



## **Multi-biometric Watermarking Based on SVD and 3D Spiral Optimization**

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This paper presents a multichannel watermarking approach for embedding three different gray level biometric images into RGB host image, based on SVD and 3D spiral optimization. There are two important specifications in watermarking process. First one is robustness which means that the watermark should be detected with extraction process even though there is an attack to the watermarked image. The second one is impercibility that a person couldn't detect watermark without extraction process.

In this work, while mixing host image and watermark image, a scale factor is used. Here the scale factor is the ratio of singular matrices between watermark image and host image. First, same scale factor is used for each channel during watermarking. It is seen that robustness is directly proportional with scale factor value, while impercibility is inversely proportional with scale factor value. This means that optimization of scale factor is important to achieve high performance for both robustness and impercibility. Therefore, 3D spiral optimization is used to get optimum scale factor for each channel. Spiral optimization was firstly proposed for 2-dimensional continuous optimization problems but then it is improved to n-dimensional problems too. It is such a heuristic algorithm to solve the multi-point search problem. It simulates the natural spiral phenomenon. The spiral model starts with initial state and converges to the spiral center. In this study Lenna 512x512 RGB image is used as host and 128x128 three biometrics (palm, iris and ear) are used as watermark. Furthermore, nine types of attacks are applied to watermarked image in order to experience robustness. These attacks are adding noises (Salt and Pepper, Gauss, Speckle), rotation, cropping, two different resizing and two different jpeg compression.

After applying these attacks to watermarked image, the correlation coefficients between original watermark and retrieved one are obtained as 0.9927 for noise attacks, 0.9997 for crop attack, 0.9992 for resizing and 0.9998 for JPEG compression. The PSNR values between original host image and watermarked image are as 29.3381 dB for R channel, 29.9055 dB for G channel and 26.7860 for B channel.

**Keywords:** Multi-channel watermarking, multi-biometrics, spiral optimization, singular value decomposition