High payload using mixed codebooks of Vector Quantization

H. B. Kekre, Tanuja K. Sarode, Archana Athawale, Kalpana Sagvekar

***Abstract*—Data hiding involves conveying secret messages under the cover digital media such as images. It is the science of concealed communication. The term hiding can refer to keeping the very existence of the embedded messages imperceptible. Intuitively, a technique that introduces less embedding distortion to the cover object will generally cause changes that are more difficult to detect, and will therefore provide more security. In this paper, we propose a data hiding method based on VQ compressed images. Codebooks of secret message & cover images are combined using shuffle algorithm. Experimental results indicate that our proposed scheme provides 100% hiding capacity or more that means secret message can be of same or more size than cover image and better image quality compared with existing schemes based on VQ compressed images.**

***Index Terms*— Data hiding, Vector Quantization, Codebook, Compression.**

I. Introduction

Reversible data embedding, which is also called lossless data embedding, embeds invisible data (which is called a payload) into a digital image in a reversible fashion. As a basic requirement, the quality degradation on the image after data embedding should be low. An intriguing feature of reversible data embedding is the reversibility, that is, one can remove the embedded data to restore the original image. From the information hiding point of view, reversible data embedding hides some information in a digital image in such a way that an authorized party could decode the hidden information and also restore the image to its original, pristine state. The performance of a reversible data-embedding algorithm can be measured by the following.

1) Payload capacity limit: what is the maximal amount of information can be embedded?

2) Visual quality: how is the visual quality of the embedded image?

3) Complexity: what is the algorithm complexity?

The motivation of reversible data embedding is distortion-free data embedding [1]. Though imperceptible, embedding some data will inevitably change the original content. Even a very slight change in pixel values may not be desirable, especially in sensitive imagery, such as military data and medical data. In such a scenario, every bit of information is important. Any change will affect the intelligence of the image, and the access to the original, raw data is always required. From the application point of view, reversible data embedding can be used as an information carrier. Since the difference between the embedded image and original image is almost imperceptible from human eyes, reversible data embedding could be thought as a covert communication channel. By embedding its message authentication code, reversible data embedding provides a true self authentication scheme, without the use of metadata.

Data hiding algorithms are applied in the spatial domain, transform domain and other compressed domain. In the spatial domain, [2-4] the least significant bit (LSB) of each pixel is modified in the cover image to embed the secret data. In transform domains [5-6] Images are first transformed into transform domain, and then data are embedded by modifying the transformed coefficients. In compressed domain data hiding [7, 8] is achieved by modifying the coefficients of the compressed code of a cover image.

One of the most commonly studied image compression techniques is VQ [17], which is an attractive choice because of its simplicity and cost-effective implementation. Indeed, a variety of VQ techniques have been successfully applied in real applications such as speech and image coding [18], [20], VQ not only has faster encode/decode time and a simpler framework than JPEG/JPEG2000 but it also requires limited information during decoding, and those advantages cost VQ a little low compression ratio and visual quality. VQ works best in applications in which the decoder has only limited information and a fast execution time is required [19].

The rest of this paper is organized as follows: VQ compression techniques are briefly described in Section 2. Section 3 describes existing approach. The proposed data hiding is introduced in Section 4. Section 5 presents the experimental results of the proposed scheme. Finally, the conclusions are given in Section 6.

II. VQ Compression Techniques

Vector Quantization (VQ) [9-14] is an efficient technique for data compression [29-33] and is very popular in a variety of

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research fields such as image segmentation [21-24], speech data compression [25], content based image retrieval CBIR [26, 27] and face recognition [28].

A. Linde Buzo and Gray (LBG) Algorithm[9],[10]

In this algorithm centroid is computed as the first codevector for the training set. In Fig. 1 two vectors v1 & v2 are generated by adding constant error to the codevector. Euclidean distances of all the training vectors are computed with vectors v1 & v2 and two clusters are formed based on nearest of v1 or v2. This procedure is repeated for every cluster. The drawback of this algorithm is that the cluster elongation is +135o to horizontal axis in two dimensional cases. This results in inefficient clustering.

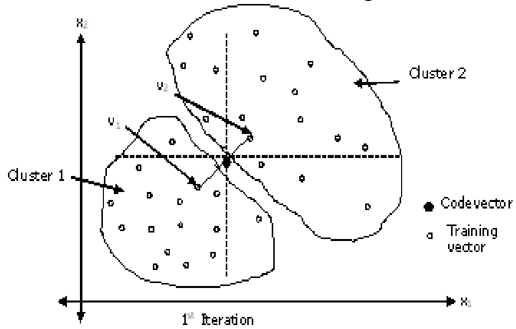

Fig.1 LBG for 2 dimensional case

B. Kekre's Proportionate Error Algorithm (KPE)[11],[12]

Here proportionate error is added to the centroid to generate two vectors v1 & v2. Magnitude of members of the centroid decides the error ratio. Hereafter the procedure is same as that of LBG. While adding proportionate error a safe guard is also introduced so that neither v1 nor v2 go beyond the training vector space. This removes the disadvantage of the LBG. Both LBG and KPE requires 2M number of Euclidean distance computations and 2M number of comparisons where M is the total number of training vectors in every iteration to generate clusters.

