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Proyecto Fin de Carrera

Evaluación subjetiva de la calidad de la imagen usando métodos de doble estímulo y comparación con medidas objetivas

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Summary

In this project was created a simulation of a radio-communication channel in Simulink (Matlab). It is a graphical tool that allows modeling, simulation and analysis of dynamic systems. The radio-communication channel includes: JPEG coder and decoder, BPSK modulator and demodulator, AWGN channel and some additional boxes to adjust the flow of data. Group of images have been sent through the channel and while changing the parameters of each box the image distortion changes. There were used two subjective methods for image evaluation: DSIS and DSCQS. The methods correlate well. Correlation with the objective methods depended on each method and a type of image distortion. Subjective and objective methods are both equally important for evaluation of image quality.

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Introduction

In this study it will be elaborated subjective assessment of image quality by using double-stimulus methods and comparison with objective measures. The most commonly used methods for the subjective assessment of image quality are double-stimulus method with a score of image distortion (DSIS, double-stimulus impairment scale) and double-stimulus method with assessment of image quality (DSCQS, double-stimulus continuous quality-scale). Each of these methods uses a specific way to represent test sequences and different scales for the assessment of image quality that affects on the final results of subjective tests. Both subjective methods (DSIS and DSCQS) will be explained in detail with instructions how to perform the testing process.

It is important to understand the results of the methods and the type of distortions that may happen in radio-communication channel. Each method has its own scale and the meaning. It will be analyzed the stability of the results for different image contents. In the end objective methods and results will be compared with subjective methods (PSNR, MSE and SSIM). It is expected that there will be differences between the results, but it is important to understand the advantages and disadvantages of each method. The goal is to find a correlation between these two methods.

Simulation of radio channel

Simulation that we used for image transport through radio cannel was made in simulink which is a part of Matlab software system. Simulink is a graphical tool that allows modeling, simulation and analysis of dynamic systems. The elements that were used are: *image from file box, JPEG coder/decoder, frame converter, integer to bit converter, bit to integer converter, BPSK modulator/demodulator, AWGN channel, video viewer* and *simout*. The point of this simulation was estimation of image quality on the end of radio channel – receiver.

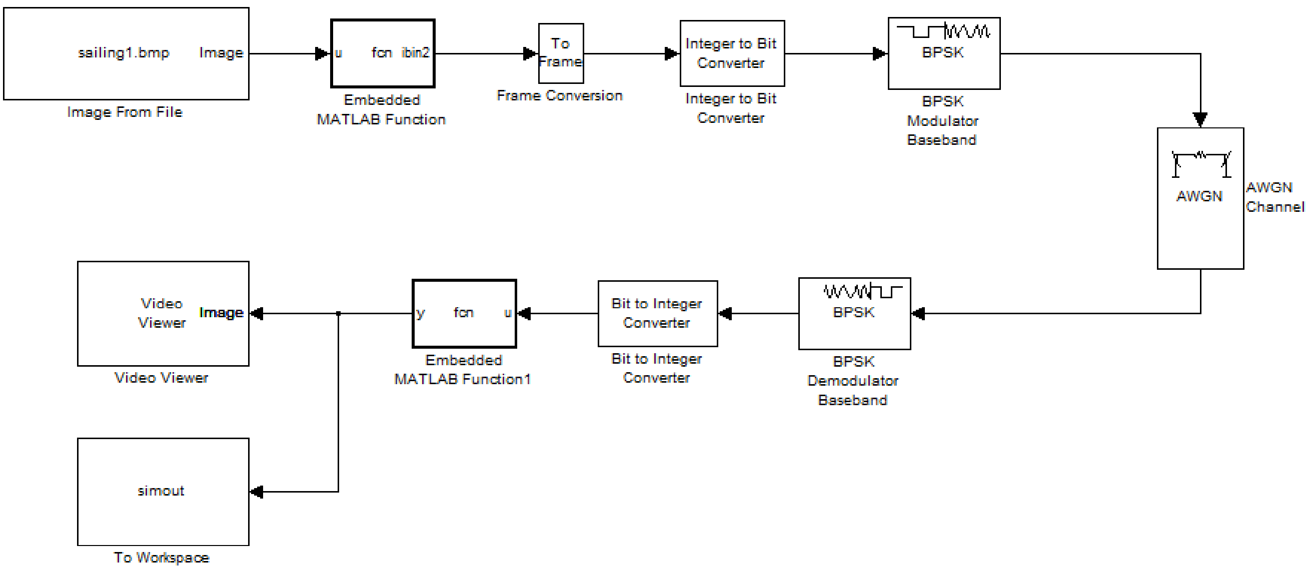


Figure 1: Simulation of radio communication channel in MATLAB Simulink

Image from file box is a source of images which were sent through radio channel. Image size may vary. Before image gets into the AWGN channel, it has to be coded by JPEG coder. JPEG stands for *Joint Photographic Experts Group* which is the name of the association that made the standard for image coding. In other words JPEG is a standardized process for image compression.

