Abstract—In this paper, a data representation scheme called Virtual Queue Decomposition (VQD) is modified and applied to a reversible data embedding method using reflective blocks [1]. Due to the limitation of the data representation scheme in proposed [1], some available bins are left unutilized. Thus, the aim of this paper is to further increase the embedding capacity by fully utilizing the available bins in the histogram of every block. The priority rules in VQD are modified to operate with histogram based data embedding method while increasing the embedding capacity. Experimental results indicate that an average increment of 43650 bits is gained, with a new embedding capacity of 616345 bits in the best scenario.

I. INTRODUCTION

Information hiding consists of two major disciplines, namely external information insertion and encryption. External information insertion embeds additional data (payload) into the host content while encryption converts meaningful content into an unintelligible form [3]. Nevertheless, encryption often produces results in noise (perceptually) because correlation among entities in the content are damaged. Thus, it leads to inefficiency in application of compression (or other operations) using the output generated by encryption. Hence, partial encryption (or scrambling) is utilized to conceal the actual meaning of host content using permutation and/or substitution [4]. Meanwhile, reversibility is another important property in these two disciplines, which means the host content can be completely restored (or partially restored depending on the proposed algorithm) after the reversing process using the generated output (by the scrambling or embedding algorithm) [5].

Fu et al. [6] proposed three pixel-level scrambling algorithm based on simple XOR operation. Wong et al. [7] scrambles the input medium by using their proposed simple permutation function and simple noise function. The distortion level in Wong et al. method is controllable, which means visual quality (or in other words, distortion) is adjustable.

External information insertion in image can be easily achieved by using bit-plane flipping or bit-plane replacement [8]. However, these methods are irreversible and readily decodable. Tian et al. proposed to expand the spaces for data embedding using simple integer transform [9]. Although this technique is reversible, it can only embed small amount of data. Vleeschouwer et al. [10] also proposed a reversible data embedding method using histogram modification in blocks of image. It transformed the histogram into circular representation and changed the center of mass to represent payload. Histogram shifting [11] is another popular method for data embedding due to its simplicity in implementation. Although this class of data embedding method is reversible, it can only embed limited amount of external information.

In recent years, research on the unification of both disciplines has gained attention. Kundur et al. [12] scrambles the paid video content to prevent unauthorized viewing while injecting fingerprint into it to trace illegal distributor. Zhang et al. [13] proposed a commutative reversible data hiding method in encrypted images. Recently, a unified method called reversible data embedding using reflective blocks [1] is proposed in which the visual quality (i.e., distortion) can be flexibly controlled. While [1] is able to embed payload up to \(\sim 592445\) bits in a \(512 \times 512\) pixels host image, there is still room for improvement. This is because some bins are left unutilized due to the limitation of the previous data representation scheme.

In this work, a data representation scheme called Virtual Queue Decomposition (VQD) [2] is modified and employed in [1] to increase the embedding capacity. A brief review on the reversible data embedding method using reflective block and VQD are described in Section II and Section III, respectively. Section IV presents the proposed modification of VQD in the data embedding method while Section V highlights some issues of this employment. Effectiveness of the employment is verified in Section VI. Lastly, the paper concludes in Section VII.

II. REVIEW OF THE REVERSIBLE DATA EMBEDDING USING REFLECTIVE BLOCKS [1]

Figure 1 shows the process flow of the reversible data embedding method using reflective blocks [1] which is based on histogram modification technique. It associates the occupied histogram bins with available histogram bins for data embedding purposes.

Initially, input image \(G\) with \(k\)-bit depth is divided into blocks each of size \(b_i \times b_i\) pixels. For every block \(B_j\) in the image, the minimum \(\min_j\) and maximum \(\max_j\) bin values are recorded and output as side information. The side information is combined together with the external information as payload which will be embedded later.