

# Security analyses of false positive problem for the SVD-based hybrid digital image watermarking techniques in the wavelet transform domain

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**Abstract** Singular Value Decomposition (SVD) comprises many important mathematical properties that are useful in numerous applications. Newly developed SVD-based watermarking schemes can effectively maintain minor changes despite the large altered singular values  $S$  caused by the attacks. Due to the stability and the properties of  $S$ , most of the researchers prefer to embed into  $S$ . However, despite satisfying the stability and robustness criteria, SVD-based image watermarking can still encounter false positive problems (FPP). Avoiding FPPs is one of the popular research topics in the field of SVD-based image watermarking. Satisfying robustness and imperceptibility requirements, as well as preventing FPPs, in SVD-based image watermarking is crucial in applications such as copyright protection and authentication. In this paper, false positive problem is studied, analysed and presented in detail. Different schemes are studied and classified based on the probability of exposure to false positive problem. All types of SVD-based embedding algorithms that leads to false positive problem and the related potential attacks has been evaluated using the reliability test as well as all solutions to false positive problem are reviewed. To understand how the attacks can threaten the rightful ownership and how to avoid these attacks, the three potential attacks of false positive problem has been demonstrated using recent proposed watermarking schemes. The main perspective of this paper is to gather all the issues belong to the false positive problem with SVD-based schemes.

**Keywords** Image watermarking · Singular value decomposition · Wavelet transform · False positive problem · Copyright protection