It is designed for compression of the color images and black and white images (grayscale) as well. JPEG is generally used for the compression of static images and it is not suitable for text, video, simple drawings or technical drawings. JPEG and GIF are the most popular formats for transferring images on the internet because of the high degree of compression and support for almost all web browsers.

JPEG is a compression method with losses, which means that the compressed image is not quite the same as original one. It has been designed to take advantage of the human eye limitations, for example, small changes in brightness are much more noticeable than a small change in color of image. JPEG standard includes two basic compression methods. First one is based on the DCT (discrete cosine transformation) and it works with losses. It is most frequently used method. The other one is based on predictive coding and belongs to the lossless compression. In this simulation it has been used DCT coder which means that we have losses.

After coding image gets divided into frames which are going into *integer to bit converter box*. In the end we have to make a BPSK modulation over the frames to protect them from channel noise interference. On the receiver side we have the same procedure in reverse. Finally we can see the image on video viewer and make estimation of its quality.

Methods of assessment of image quality

Image processing leads to various distortions in the image that reduces its quality. Therefore the assessment of image quality is very important component of this process. There are two types of methods of assessment of image quality:

- Objective methods
- Subjective methods

Objective methods are performed by using a measuring instrument, mathematical calculation or a model. Typical examples of objective methods are: MSE (Mean Squared Error), PSNR (Peak Signal-to-Noise Ratio), SSIM (Structural Similarity), MSSIM (Multiscale Structural Similarity), VIF (Visual Information Fidelity), VSNR (Visual Signal-to -Noise Ratio).

Double-stimulus methods

Double-stimulus methods are subjective methods which are used to improve entire transmission system and its functionality. It is important to keep the picture quality and the overall service quality as well. In the process of continuously improving the subjective assessment methodology, and adapting it to the most recent technological developments it has been launched the RACE MOSAIC project. RACE MOSAIC was set up to find the best solutions of specific digital picture quality issues. From the work of this project, the **S**ingle-**S**timulus **C**ontinuous **Q**uality **E**valuation (SSCQE) method was developed. SSCQE was recently introduced in ITU-R Recommendation BT.500-7. This format already offers the possibility of storing objective measurement data and subjective assessment data in a compatible way for parallel processing.

The introduction of digital audio-visual services needed a new subjective protocol which is able to measure the quality of service on longer viewing sequences. Therefore an adapted version of the SSCQE methodology has been developed, using simultaneous double visual stimuli. This new method is called **D**ouble-**S**timulus **C**ontinuous **Q**uality **E**valuation (DSCQE). DSCQE uses longer test sequences than

SSCQE method. The results of different research studies has showed that the reporting time and the human memory processes play an extremely important role. Therefore is important to confirm that the observers could assess the picture and service quality accurately over sequences of 30 to 60 minutes.

The double-stimulus impairment scale (DSIS) method (the EBU method)

This method is used for assessment of impaired images which have been transported through transmission channel. DSIS method is cyclic which means that the assessor is first presented with an unimpaired reference, then with the same image impaired. Following this, he is asked to vote on the second, keeping in mind the first. In sessions, which last up to half an hour, the assessor is presented with a series of pictures or sequences in random order and with random impairments. The unimpaired picture is included in the pictures or sequences

to be assessed. At the end of the series of sessions, the mean score for each test condition and test picture is calculated. Stability of the results is greater for small impairments than for large one.

Grading scales

The five-grade impairment scale should be used:

5	imperceptible
4	perceptible, but not annoying
3	slightly annoying
2	annoying
1	very annoying

Assessors should use a form which gives the scale very clearly, and has numbered boxes or some other means to record the grading.

Presentation of the test material

There are three variants of the structure of presentations:

