

HIDING MULTIPLE WATERMARKS IN TRANSPARENCIES OF VISUAL CRYPTOGRAPHY

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ABSTRACT. *This paper proposes a scheme to hide multiple watermarks in transparencies of visual cryptography. On one hand, the main properties of the traditional visual cryptography are still maintained. On the other hand, not only the encrypted image can be visible when stacking the transparencies, but also two extra watermarks can be extracted with simple computations. The scheme can be applied to hide some affiliated information of the secret image. Experimental results demonstrate the scheme is effective and practical.*

Keywords: Multiple watermarking, Visual cryptography, Lossless recovery

1. **Introduction.** Visual cryptography [1] is a technique of hiding a two-tone (e.g. a binary pattern, a halftone image) secret image into a set of binary transparencies images which look like random noise. In decryption, the secret image is perceptible by human visual system as long as stacking transparencies, while no extra computations and prior knowledge are required. This is the key advantage of visual cryptography compared with other cryptography algorithms in which complex computations are involved. Generally, a visual secret sharing scheme is constructed based on a $\{k, n\}$ -threshold framework. That is, a secret image is hidden in n transparencies distributed to n participants. Only when k or more transparencies are stacked, the secret content is visible. In recent years, researchers have developed plenty of visual cryptography techniques for halftone images [2], gray level images [3, 4] and color images [5].

Digital watermarking is a powerful technique to protect copyright, authenticate content, detect alterations, etc. Up to now, many watermarking techniques have been developed [6-13]. Multiple and multipurpose watermarking usually can be used in many practical applications [14-16]. In visual cryptography, it is desirable to embed data in encrypted transparencies to protect them. In this paper, we focus on embedding two different watermarks transparencies in visual cryptography.

In particular, this paper proposes a novel scheme joint two watermarks embedding in transparencies and secret image encryption, which based on $\{2, 2\}$ -threshold visual cryptography scheme (VCS). Besides the secret image S , another two watermarks W_1 and W_2 is also encrypted in two transparencies T_1 and T_2 . When stacking T_1 and T_2 , content of S can be clearly recognized. Moreover, W_1 and W_2 can be extracted with the aid of a computer. Compared with the traditional $\{2, 2\}$ VCS, our scheme can be