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Comparison of Genetic Algorithm based Watermarking Techniques using Tournament Selection Approach and Roulette Wheel Approach for Fidelity Optimization

Sachin Goyal and Roopam Gupta

Department of Information Technology
RGPV, Bhopal, India
sachingoyal@rgtu.net, ropamgupta@rgtu.net

Abstract

To protect digital content from illegal copy or reproduction, digital watermarking techniques are used which embed watermark into digital content and extract the same from the digital content to help in digital media protection. As techniques based on spatial and frequency domain are reported to have several limitations due to unsatisfactory values of fidelity by various researchers, new techniques based on genetic algorithm have been developed with an objective to optimize the values of fidelity of watermarked image. Genetic algorithms are used to find suitable locations for watermark insertion within a cover image, using either tournament selection approach or roulette wheel selection approach to provide optimization of fidelity. This paper is an attempt to provide a comparative study of the results obtained with genetic based watermarking techniques using roulette wheel selection approach and tournament selection approach . The variation of maximum fitness with respect to changing embedding strength, number of genes, mutation probability. Crossover probability and varying payloads has been compared and discussed for both the selection strategies.

Keywords: *Digital watermarking, genetic algorithm, fidelity, PSNR, roulette-wheel selection, tournament selection*

1. Introduction

There are many watermarking methods [1] which have been developed to embed a watermark into the cover image. Some of the important contributions of various proposed methods of digital watermarking during initial research period in digital watermarking are presented here. A watermark was generated using the least significant bit of the original image by Schyndel *et al.* [2] to produce the watermarked image. The watermark was extracted from a suspected image by taking the least significant bits at the proper locations. Cross-correlation of the original and extracted watermark was made by Schyndel, which showed that the resulting image contained an invisible watermark with simple extraction procedures. Cox *et al.* [3] pointed that, in order for a watermark to be robust to attack, it must be placed in perceptually significant areas of the image. Yen and Huey et al [4] chose pair of position with same quantization scale in standard JPEG quantization table as cover image and it use the concept of discrete cosine Transformation. Huang *et al.* [5] paper used a concept of DCT and proposed a Progressive watermarking Techniques with genetic algorithm. M.J Anwar *et al.* [6] this method is more robust against JPEG compression. In this method genetic algorithm is used to find best position in image block that the positions have a mathematical relationship. Somying promcharoen and yuttapong rangsanseri [7] this approach used a fuzzy C-mean algorithm to classify 8x8 DCT block as texture or non-texture region. In this paper, a digital image watermarking by using genetic algorithm to optimize parameters used in block based DCT watermark embedding. M. Rafig [8] have proposed

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a watermarking algorithm in the DCT domain using an evolutionary algorithm. S. Goyal *et al.* [9 10] use a roulette-wheel and tournament selection strategy in genetic algorithm and optimize the fidelity in spatial domain. This paper provides comparative study of the results obtained with genetic based watermarking techniques using roulette wheel selection [9] approach and tournament selection approach [10].

Section II provides the methodology adopted with roulette wheel selection and Tournament Selection approach for fidelity optimization. Section III show Experimental Result and Compare the algorithm which was proposed in earlier papers [9 10]. Conclusion is given in section IV.

2. Roulette-Wheel Approach and Tournament Selection Approach for Fidelity optimization

The purpose of selection is to stress fitter individuals in the population in hope that their off springs have higher fitness. Chromosomes are selected from the initial population to be parents for reproduction. This approach work as follows:

1. Initial population consisting of random location for watermark insertion is chosen.
2. Fitness is designed in such a way that higher fidelity, the higher shall be the value of fitness function.
3. Best individual are select using either Roulette-wheel or tournament selection strategy
4. Now, the crossover and mutation is done to produce new set of locations *i.e.* new population.
5. Step from 2 to 4 are repeated till termination condition is obtained.

