, we can hide the next bits which is ‘00’ using the first letter of the beginning of the next sentence – which is ‘O’ belonging to group 4 again. Hence skipping that sentence we move to the next sentence that starts with a ‘S’, member of group 2. So, we skip that sentence too and move to the next one. However the next sentence starts with a ‘P’ that belongs to group 1, representing the bits ‘00’. Following the above method, our generated cover text is “Ostrich is a bird. Peacock is our national bird.” that is to be sent to the intended recipient.

The proposed algorithm for generating the summary is as follows:

#### 3.2.1. Hiding Algorithm
Input:
1. Secret message
2. Any text in English language (may be a newspaper article)

Steps:
1. Convert the secret data to binary bit stream.
2. Check, if the total length of the bit stream is even or odd. If odd, add an extra ‘0’ bit in the msb. Now divide the total bit stream in the groups of two bits each.
3. Convert the text file to upper case.
4. For each group of secret bits, check whether any of the character that represent the group following Table 3, is the starting character of the sentence, provided the first word is not an article. In second case, go to the first letter of the next word.
   (a) If yes, select the sentence and add it to the cover text.
   (b) If not, move to the next sentence.
5. The process is to be carried out, until the total secret bit stream is exhausted.
6. The obtained cover text is the generated summary of the text and is to be sent to the intended recipient.

Output:
1. Cover Text i.e. the summary of the selected text.

Reversely, to extract the secret message, the first letter of the first word of each sentence is scanned and the corresponding binary value is added in a file, storing the secret bits, following the table 3. The obtained binary bit stream is converted back to the alphanumeric form, to get the secret message.

The proposed algorithm for data extraction is as follows.

3.2.2. Extraction Algorithm

Input:
1. Cover Text, that was the output of hiding algorithm

Steps:
1. Scan the first letter of the first word of each sentence, provided the first word is not an article. In the second case, scan the first letter of the next word.
2. Check, the obtained character belongs to which group according to Table 3. Append the bit value, represented by the character, in a file.
3. Convert the secret bit stream to the alphanumeric form.
4. The obtained alphanumeric message is our received secret message.

Output:
1. Secret Message

4. Experimental Results

The text file we have used for implementation purpose i.e. the text that is the input to our system, is as shown in Fig. 3. For implementing the algorithms we have selected the secret message to be hidden in the cover text, as “Hi”, as shown in Fig. 4. To hide the message the program first converts the secret message to its corresponding binary stream ‘00010111001011’. Since the length of the bit stream is even, so we divide the total bit stream into groups of two bits each and the obtained first group is ‘00’. We have used the approach based on bisection of the letters along both horizontal and vertical axis for implementation and for that purpose we have used the Table 3. Accordingly the system starts scanning the selected text, shown in Fig. 3 and the first sentence obtained is “Newspapermen make news.” The first letter of the first word of the scanned sentence is ‘N’, that belongs to the group ‘00’ as after bisection of ‘N’ along both vertical and horizontal axis, we find that in both the case the two bisected halves are not equal. As ‘N’ is capable of hiding ‘00’, so the corresponding sentence would be selected and saved in the cover file i.e. the file containing summery of the text. Following the same method, the next sentence is scanned and the the
first letter in this case is ‘T’, belonging to group ‘10’. But the next group of bits to be hidden is ‘01’. So this sentence won’t be the part of summary and system will move to scan the next sentence. This way, following the same method repeatedly, we get the required text summary i.e. the output of our system, as shown in Fig. 5.

Reversely at the receiver end, the input is the cover text, as shown in Fig. 5 and system starts scanning it. The first scanned sentence is “Newspapermen make news.” The first letter of the sentence is ‘N’, that belongs to group ‘00’. Hence the system will store the bit value ‘00’ in a file. The next starts with ‘L’, that belongs to group ‘01’ and the system will append the bit value ‘01’ in the existing file. This way by following the same approach, the finally obtained total bit stream is ‘00010111001011’.

After that, the generated bit stream is converted to alphanumeric values considering each 7 bits at a time and from that the characters are generated that was the original secret data. In this experiment we get back the original secret message, “Hi” that was hidden in the text summary at the hiding end as shown in Fig. 6.