1. The reference picture or sequence and the test picture or sequence are presented only once

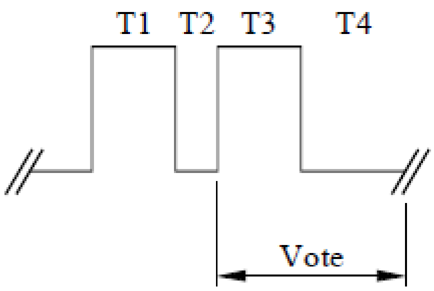


Figure 2: First version of DSIS

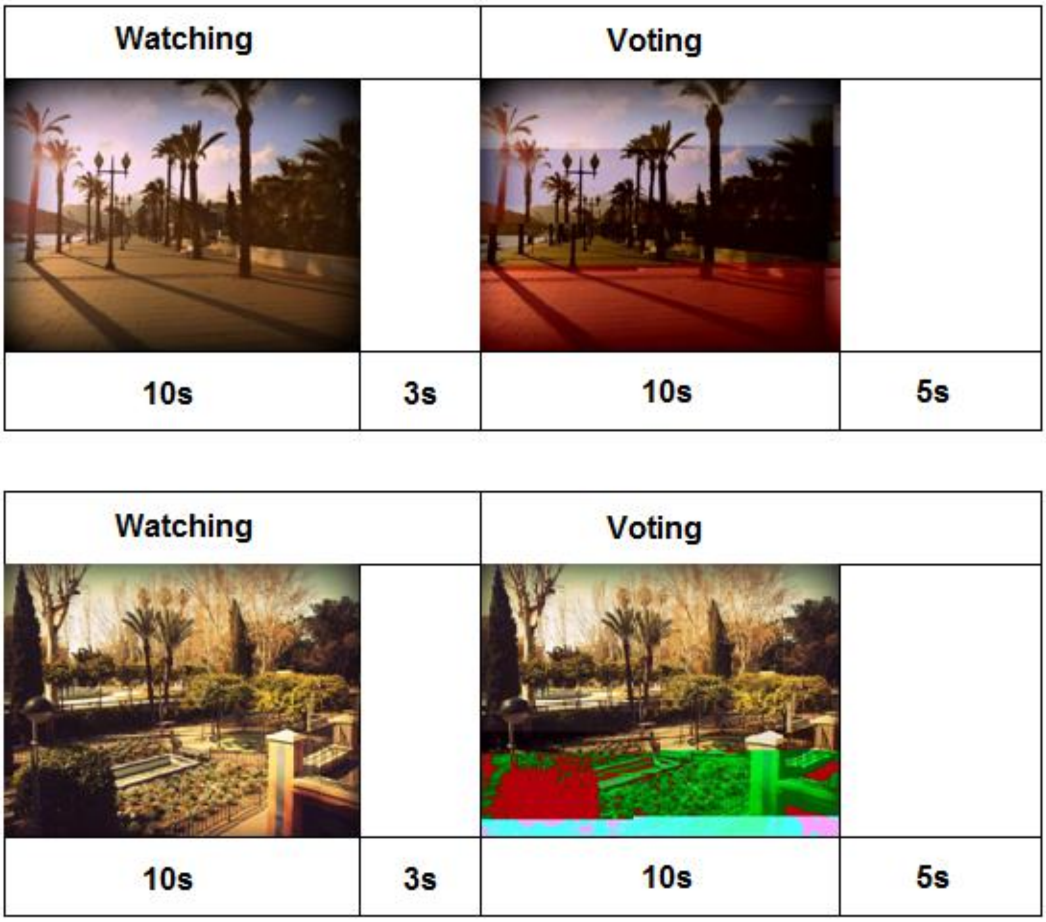


Figure 3: Timeline of first variant

2. The reference picture or sequence and the test picture or sequence are presented twice

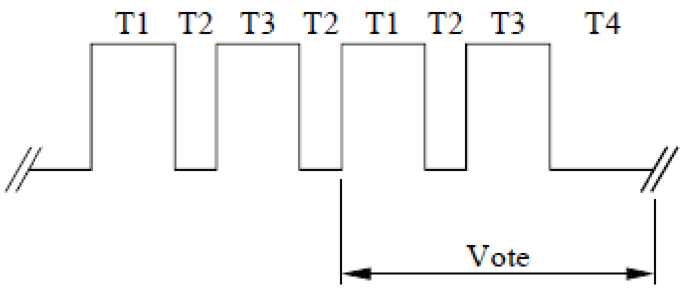


Figure 4: Second version of DSIS

Figure 5: Timeline of 2nd variant

3. This variant is consuming first variant couple of times (more than 2 times)

Phases of presentation:

T1 = 10s	Reference picture
T2 = 3s	Mid-grey background
T3 = 10s	Test condition
T4 = 5-11s	Mid-grey background

At the beginning of each session, it is important to give an explanation of whole process of evaluation to the observer. That includes type of assessment, the grading scale, the sequence and timing (reference picture, grey, test picture, voting period). The range and type of the impairments to be assessed should be illustrated on pictures other than those used in the tests. It must not be implied that the worst quality seen necessarily corresponds to the lowest subjective grade. Observers should be asked to base their judgment on the overall impression given by the picture. The observers should be asked to look at the picture for the whole of the duration of T1 and T3. Voting should be permitted only during T4.

The double-stimulus continuous quality-scale (DSCQS) method

The Double Stimulus Continuous Quality Scale (DSCQS) method (ITU-R recommendation BT.500) is widely used for the quality assessment of systems and transmission paths used for television broadcasts. This method is more effective in cases where it is not possible to present the full range of quality conditions. It is capable for simultaneous assessing of the difference in quality between a reference video/image and an assessment video/image.

