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High-payload completely reversible data hiding in encrypted images by an interpolation technique

Key words: Encrypted image; Data hiding; Image recovery; Real reversibility; Interpolation

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Motivation

1. With the increasing demand for privacy protection, it is of great use to reversibly embed data in encrypted images.

2. The schemes proposed by Zhang (2011), Hong *et al.* (2012), and Liao and Shu (2015) confine errors in data extraction and image distortion during image recovery.

3. In the existing methods, the data hider can embed only a small payload of data.

4. Reversible data hiding in encrypted images is difficult and not perfect.

Main idea

1. We propose a reversible data hiding method for encrypted images. We introduce the interpolation technique to generate a location map to record whether the pixels could be embedded or not, and then embed the additional data through modifying the MSB.

2. Both the embedding rate and embedding capacity can be improved significantly.

Method

1. The proposed scheme is made up of five phases, namely location map generation, image encryption, data embedding, location map extraction and image decryption, and data extraction and image recovery.
2. The content owner first uses an interpolation technique to estimate whether the location can be used for embedding or not and generates a location map before encryption.
3. The data hider embeds the additional data through flipping the most significant bits (MSBs) of the encrypted image according to the location map.

Method (Cont'd)

4. At the receiver side, before extracting the additional data and reconstructing the image, the receiver decrypts the image first.

Major results

1. Table 3 shows the maximum embedding rate of the eight test images. It is evident that the maximum embedding rate is near 0.5, which is larger than that obtained using other existing methods.

Table 3 Maximum embedding rate and maximum pure embedding rate of the eight test images

Image	Maximum embedding rate	Maximum pure embedding rate
Lena	0.4922	0.4921
Airplane	0.4922	0.4920
Barbara	0.4901	0.4525
Baboon	0.4911	0.4708
Boat	0.4921	0.4901
Hill	0.4922	0.4921
Peppers	0.4922	0.4919
Lake	0.4922	0.4920

Major results (Cont'd)

2. Regarding the error rate, the proposed method extracts the additional data free of error.

3. Regarding image quality, the decrypted image's PSNR of our scheme is low because of the operation of flipping the MSB. However, after adopting the interpolation technique as a filter, the PSNR is improved to be better than those existing methods.

Table 7 Performance comparison among the proposed method and related methods for Lake at two embedding rates of 0.0156 and 0.0625

Method	Error rate (%)		PSNR (dB)			
			Decrypted image		Recovered image	
	0.0156	0.0625	0.0156	0.0625	0.0156	0.0625
Zhang (2011)	5.4440	26.843	37.92	37.90	47.73	40.80
Hong *et al.* (2012)	1.3670	10.535	37.90	37.90	53.67	44.97
Liao and Shu	2.3440	13.930	37.92	37.89	51.45	43.77
Wu and Sun (2014)	0.0002	0.032	30.64	27.06	63.76	59.57
Proposed method	0	0	27.07/48.35*	21.04/42.57	∞	∞

* The first value is the PSNR of the directly decrypted image, and the second value is the PSNR of the decrypted image after interpolation

Conclusions

1. We propose a reversible data hiding method for encrypted images.

2. We introduce the interpolation technique to generate a location map to record whether the pixels could be embedded or not, and then embed the additional data through modifying the MSB.

3.Both the embedding rate and embedding capacity were improved significantly. In addition, real reversibility is realized using our method, which means both data extraction and image decryption are free of error.