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Real-time reversible data hiding based on multiple histograms modification*

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Abstract Prediction-error expansion (PEE) has been widely utilized in reversible data hiding (RDH) due to its advantage of high quality marked image. Recently, a RDH method based on multiple histograms modification (MHM) has been proposed, achieving good performance at low capacity. However, its exhaustive expansion-bin-selection mechanism is time consuming, so that it can only choose a single pair of expansion bins in each histogram for embedding data. As an extension of MHM, a novel RDH scheme for high capacity embedding is proposed in this paper. In the proposed method, multiple pairs of expansion bins are utilized in each histogram and a greedy search algorithm is designed to determine the nearly optimal expansion bins. The results of experiments demonstrate that the proposed scheme has real-time performance and high quality marked image, and it outperforms the original MHM-based RDH method and some other state-of-the-art works.

Keywords Reversible data hiding · Prediction-error expansion · Real-time embedding · Greedy algorithm

1 Introduction

Information hiding aims to protect the contents of digital multimedia from acquisition by unauthorized parties, which has been widely used in content authentication and copyright protection, etc. Typical information hiding techniques include digital watermarking [1], steganography and steganalysis [2–4], etc. In some sensitive application scenarios, such as military and medical image processing , it is not only necessary to extract the embedded information, but also to recover the cover data without any distortion. To meet this demand, reversible data hiding (RDH) came into being, and has attracted the attention of more and more researchers [5–17]. Embedding capacity and PSNR are typically regarded as the standards for measuring RDH performance. As the embedding capacity increases, the modifications on the image is more, and thus the visual imperceptibility between the marked image and the cover image becomes worse. So it's challenging to introduce as low a distortion as possible when the embedding capacity is high. What's more, with the rapid growth of the Internet and big data, people need to embed copyright or other annotation information into a large number of multimedia files, and then transmit or upload them to the cloud space through the network. Similarly, with the popularity of mobile Internet and cell phones, it is desirable to be able to embed personal information on multimedia files such as photos in real time on the mobile side. Therefore, how to reduce the computational complexity of RDH to satisfy real-time applications is another urgent problem to be solved.

There are two classical approaches in RDH: the methods based on difference expansion (DE) [18–22] and histogram shifting (HS) [23–26]. DE was firstly proposed by Tian in [18], in which the difference of pixel pairs are expanded to embed data. The well-known work HS was initially proposed by Ni *et al.* in [23], in which the image histogram is generated, and certain histogram bins are selected for expansion embedding while others are shifted to provide vacant spaces. Later on, Thodi and Rodriguez utilized prediction-error instead of the difference value for expansion in [20]. As an extension of DE, prediction-error expansion (PEE) outperforms the former because it can further exploit the spatial correlations of pixels neighborhood. Nowadays, one of the most popular approaches in RDH is to incorporate

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