Analysis of Pixel Impact Factor-Based Image Fidelity Measure In Correlation With Subjective Measurement

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Abstract
In this article I analyze correlation of Pixel Impact Factor-Based image fidelity measures in correlation with subjective measurement. I demonstrate that PIF-Based measures outperform well-known fidelity measures in terms of correlation with subjective human perception.

As a result PIF-Based measures can be utilized to implement automated digital watermarking systems.

1. Introduction
Digital watermarking is a rapidly developing field of science and technology [1]. In today’s digitalized world, computer techniques that enable easily confirming work ownership or copyright laws are crucial. Image watermarking is one of the biggest fields to use digital watermarking systems and one of the most important techniques is invisible digital image watermarking. Invisible digital watermarking is inserting watermark into image in ways that original image and watermarked image should differ as little as possible. Currently there are no standards, that consider fidelity between original and watermarked image. However, in the past many works have been presented, that deal with signal similarity measures [2] [3]

1.1 Background
Inserting watermark into image always interferes its structure so we need to measure this distortion. It can be done with subjective or objective measurement. Both methods have disadvantages. Subjective measurement is expensive, time-consuming, inconvenient and cannot be implemented in automated environment. Objective measurement is mostly based on mathematically defined algorithms. Many of these methods are not taking into consideration specific place where distortion is inserted but difference between two images. Considering Human Visual System (HVS) place of inserting watermark is important because two images with the same value for objective measure can be differently perceived by human.

To eliminate this drawback, in recent work, I proposed improvements of well-known objective measures [4] with Pixel Impact Factor (PIF) [5].

1.2 Proposed method
Pixel Impact Factor coefficient reflects to importance of each pixel according to its neighborhood.

This method is completely explained in recent work [5]

1.3 Testing procedure
For test I used 9 images selected from USC-SIPI images database [6]. These are: Lena, Armored, Baboon, Desert, Desert2, Desert3, F16, Landscape, Pepper. Each image is size of 512x512 pixels.

All images are gray-scaled and its contents vary. For purpose of testing I inserted specially designed watermark in each image. Watermark is a block of White Gaussian Noise, size 100x100 pixels. For every position of watermark in image there was calculated PSNRPIF measure. I inserted watermark in place of maximal and minimal values of PSNRPIF.

Prepared groups of 3 images: original image, maximum PSNRPIF and minimum PSNRPIF value watermarked images I gave the assessment of human observers. Each observer has 1-10 points scale to measure fidelity of watermarked image to original image.

1.4 Risks
Prepared test has been published in Internet [7] so anyone could use it. It has some advantages and disadvantages. Advantages are that many people could easily resolve it in short time. Disadvantages are that unsupervised solving could lead to misunderstanding of the task and different use of the proposed scale.

As results shows there were some people that misunderstood their task. Generally this wrong results does not affect whole.

2. Results
Results can be divided in two groups: first – where responses are explicitly distributed and second – where responses are unequally distributed. First group can be represented by results of image Lena.
For purpose of this article I inserted arrows that show positions where watermark was inserted Fig. 2.

Chart 1 shows distribution of responses for image with much better visible watermark while Chart 2 shows distribution of responses for image where watermark was almost invisible.

Results are more consistent for invisible watermark because most evaluators couldn’t notice watermark. For more visible watermark results are ambiguous.

Both trend lines shows clearly where watermarked image is more similar to original image.

In my testing images there were images with very homogeneous content. Best example is F16 image.

Distribution of responses was like on Chart 3 and Chart 4. Because both images have highly visible watermarks, respondents have troubles to identify more and less similar image to original image. It is shown clearly by trend lines.

Quite different responses have been given for image Baboon, where watermark was hard to notice in both cases.
3. Conclusions

Taken research shows that there are still problems with images fidelity analysis based on mathematical measures. PIF-Based measures are much better suited to use in automated environment but its quality strongly depends on image content. For images with heterogeneous content they work very good, while for homogeneous content differences for measure values are too small.

Still, there is noticeable correlation between human subjective measures and PIF-Based measures.

4. Future work

Tests should be once again completed in smaller, supervised environment to avoid misunderstanding task by observers. Comparison of this results will give better understanding how is human observer perceiving distortion in image.

5. Bibliography

[7] [Online]. Available: https://docs.google.com/forms/d/1M8E7S4a9Uz_nmuW2EzJoJ3M1oWF1vaWF4Wdc1-d0Vs/viewform.

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