The Principal of Roulette-wheel [11-12] selection is a linear search and it can be visualize similar to roulette-wheel in a casino. Usually a proportion of the wheel is assigned to each of the possible selected based on their fitness of a selection by the total fitness of all the selection.

Tournament Selection [11-12] is a method of selecting an individual from a population. Tournament selection involves running numerous “tournament” among a few individuals chosen at random from population. The victor of each tournament is selected for crossover.

3. Experimental Result and Comparison

Roulette-wheel and Tournament selection strategy [9-10] is used to find out the desired locations for watermark insertion for fidelity optimization. In our experiments, the cover images used is Lena size (512 X 512) shown in figure 1and the binary two dimensional matrix with varying length in different experiments as the watermark. Experimental parameter are given as papers [9 -10]

Experiment 1

Thus it is clear from table 1 and figure 2 to 5 that the highest value of maximum fitness obtained is 78.1907 with the number of watermark bits = 16 and number of genes = 80 with embedding strength = 0.1 in case of tournament selection strategy and the highest value of maximum fitness obtained is 73.4850 with no of watermark bits = 16 and number of genes = 80 with embedding strength = 0.1 in case of roulette wheel selection method.

Table 1. Comparative Table of Variation of Maximum Fitness Vs Embedding Strengths

Watermark Bits/ No. 0f Genes	Maximum Fitness when Embedding Strengths=0.1		Maximum Fitness when Embedding Strengths=0.2		Maximum Fitness when Embedding Strengths=0.3		Maximum Fitness when Embedding Strengths=0.4		Maximum Fitness when Embedding Strengths=0.5	
	Tournament Selection	Roulette Wheel	Tournament Selection	Roulette Wheel	Tournament Selection	Roulette Wheel	Tournament Selection	Roulette Wheel	Tournament Selection	Roulette Wheel
16/80	78.1907	73.4850	74.2013	68.2695	68.1523	63.5633	64.4774	61.2810	64.3328	58.6833
20/100	75.9836	72.3213	72.3153	66.2614	66.3448	62.0214	65.7418	59.8865	60.7591	58.2793
24/120	74.4120	71.5851	68.6929	65.1345	65.7568	61.1399	64.3524	59.0840	61.3901	57.0121
28/140	73.6137	69.6006	68.8274	64.3120	63.2830	60.2322	61.7785	57.6576	60.3328	56.8408
32/160	71.9436	68.9753	65.4888	63.9612	62.6579	60.5623	60.2618	56.4570	57.4112	55.9521
40/200	71.7780	68.3329	64.9562	62.1386	60.4088	59.1342	59.5264	55.8521	56.4498	55.0198
56/280	69.027	66.7266	62.7078	62.2650	60.2377	57.3567	57.8788	54.2031	55.6938	53.9854
112/560	66.2833	65.6401	61.2312	59.6134	56.3472	56.2511	54.2084	53.8268	52.5103	51.8345
128/640	65.1021	65.3751	60.9102	59.1463	56.1604	55.4706	53.6875	53.1240	51.6456	51.2231
256/1280	64.7346	64.7660	58.7120	58.2441	55.1922	55.1922	52.9507	52.6525	50.7522	50.4143

The maximum value of fidelity varies between 78.1907 to 64.3328 for tournament selection method when embedding strength varies form 0.1 to 0.5 and varies from 73.4850 to 58.6833 in case of roulette wheel selection method when embedding strength varies from 0.1 to o.5.

Thus it can be inferred from this experiment that the fidelity obtained with tournament selection strategy has an edge over the fidelity obtained with roulette wheel strategy with changing values of embedding strength for a specific value of no of genes and number of watermark bits.

It is also observed from table 1 that with less no of watermarking bits / no of genes, the value of maximum fidelity obtained with tournament selection strategy is much better as compared to roulette wheel selection strategy. However, with increasing number of watermark bits and number of genes, this difference goes on diluting. Figure 2 (a) to (d) shows variation of maximum fitness with respect to changing Embedding Strength.

