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A new scheme for covert communication via 3G encoded speech ☆

Haibo Miao [a,b,*], Liusheng Huang [a,b], Zhili Chen [a,b], Wei Yang [a,b], Ammar Al-hawbani [a]

[a] *Department of Computer Science and Technology, University of Science and Technology of China, Hefei 230026, China*
[b] *Suzhou Institute for Advanced Study, University of Science and Technology of China, Suzhou 215123, China*

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ABSTRACT

Mobile communication through 3G network has grown rapidly in recent years. It might be of interest to transmit secret messages over 3G voice channels. In this paper, we introduce a new covert communication scheme via Adaptive Multi-Rate Wideband (AMR-WB) encoded speech. An adaptive suboptimal pulse combination constrained (ASOPCC) method is presented to embed data on compressed speech signal of AMR-WB codec. The method takes advantage of the "redundancy", created by non-exhaustive search of algebraic codebook, to encode secret information. An embedding factor η is used to control embedding bits. By properly setting η, ASOPCC can offer a better trade-off between speech quality and embedding capacity in the process of coding mode switching. Experimental results show that the proposed method is quite promising for both high capacity and good imperceptivity. Although ASOPCC is only applied to AMR-WB codec in this article, it can be further used by any other speech coding based on Algebraic Coded Exited Linear Prediction (ACELP).

1. Introduction

Steganography is a technique of covert communication. It conveys secret messages hidden in digital media in such a way that the existence of the messages is concealed [1,2]. Many steganographic methods have been proposed by using text, image, audio and video as cover medium. In recent years, with the significant development of 3G mobile technology (e.g., CDMA2000, WCDMA and TD-SCDMA), wireless communication through 3G network has become a part of our daily life. Given the advantages of mobility and instantaneity, covert communication through 3G voice channel might be interesting. 3G voice channel usually adopts one of the speech coding standards: AMR-WB, EVRC-B and VMR-WB. In this paper, we just focus on AMR-WB, which is widely used in WCDMA and TD-SCDMA system.

Steganography and watermarking are two branches of data hiding. They both describe methods to embed data transparently into a carrier signal. Watermarking is mainly used for copyright protection, copy protection and content authentication. Therefore robustness against attacks is a crucial issue. Steganography aims to establish a covert information channel in end-to-end connections. It pays more attention to hide the fact of transmitting secret message from third people. In this case, embedding capacity, transparency (in terms of perceptual quality) and statistical undetection become important factors.

Lots of steganographic methods on speech signals have been developed so far. Conventional schemes are mostly performed on signal domain or transformed domain. They can be classified into six approaches: least significant bit (LSB) [3], phase coding (PE) [4], spread spectrum (SS) [5], cepstrum domain (CD) [6], echo data hiding (EH) [7] and tone insertion

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* Corresponding author at: Department of Computer Science and Technology, University of Science and Technology of China, Hefei 230026, China. Tel.: +86 512 87161305; fax: +86 512 87161118.
E-mail address: mhb@mail.ustc.edu.cn (H. Miao).

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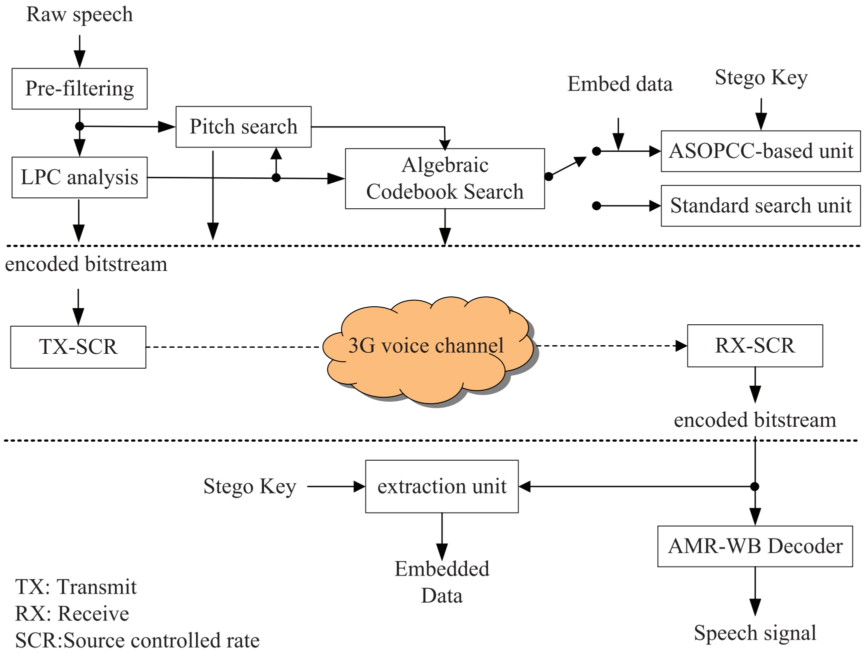

Fig. 1. Covert communication through 3G voice channel.

(TI) [8,9]. However, these approaches are no longer usable for 3G encoded speech, because that speech coding and decoding process will disturb messages embedded in stego signals. In order to convey information through 3G voice channel, steganographic data should be embedded into compressed or encoded signals. The manipulation is then performed either during coding process or after that. The former usually is combined with coding algorithms and changes the codec, by which, some coding parameters are modified to carry secret information. In contrast to that, the latter works on content of the compressed bitstream directly, for example, overwriting least significant bits. Naturally, the two methods would be appropriate to transmission systems using audio compression.

In this paper, based on the former idea, a new steganographic scheme on 3G encoded speech is proposed for covert communication. The scheme relies on an adaptive suboptimal-pulse-combination constrained (ASOPCC) method, searching a suboptimal codevector, whose pulse combination meets certain constraint. ASOPCC is integrated with AMR-WB codec, causing algebraic codebook parameters of encoded signals to be altered, creating a steganographic effect and achieving the purpose of secret communication. Then, considering that AMR-WB has nine encoding modes, we introduce an embedding factor η to control embedding rate in different modes. In fact, the prime criteria for steganography are perfect transparency and high embedding capacity. Transparency is a measure of distortion due to message embedding, in terms of speech quality here. As is well known, there is a trade-off between the two criteria, for that the pursuit of high capacity is bound to decrease transparency. In our research, we attempt to make a worthy trade-off to enhance the balance between speech quality and embedding rate. Several experiments are done to investigate how speech quality is sensitive to embedding strength, whereby different values are assigned to η in different modes. Finally, it turns out that, by properly setting η, ASOPCC not only leads to high embedding rate, but also gains quite good speech quality, as well as lowers the possibility of detection. We give some recommended values for η in different coding modes in the present paper. Meanwhile, our method also allows users to determine η to customize embedding rate and speech quality according to their own needs. That is to say, the proposed method is both adaptively self-adjustable and user-customizable. The proposed covert communication system is illustrated in Fig. 1.

The remainder of this paper is organized as follows. Section 2 introduces an overview of the background, including related works in steganography for mobile voice channel and AMR-WB coding standard. In Section 3, we focuses on description of the ASOPCC method, followed by Section 4, which gives the experiments, test results and analysis. Finally, conclusions are presented in Section 5.

2. Background

2.1. Related works in steganography for mobile voice channel

Not a significant amount of steganography method is available on mobile voice channel. This can be attributed to the existence of compression encoder in modern mobile communication systems, e.g. GSM and 3G, and most traditional