III. A BEST-PAIR-FIRST CAPACITY-DISTORTION CONTROL FOR DATA HIDING ON VQ COMPRESSION DOMAIN [16]

In Jo et al.'s [15] approach, each pair of code-vectors in CB with the shortest Euclidean distance will be split into either groups {G0, G1} or G-1. In [16] approach, will perform the same splitting task. The difference is that group G-1 will contain zero codevector by setting the threshold t to a maximum value. Thus, each code-vector Xi in G0 will always has a matching code-vector Xj in G1 with the closest Euclidean distance. Xi and Xj is then treated as a matching pair of code-vectors. Then sort all matching pair of code-vectors based on their Euclidean distance in ascending order. A pair of code-vectors (also a pair of indices) is then assigned a label w according to its sorting order. Thus, an index i and its matching index j both will have a smaller label w as long as they have a smaller Euclidean distance. Since the codebook CB contains n code-vectors, the values of label w will range from 1 to n/2. Label w will be used as the selection criterion for data embedding. That is, pair of VQ indices with smaller w will be used to embed data first. Based on the above preprocessing, the proposed best-pair-first approach for VQ compressing and data hiding can be described as follows.

A. VQ Encoding and Data Hiding

Step 1: Perform VQ compression on image I using codebook CB as described in Section 2. This will generate a compressed file F that contains a sequence of indices to serve as the VQ compression codes before data hiding.
Step 2: Let label w = 1.
Step 3: Sequentially examine all indices in F to find next index i that was assigned label w during the preprocessing stage.
Step 4: Compare index i with next secret bit b in S. If b = 0 and i ε G0, or b = 1 and i ε G1, leave index i intact. Otherwise, change index i in F to be its matching index j (for Alt (Xi) = Xj).
Step 5: If there are more secret bits in S to be embedded, repeat Step3 to Step4, until all indices in F have been examined.
Step 6: If there are still more secret bits in S to be embedded and w < n/2, let w = w+1 and go to Step3. The result is a new compression file F' with the embedded message S.

The idea is that indices in F with smaller label w will be used for embedding data, first. The embedding is done through alternating an index i with its matching index j based on the value of secret bit b and the group G0 or G1 that index i belongs to. The scanning and alternating of indices in F will continue until all secret data in S had been embedded

B. VQ Dencoding and Data Extraction

The VQ decoding and data extracting for the proposed approach can be described as follows.
Step 1: For each index i in F', perform a simple table look-up operation on the same codebook CB to find its code-vector Xi. Xi is then served as the decoded image-vector for index i. The table look-up operation will continue until all image vectors have been recovered. The result of Step1 is the decoded stego-image I'.
Step 2: Let label w = 1.
Step 3: Sequentially examine all indices in F' to find next index i that was assigned a label w during the preprocessing stage.
Step 4: If i ε G0, output a secret bit 0, else output a secret bit 1.
Step 5: If there are more secret bits in S to be extracted, repeat Step3 to Step4, until all indices in F' had been examined.

Step 6: If there are still more secret bits in S to be extracted and w < n/2, let w = w+1 and go to Step3. As stated above, the stego-image I' can be decoded through the simple table look-up operation in Step1. Step 2 to Step 6 will extract secret message S with the similar logic as in data embedding process.

IV. PROPOSED APPROACH

Codebook of size N/2 is generated for cover image as well as secret image using codebook generation algorithm. Now two codebooks are merged to get mixed codebook of size N using shuffle algorithm which generates unique random numbers starting from 0 to N-1. Shuffle algorithm is as follows:

1. Select a distance d which is relatively prime to N.
2. Start generating the random number starting from 0. Numbers generated are 0, d, 2d, 3d and so on.
3. If number generated is > N then subtract N from it and take mod d value as next random value. Go on adding d to previous value to get the next value.
4. The algorithm stops when the cover image codebook size is reached. Remaining indices are assigned to the secret message.

If N is power of 2 then all odd numbers are relatively prime to N. The mixed codebook & distance d is sent to the receiver in order to reconstruct cover image & secret image by separating mixed codebook into individual codebook by generating unique random number upto N using distance d.