This subjective method was developed to measure the quality of service on longer viewing sequences. The method is cyclic which means that the assessor is asked to view a pair of pictures. One is the original video or image without any transmission errors and the other is the same but after alteration by transmission errors. In other words, both images are from the same source, but one passed through radio channel and the other one came directly from the source. The observers assess the quality of both images by direct comparison.

In sessions which last up to half an hour, the assessor is presented with a series of picture pairs in random order and with random impairments covering all required combinations. It means that the assessor doesn't know which picture in a pair is original and which one is distorted. At the end of the sessions, the mean scores for each test condition and test picture are calculated.

Presentation of the test material

A test session comprises a number of presentations. There are 2 variants of presentation. For *Variant 1* which has a single observer, for each presentation the assessor is free to switch between the A and B images (condition) until he has the mental measure of the quality of both images. Image A is unimpaired and the image B is impaired, which means that image A comes directly from the source while image B is transported through the radio channel and it is distorted. The assessor may typically choose to do this two or three times for periods of up to 10 s.

Variant 2 uses a number of observers simultaneously. The pair of images is shown one or more times for an equal length of time to allow the assessors to gain the mental measure of the qualities just like in the *Variant 1*. Then the pair is shown again one or more times while the results are recorded. The number of repetitions depends on the length of the test sequences. For still pictures, a 3-4 s sequence and five repetitions (voting during the last two) may be appropriate. The stability of results of this variant with a limited range of quality is considered to be still under investigation.

Variant A is very similar to DSIS method:

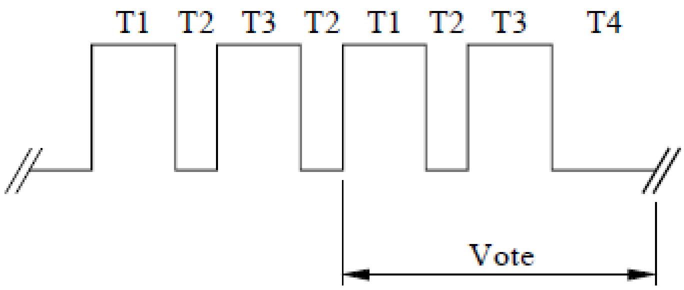


Figure 6: Third version of DSIS

T1 = 10s	Reference picture
T2 = 3s	Mid-grey background
T3 = 10s	Test condition
T4 = 5-11s	Mid-grey background

Timeline

Figure 7: Two versions of timelines

Grading scale

The method requires the assessment of two versions of each test image. One of each pair of test image is unimpaired and the other is impaired. The unimpaired image serves as a reference, but the observers are not told which is the reference image. In the series of tests, the position of the reference image is changed in pseudo-random fashion. The observer is asked to assess the overall image quality of each presentation by inserting a mark on a vertical scale. The vertical scales are printed in pairs to accommodate the double presentation of each test image. The scales provide a continuous rating system and they are divided into five equal lengths: excellent, good, fair, poor, bad. They correspond to the normal ITU-R five-point quality scale. Scale divisions are clearly separated. Figure 6 shows a section of a typical score sheet.

Analysis of the results

The assessments of each test condition include a score of the original image (reference) and impaired image. Those assessments are converted from measurements of length on the score sheet to normalized scores in the range 0 to 100. Each one of five equal lengths worth 20 points. Then, the differences between the assessment of the reference and impaired image are calculated. In any test procedure it is important to decide acceptability criteria before the assessment is started. This is especially important in DSCQS method because of inexperienced users who can misunderstand the meaning of the quality scale values. Therefore is used an example of test before the regular assessment. Still the results can vary more than is it expected. It is most important that each assessor has the same criteria of evaluation during the entire duration of testing.