Figure 1. Lena Image (512x512)

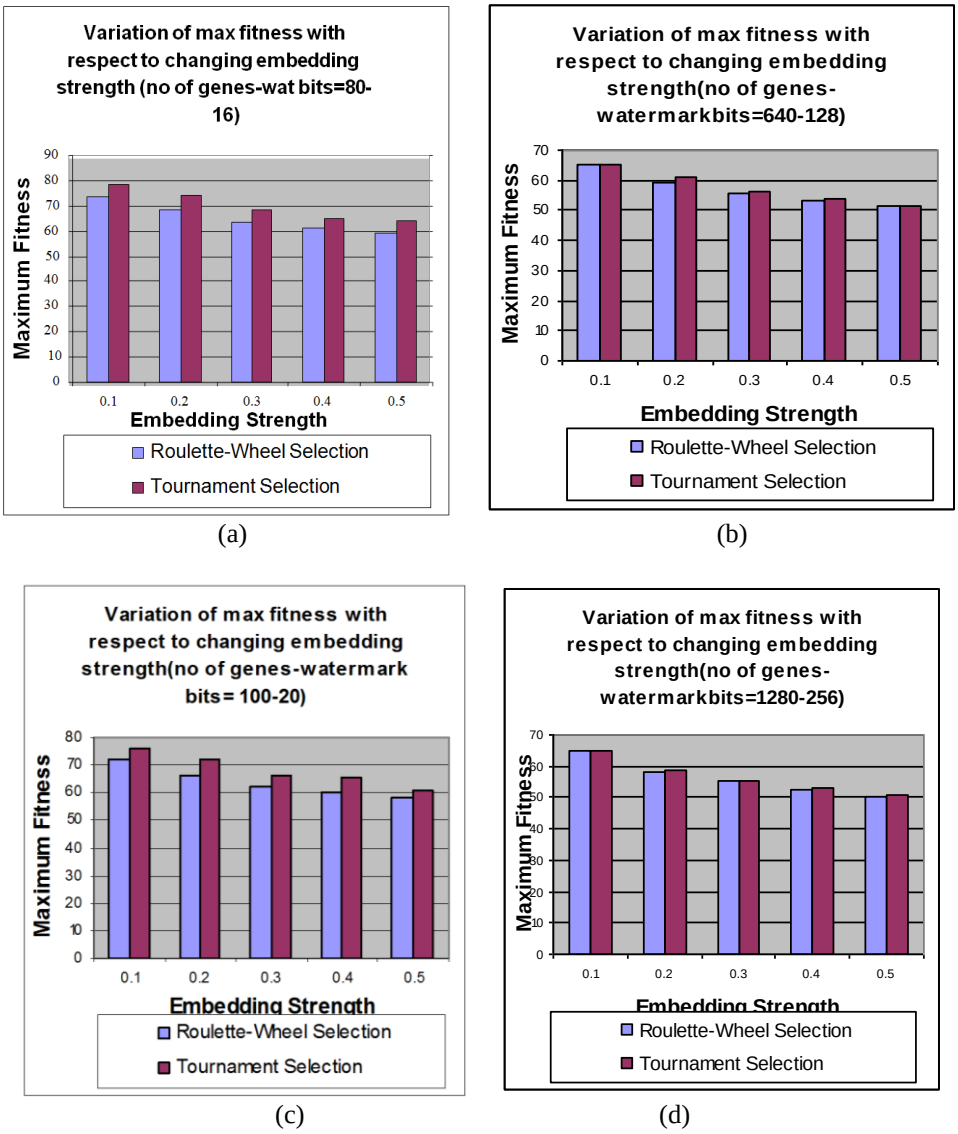


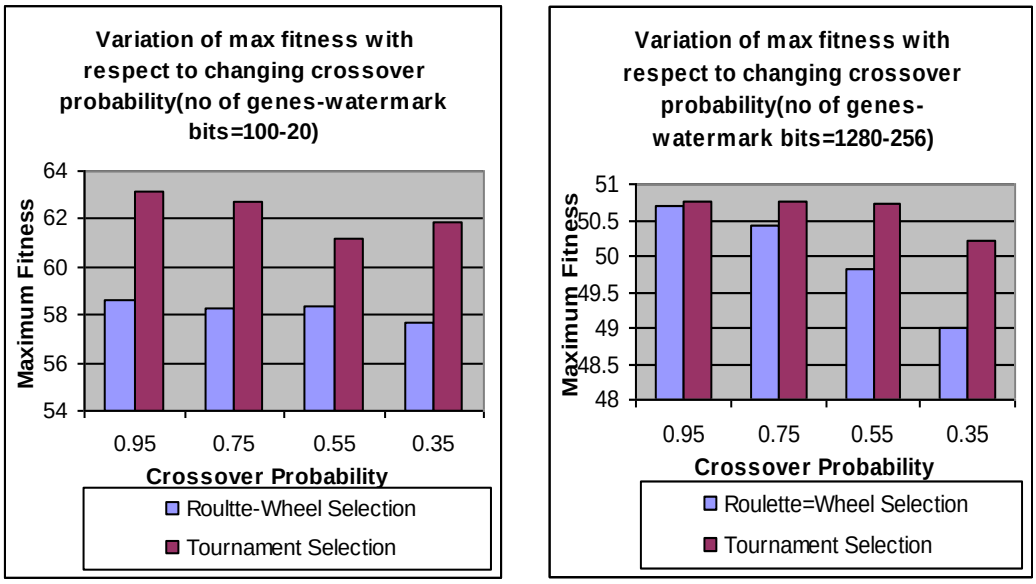
Figure 2. (a) – (d) Variation of Maximum Fitness with Embedding Strength

Experiment 2

Thus it is clear from table 2 that the highest value of maximum fitness obtained is 64.6275 with the number of watermark bits = 16 and number of genes = 80 with crossover probability = 0.85 in case of tournament selection strategy and the highest value of maximum fitness obtained is 59.0554 with no of watermark bits = 16 and number of genes = 80 with crossover probability = 0.85 in case of roulette wheel selection method.

The maximum value of fidelity varies between 64.6275 to 62.2245 for tournament selection method when crossover probability varies form 0.85 to 0.35 and varies from 59.0554 to 58.4439 of roulette wheel selection method when crossover probability varies form 0.85 to 0.35.

Thus it can be inferred from this experiment that the fidelity obtained with tournament selection strategy has an edge over the fidelity obtained with roulette wheel strategy with changing values of crossover probability for a specific value of no of genes and number of watermark bits. Figure 3(a) and (b) shows Variation of maximum fitness with respect to changing crossover probability.



(a) (b)