V. RESULTS & EVALUATION

In the existing approach, each input image-vector could hide one secret bit of data as described in Section 3. So, the VQ-hiding's upper bound is 16384 (i.e., 512 × 512/16) bits for a 512 × 512 gray-level cover image with the codebook CB of size 512 × 16. Total hiding capacity is only 6.25%.

In our proposed approach, codebooks of cover image & secret image are combined to get mix codebook. So that hiding capacity is 100% or more.

Fig. 2. shows the Cover images of size 256×256. In each cover image one secrete image given in Fig. 3 is hidden.

Fig. 3. shows the Secrete images of size 256×256.


(a)

(b)

(c)

(d)

Fig. 2. Cover images of size 256×256

(a)


(b)

Fig. 3. Secrete images of size 256×256

We have generated codebook of size 256×12 for cover image & secret image. Then these two codebooks are combined giving 512×12 codebook using shuffle algorithm. There is only VQ distortion in reconstructing the image.

Table 1: Comparisons of the algorithms LBG, KPE with respect to MSE, PSNR for cover images

	LBG		KPE	
	MSE	**PSNR**	**MSE**	**PSNR**
Bird	208.25	24.94	196.69	25.19
Sunset	15.22	36.31	16.00	36.09
Ganpati	151.09	26.33	150.42	26.36
Deer	248.63	24.18	242.13	24.29

Table 2: Comparisons of the algorithms LBG, KPE with respect to MSE, PSNR for Secrete images.

	LBG		KPE	
	MSE	**PSNR**	**MSE**	**PSNR**
Pancard	54.37	30.78	53.91	30.81
Creditcard	151.09	26.34	150.42	26.36

For the same cover images given in Fig.2 the following message by Abraham Lincoln is hidden. The Entire message is converted to codebook of size 256x12 and then proposed algorithm is used to hide the message codebook in the cover image codebook. To improve the secrecy of text message every byte of text message is exored with key. The text message is extracted by exoring with same key.

Hidden Message:

Abraham Lincoln (February 12, 1809 – April 15, 1865) served as the 16th President of the United States from March 1861 until his assassination in April 1865. He successfully led his country through its greatest internal crisis, the American Civil War, preserving the Union and ending slavery. Before his election in 1860 as the first Republican president, Lincoln had been a country lawyer, an Illinois state legislator, a member of the United States House of Representatives, and twice an unsuccessful candidate for election to the U.S. Senate. He won an election to legislature. Find below a beautiful letter written by Abraham Lincoln.

Respected Teacher,

My son will have to learn I know that all men are not just, all men are not true. But teach him also that for ever scoundrel there is a hero; that for every selfish politician, there is a dedicated leader. Teach him that for every enemy there is a friend.

It will take time, I know; but teach him, if you can, that a dollar earned is far more valuable than five found.

Teach him to learn to lose and also to enjoy winning. Steer him away from envy, if you can.

Teach him the secret of quite laughter. Let him learn early that the bullies are the easiest to tick.

Teach him, if you can, the wonder of books. But also give him quiet time to ponder over the eternal mystery of birds in the sky, bees in the sun, and flowers on a green hill –side.

In school teach him it is far more honourable to fail than to cheat. Teach him to have faith in his own ideas, even if every one tells him they are wrong.

Teach him to be gentle with gentle people and tough with the tough.

Try to give my son the strength not to follow the crowd when every one is getting on the bandwagon.
Teach him to listen to all men but teach him also to filter all he hears on a screen of truth and take only the good that comes through.
Teach him, if you can how to laugh when he is sad. Teach him there is no shame in tears.
Teach him to scoff at cynics and to beware of too much sweetness. Teach him to sell his brawn and brain to the highest bidders; but never to put a price tag on his heart and soul.
Teach him to close his ears to a howling mob… and to stand and fight if he thinks he's right.
Treat him gently; but do not cuddle him because only the test of fire makes fine steel. Let him have the courage to be impatient, let him have the patience to be brave.
Teach him always to have sublime faith in himself because then he will always have sublime faith in mankind. "This is a big order; but see what you can do. He is such a fine little fellow, my son".
- Abraham Lincoln
I wonder why teachers fail to implement this?
we often see teachers favouring bright students and the average students do feel
rejected and loose their confidence even if they have talent in them, the foundation of every student
is his primary education and I belive teachers teacher teaching in primary school should take these factors into consideration and develop each and every student and make a good citizen.

VI. CONCLUSIONS

In the existing algorithm only limited amount of information can be hidden in index based cover image. Whereas through our proposed approach by combining the codebook we can achieve hiding capacity of 100% or more that means secret message can be of same or more size than the cover image. There is only distortion caused by VQ while reconstructing the image, no other error is introduced for images while for text, since the codevector set is prepared directly by converting it into codevector, no error is introduced after extraction. It is not necessary to use same VQ algorithm for both cover and secret image. This adds to the secrecy of embedded message.

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