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Comparative Study on the Evaluation and Benchmarking Information Hiding Approaches Based Multi-Measurement Analysis Using TOPSIS Method with Different Normalisation, Separation and Context Techniques

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Abstract

This paper presents a comparative study of evaluation and benchmarking information hiding approaches based on multi-measurement analysis using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method in terms of different parameter settings because several settings of TOPSIS are continually making complex decisions within any study case. The problem is extended from original TOPSIS in terms of different contexts, distance and normalisation techniques. However, each technique changes the behaviour of data differently. The literature presents no evidence that any of those techniques affects the final decision. Supporting results are needed to justify which technique is the best for this particular study on evaluation and benchmarking digital watermarking approaches. For these purposes, two experiments are performed. In the first experiment, a noise-gate-based digital watermarking approach is developed, and a scheme for noise gate digital watermarking approach is enhanced. A total of 60 audio samples with different audio styles are tested using the two algorithms. A total of 120 samples are evaluated according to three different metrics, namely, quality, payload and complexity, to generate a set of digital watermarking samples. In the second experiment, three different weights are selected in the decision making process. For the first weight, 50% of importance is given to size and 25% each for quality and complexity. In the second weight, 50% is given to quality and 25% each to size and complexity. In the last weight, 50% of importance is given to complexity and 25% each to size and quality. In the decision making solution, the algorithm adjustment and parameter selection of TOPSIS are identified and tested based on three parameters, namely, normalisation, separation and contexts. In the normalisation process, two different linear normalisation and vector normalisation techniques are used. In the separation process, two different techniques, namely, Manhattan and Euclidean distances, are used, and each of these measurements has different philosophies. In the context process, two different contexts, such as decision making based on signal and group, are used. The results are as follows: (1) The preferred normalisation technique is followed by vector normalisation. (2) We recommend linear normalisation with TOPSIS by integrating the results from our experiment and the literature experiment. (3) The separation measurement has an effect on decision making algorithms, and the Euclidean measurement in the separation process reflects more accurate results than the Manhattan measurement. (4) The framework selects one of the two context settings, that is, group or individual, which will give the same results. However, group decision making is the recommended approach in the case of selection where priority weights are generated from the evaluators.

Keywords: multi-criteria analysis, evaluation and benchmarking, information hiding approaches, multi-criteria decision making technique.

1. Introduction

The benchmarking process typically refers to the collection of a large amount of quantitative data to ensure the quality of products. Therefore, information hiding approaches should be tested, evaluated and benchmarked in a standard manner. According to [74], information hiding is faced with two main obstacles. Firstly, new attacks rapidly appear with newly proposed digital watermarking approaches. Secondly, the tools and evaluation methodologies are nearly non-existent. Overall, benchmarking tools for information hiding techniques are insufficient [74].

Steganography and digital watermarking development has two main requirements [3-6, 11-13]. Firstly, perceptual transparency or noticeable perceptual distortion, which is the cover object or carrier and stego-object (the cover that contains hidden data), must be undetectable [19, 20, 26-31, 38-40, 94]. The other requirement is the ability of the cover file to carry high data rate [46-49, 55, 57, 58, 83-85]. In particular, the main burden experienced by digital watermarking developers is that achieving high robustness and high payload at the same time is impossible when the perceptual transparency parameter is fixed [15, 16].

Inaudibility, payload and robustness to attacks are the corners of the magic triangle, as shown in Figure 1. The magic triangle is presented by [2, 7, 15, 16, 34, 42, 45, 54, 62, 73, 76, 78, 81, 97, 98], which indicate the basic requirements for the design of information hiding techniques [101-105]. The magic triangle model is suitable for visualising the essential trade-offs between the watermark payload and robustness to a particular watermark attack. Therefore, the perceptual quality of digital watermarking should be maintained at an acceptable level. The two objectives are impossible to achieve at the same time. Hence, robustness is sacrificed if a high payload watermarking is required [71]. This trade-off is reflected in the evaluation and benchmarking processes.