Figure 3. (a) and (b) Variation of Maximum Fitness with Crossover Probability

Experiment 3

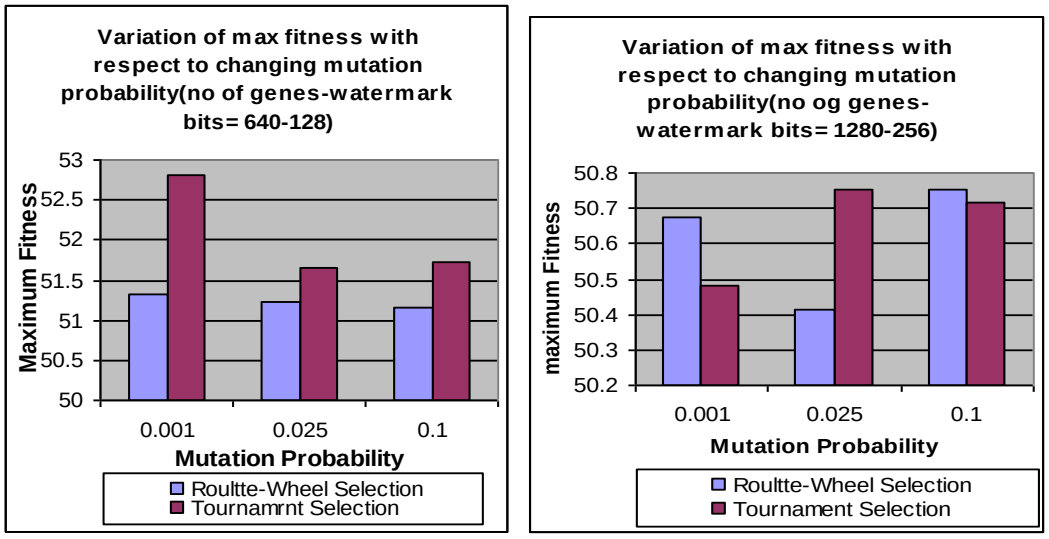
Thus it is clear from table 3 that the highest value of maximum fitness obtained is 65.4005 with the no of watermark bits = 16 and number of genes = 80 with mutation probability = 0.001 in case of tournament selection strategy and the highest value of maximum fitness obtained is 59.1461 with no of watermark bits = 16 and number of genes = 80 with mutation probability = 0.001 in case of roulette wheel selection method.

The maximum value of fidelity varies between 65.4005 to 60.4405 for tournament selection method when mutation probability varies form 0.001 to 0.1 and varies from 59.1462 to 58.0720 of roulette wheel selection method when mutation probability varies form 0.001 to 0.1.

Thus it can be inferred from this experiment that the fidelity obtained with tournament selection strategy has an edge over the fidelity obtained with roulette wheel strategy with changing values of mutation probability for a specific value of no of genes and number of watermark bits.

It is also observed from table 3 that with less no of watermarking bits / no of genes , the value of maximum fidelity obtained with tournament selection strategy is much better as compared to roulette wheel selection strategy.

Thus, with higher no of watermark bits, the results produced by both the selection strategies are quite similar. Figure 4(a) and (b) shows variation of maximum fitness



(a) (b)

Figure 4. (a) and (b) Variation of Maximum Fitness with Mutation Probability

Table 3. Comparative Table of Maximum Fitness Vs Mutation Probability

Watermark Bits/ No. 0f Genes	Maximum Fitness when Mutation probability=0.001		Maximum Fitness when Mutation Probability =0.025		Maximum Fitness when Mutation Probability =0.1	
	Tournament Selection	Roulette Wheel	Tournament Selection	Roulette Wheel	Tournament Selection	Roulette Wheel
16/80	65.4005	59.1461	64.3328	58.6833	60.4405	58.0720
20/100	61.2048	58.4750	60.7591	58.2793	59.4490	58.1832
24/120	62.1927	57.9520	61.3901	57.0121	59.1827	56.6025
28/140	61.3076	56.5310	60.3328	56.8408	56.6026	55.9825
32/160	58.6093	56.5289	57.4112	55.8603	55.9508	55.2598
40/200	58.5565	56.2124	56.4498	55.0198	55.0841	54.3355
56/280	56.4077	54.1998	55.6938	53.9854	53.3143	53.1354
112/560	55.0254	52.2860	52.5103	51.8345	52.1111	51.4612
128/640	52.8031	51.3112	51.6456	51.2231	51.7361	51.1474
256/1280	50.4836	50.6723	50.7522	50.4143	50.7143	50.2522

4. Conclusions

This paper has presented a comparative study of the variations in maximum fidelity obtained using watermarking techniques with genetic algorithms using roulette wheel selection method and tournament selection method. The results obtained from both these selection with respect to changing crossover probability. Obtained between the two selection strategies with different settings of the number of genes, crossover probability, Mutation probability, embedding strengths and payloads etc. This work can serve as the basis of using a specific selection strategy for the fidelity optimization with a given set of parameters.

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