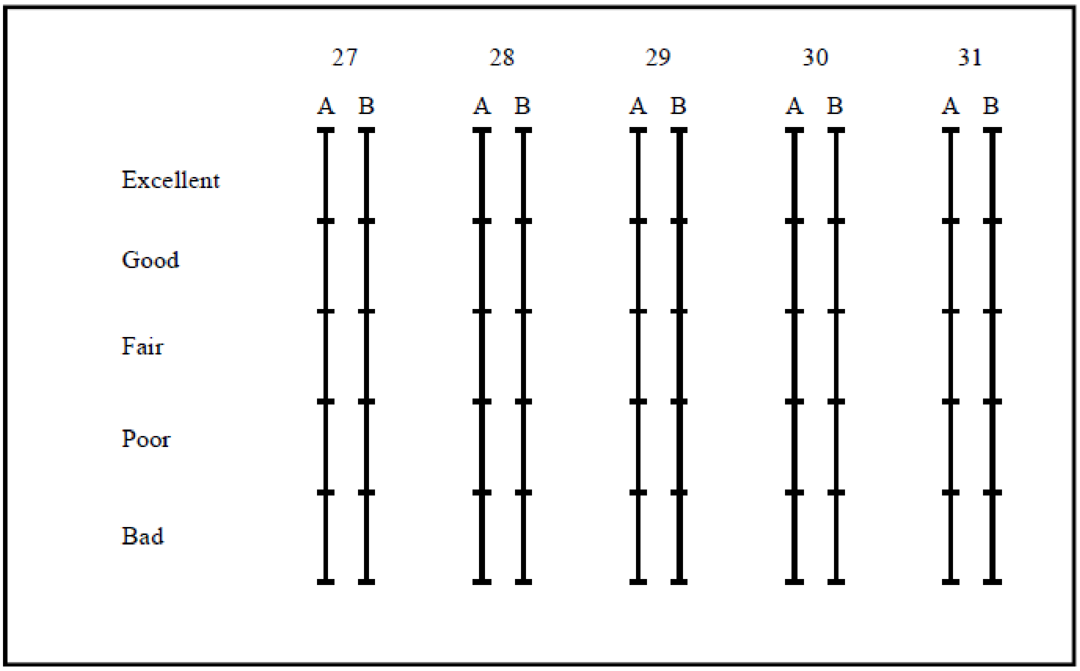


Figure 8: Grading scale for DSCQS

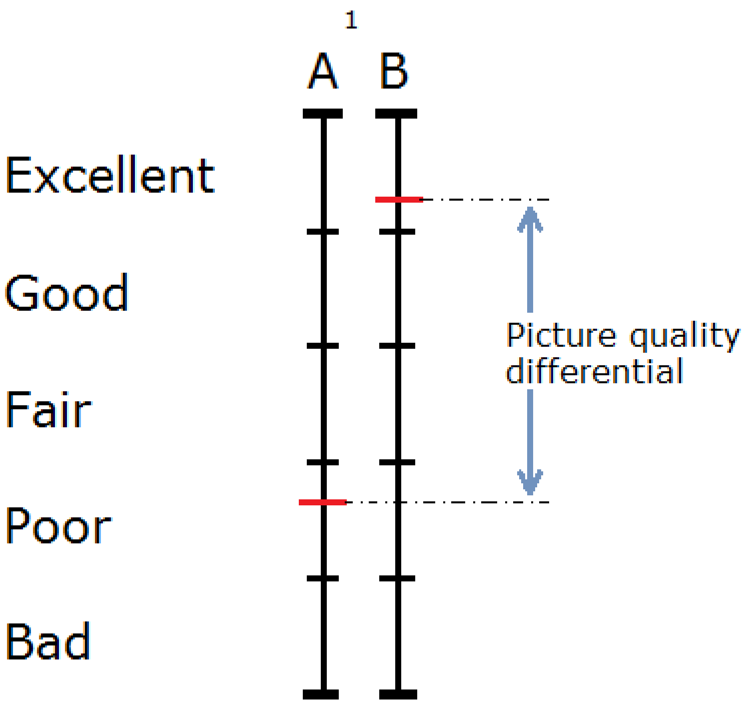


Figure 9: Measuring quality differential between original and distorted image

Testing

Both methods were given scores by 16 people. Before the regular testing each assessor got a test example which does not include the images from regular test. After the practice they did both methods one after the other. They were evaluating images one by one. Because of the total duration of the testing process, methods have been modified. Database contains 50 images in total which would take more than 40min for each method. That is why the assessors were allowed to evaluate the images immediately in the first round. That has reduced the duration of both methods in half. Therefore each method took around 20min and the results were analyzed after the whole process of testing.

Both methods gave effective results. Although there are some small differences between them, correlation of both methods is evident. It is understandable that each assessor has their own opinion which why scores are slightly different. However, it is easy to recognize how some images got worse scores and some better scores from all assessors. Hierarchy of image quality for all assessors was more or less the same. Process of evaluation was successful.

Test 1:

Figure 10: Original image: Port, Distorted images: Port 1, Port 2, Port 3, Port 4

Metric	Port	Port 1	Port 2	Port 3	Port 4
MSE	0	1077,84626	1645,15729	2994,47432	3787,74678
PSNR	undefined	17,8052354	15,9687293	13,3675977	12,3469942
SSIM	1	0,70873721	0,85712263	0,5127758	0,53869546
DSIS	4,8125	3,375	2,625	1,9375	1,375
DSCQS	94, 3125	60,5	44,5	28,5	16,5
DSCQS differential	0	33,8125	49,8125	65,8125	77,8125

Test 2:

Figure 11: Original image: Garden, Distorted images: Garden 1, Garden 2, Garden 3, Garden 4

Metric	Garden	Garden 1	Garden 2	Garden 3	Garden 4
MSE	0	2288,37914	1285,98035	1463,90537	1066,29719
PSNR	undefined	14,5355238	17,0384603	16,4756736	17,852021
SSIM	1	0,35754583	0,79027174	0,58472407	0,7586309
DSIS	4,875	3,75	2,875	3,0625	1,0625
DSCQS	90, 8125	52,8125	62,875	58,75	9,6875
DSCQS differential	0	38	27,9375	32,0625	81,125