Newspapermen make news. The just published Jobs Rated Report by careercast.com has ousted the lumberjack from the position of worst profession. Taking its place is the newspaper reporter. Says the survey: “Lumberjack is a job that has lost its lustre dramatically over the past five years and is expected to plummet even further by 2020.” In other words, like the village blacksmith and the town crier, the traditional journalist won’t be left with a profession after a few years. According to the Jobs Rated Report, a good job is one that has demand and scope, low stress levels and a great work environment. The best jobs of 2013 are: actuary, biomedical engineer, audiologist and financial planner. The worst jobs of 2013 are: reporter (news-paper), lumberjack, enlisted military personnel, actor and oil rig worker. All these careers have very high stress levels though some may have quite supportive work environments. The Career-Cast report is into its 25th edition now. Last year the best job was software engineer. That’s in decline phase: there has been a drop in hiring outlook. The other ousted professions are HR manager and dental hygienist. At the bottom end, the dairy farmer has made an exit. A great job does not have to be glamorous. Topping the list for women is the soldier, which is in the dumps at Career-Cast. Men like yoga teachers and they like women working in sports and recreation. Nobody wants the insurance agents or curiously enough, people working in consultancy and strategy. Somewhere or the other, they have slipped up on strategy: they need a Sudhir Kakkar for consultancy. In India, most lists are derivative: some HR expert sets himself up as an authority and extrapolates from a survey conducted elsewhere. But here is a survey from apex chamber Assocham polled B-school grade. In Tier II and Tier III towns, the vast majority 85 percent would prefer to join a public sector undertaking (PSU). The principal attraction, says Assocham, is “100% stability”. It’s the old story: once you get a PSU job, mediocrity takes over fro meritocracy. In the metros, however, it was a different story. Nearly, 90 percent of B-school students said that leading corporate

Newspapermen make news. Says the survey: “Lumberjack is a job that has lost its lustre dramatically over the past five years and is expected to plummet even further by 2020.” The other ousted professions are HR manager and dental hygienist. A great job does not have to be glamorous. Topping the list for women is the soldier, which is in the dumps at Career-Cast. In India, most lists are derivative: some HR expert sets himself up as an authority and extrapolates from a survey conducted elsewhere.

The just published Jobs Rated Report by careercast.com has ousted the lumberjack from the position of worst profession. According to the Jobs Rated Report, a good job is one that has demand and scope, low stress levels and a great work environment. The best jobs of 2013 are: actuary, biomedical engineer, audiologist and financial planner. The worst jobs of 2013 are: reporter (news-paper), lumberjack, enlisted military personnel, actor and oil rig worker. Last year the best job was software engineer. Nobody wants the insurance agents or curiously enough, people working in consultancy and strategy. In Tier II and Tier III towns, the vast majority 85 percent would prefer to join a public sector undertaking (PSU). The principal attraction, says Assocham, is “100% stability”.

Fig.3. Selected Text, obtained from newspaper article

Fig.4. Secret Text to be hidden

Fig.5. Cover Text, obtained after hiding the secret text

Fig.6. Extracted Secret Text

Fig.7. Summary of the selected text, as generated by Auto-Summarize Tool of Microsoft Word
5. Advantages and Disadvantages

The advantage of the proposed algorithm is that, since we are hiding the data without changing the structure of the file and by creating the summary of a publicly available text like newspaper article, therefore it will draw less attention to the unintended recipients and hence more security is added to the proposed steganographic system. While generating the text summary, as our method provides a much semantically correct output, compared with Microsoft Words auto Summarize Tool, it will draw much less suspicion and this may be considered as a great advantage of the system. Also, as there is no restriction to the size of the text file, we can hide a large volume of data using the proposed algorithm.

However the disadvantage of the system lies in the fact that once the applicability of the system is known, it can be easily attacked. So, it is urgent to keep the application of the method to a particular dataset, secret.

6. Conclusion and Future Work

In this paper we have introduced a novel approach for text steganography by generating the text summary by using the reflection symmetry of the alphabets of English language. To hide secret data bits, the proposed method checks the vertical and horizontal reflection symmetry properties of the characters present in each sentence of the text and, if followed, it selects the sentence to generate a summary of the text. The generated text summary is the cover text i.e. the stego-text generated by the system. Similarly at the extraction end, the receiver checks for the reflection symmetry properties followed by the characters present in the sentences of the stego-text and places the corresponding bits to get the secret message from the summary generated by the hiding process.

Future research can be made to increase more security to the system and to decrease the programming complexity.

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