Test 3:

Figure 12: Original image: Calblanque, Distorted images: Calblanque 1, Calblanque 2, Calblanque 3, Calblanque 4

Metric	Calblanque	Calblanque 1	Calblanque 2	Calblanque 3	Calblanque 4
MSE	0	798,2852954	2648,831649	32,90681109	293,2891496
PSNR	undefined	19,10922231	13,90026004	32,95794563	23,45784365
SSIM	1	0,923096586	0,737225573	0,91549479	0,855369534
DSIS	4,125	2,375	2,125	1,9375	1,5625
DSCQS	81,75	27,0625	42,5625	42,75	24,25
DSCQS differential	0	54,6875	39,1875	39	57,5

Test 4:

Figure 13: Original image: Pyramid, Distorted images: Pyramid 1, Pyramid 2, Pyramid 3

Metric	Pyramid	Pyramid 1	Pyramid 2	Pyramid 3
MSE	0	259,8284117	4420,118976	9332,138942
PSNR	undefined	23,98393722	11,67646402	8,430991647
SSIM	1	0,861763465	0,485577568	0,399086575
DSIS	4,5625	4	2,6875	1,4375
DSCQS	93,625	82,0625	52,0625	19,6875
DSCQS differential	0	11,5625	41,5625	73,9375

Test 5:

Figure 14: Original image: FER, Distorted images: FER 1, FER 2, FER 3

Metric	FER	FER 1	FER 2	FER 3
MSE	0	1161,818994	1906,566073	2397,933771
PSNR	undefined	17,47941888	15,328285	14,33243177
SSIM	1	0,815282621	0,75028418	0,89732336
DSIS	5	3,75	2,9375	3,5625
DSCQS	96,3125	60,8125	54,5	80,5625
DSCQS differential	0	35,5	41,8125	15,75

Test 6:

Figure 15: Original image: Burn, Distorted images: Burn 1, Burn 2, Burn 3

Metric	Burn	Burn 1	Burn 2	Burn 3
MSE	0	2123,726975	634,527594	6853,310524
PSNR	undefined	14,85981678	20,10629848	9,771799507
SSIM	1	0,581314966	0,709028865	0,426693792
DSIS	4,6875	3,125	3,5	1,3125
DSCQS	90,125	41,3125	64,5	13
DSCQS differential	0	48,8125	25,625	77,125

Test 7:

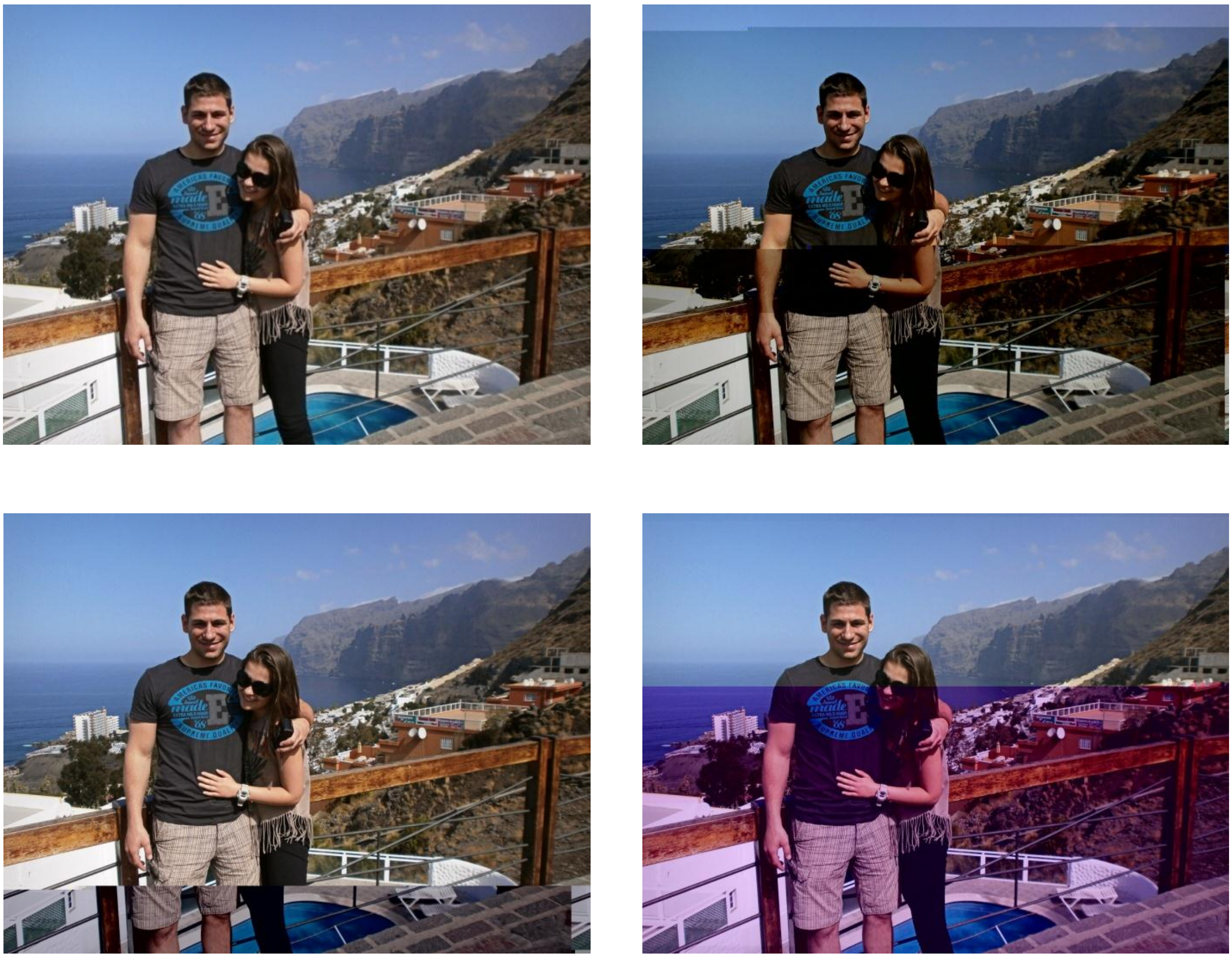
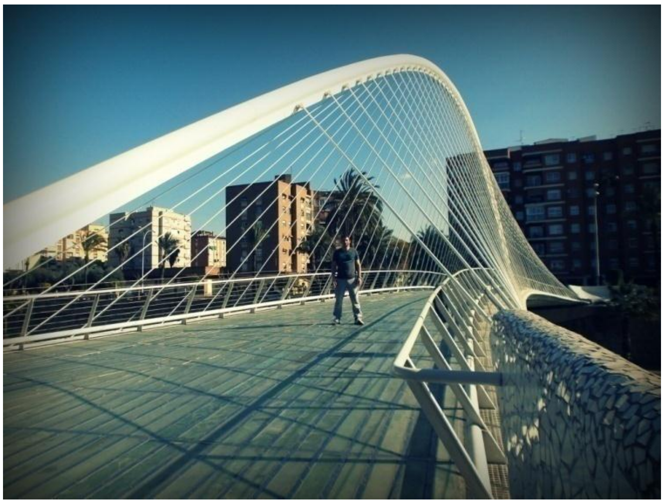


Figure 16: Original image: Los Gigantes, Distorted images: Los Gigantes 1, Los Gigantes 2, Los Gigantes 3

Metric	Los Gigantes	Los Gigantes 1	Los Gigantes 2	Los Gigantes 3
MSE	0	3195,350603	1282,116254	747,6600239
PSNR	undefined	13,08561844	17,05152955	19,39376201
SSIM	1	0,448508953	0,870405542	0,874798885
DSIS	5	3,5	3	2,5625
DSCQS	95,3125	50,8125	51,4375	47,25
DSCQS differential	0	44,5	43,875	48,0625

Test 8:



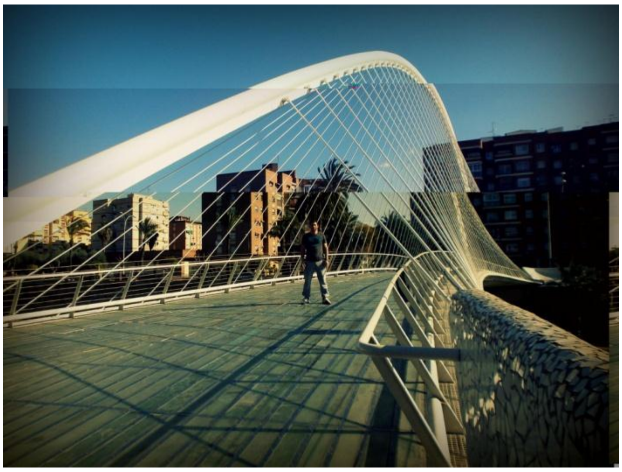


Figure 17: Original image: Bridge, Distorted images: Bridge 1, Bridge 2

Metric	Bridge	Bridge1	Bridge 2
MSE	0	287,349341	2375,373528
PSNR	undefined	23,54670155	14,37348449
SSIM	1	0,893026795	0,448308203
DSIS	4,8	4,6875	3,1875
DSCQS	94, 8125	87,6875	48
DSCQS differential	0	7,125	46,8125

Test 9:

Figure 18: Original image: Palma de Mallorca, Distorted images: Palma de Mallorca 1, Palma de Mallorca 2, Palma de Mallorca 3

Metric	Palma de Mallorca	Palma de Mallorca 1	Palma de Mallorca 2	Palma de Mallorca 3
MSE	0	241,1818713	1963,289038	2828,904081
PSNR	undefined	24,307357	15,20096119	13,61462139
SSIM	1	0,963847071	0,653149918	0,798067318
DSIS	5	3,9375	3,25	1,9375
DSCQS	96,5625	69,5	58,6875	28,6875
DSCQS differential	0	27,0625	37,875	67,875

Test 10:

Figure 19: Original image: Ship, Distorted images: Ship 1, Ship 2, Ship 3

Metric	Ship	Ship 1	Ship 2	Ship 3
MSE	0	49,76161227	3060,533162	2364,17329
PSNR	undefined	31,16185918	13,27283271	14,39401055
SSIM	1	0,927562981	0,40311773	0,682217659
DSIS	5	5	3,8125	1,875
DSCQS	93,8125	93,0625	73,125	27,0625
DSCQS differential	0	0,75	20,6875	66,75

Test 11:

Figure 20: Original image: Valencia, Distorted images: Valencia 1, Valencia 2, Valencia 3

Metric	Valencia	Valencia 1	Valencia 2	Valencia 3
MSE	0	2134,530494	1319,080561	3033,76549
PSNR	undefined	14,83777997	16,9280904	13,31098354
SSIM	1	0,899545894	0,493123483	0,446428323
DSIS	5	3,25	3	1,8125
DSCQS	97,3125	51,6875	52,0625	25,125
DSCQS differential	0	45,625	45,25	72,1875

Test 12:

Figure 21: Original image: Nature, Distorted images: Nature 1, Nature 2, Nature 3

Metric	Nature	Nature 1	Nature 2	Nature 3
MSE	0	1263,324063	1146,837687	1518,27048
PSNR	undefined	17,11565592	17,53578405	16,31731213
SSIM	1	0,5375995	0,527031249	0,521103089
DSIS	5	2,8125	1,8125	1,375
DSCQS	95,8125	41,9375	24,125	15,3125
DSCQS differential	0	53,875	71,6875	80,5

Results

Results: DSIS method

Nb.	Image	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Results
1.	Port	5	5	5	4	4	5	5	5	5	5	5	5	4	5	5	5	**4,8125**
2.	Port 1	4	4	4	3	2	3	4	3	4	4	3	4	3	3	3	3	**3,375**
3.	Port 2	3	3	3	3	1	1	2	3	3	3	3	2	3	3	3	3	**2,625**
4.	Port 3	2	1	2	2	1	1	3	3	3	3	1	3	2	1	1	2	**1,9375**
5.	Port 4	2	1	1	1	1	1	1	3	2	2	1	2	1	1	1	1	**1,375**
6.	Garden	5	4	5	5	5	4	5	5	5	5	5	5	5	5	5	5	**4,875**
7.	Garden 1	4	3	4	4	4	3	4	4	4	4	2	4	4	4	4	4	**3,75**
8.	Garden 2	3	3	3	3	3	1	3	4	3	3	1	3	4	3	3	3	**2,875**
9.	Garden 3	3	4	3	3	3	1	3	4	3	3	2	3	4	3	4	3	**3,0625**
10.	Garden 4	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	**1,0625**
11.	Calblanque	4	3	4	4	5	4	4	4	5	5	4	3	4	5	5	3	**4,125**
12.	Calblanque 1	3	2	1	3	2	2	3	3	4	3	2	1	2	3	2	2	**2,375**
13.	Calblanque 2	3	1	2	3	1	2	3	3	3	2	1	1	2	3	2	2	**2,125**
14.	Calblanque 3	3	1	1	3	1	1	2	3	3	2	1	1	1	3	3	2	**1,9375**
15.	Calblanque 4	2	1	1	2	1	1	2	2	2	2	1	1	2	2	1	2	**1,5625**
16.	Pyramid	4	4	5	5	5	4	4	5	5	5	4	4	4	5	5	5	**4,5625**
17.	Pyramid 1	4	3	4	5	4	4	4	5	5	5	2	3	4	4	4	4	**4**
18.	Pyramid 2	3	2	3	3	2	2	3	4	3	3	2	1	3	3	3	3	**2,6875**
19.	Pyramid 3	2	1	1	2	1	1	2	3	1	1	1	1	1	2	1	2	**1,4375**
20.	FER	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
21.	FER 1	4	3	4	4	3	4	5	4	4	4	3	3	4	4	3	4	**3,75**
22.	FER 2	3	2	3	3	1	3	4	4	4	3	2	3	4	3	2	3	**2,9375**
23.	FER 3	4	4	4	4	3	3	4	3	4	4	4	2	3	4	3	4	**3,5625**

24.	Burn	4	4	5	5	5	5	4	5	5	5	4	5	4	5	5	5	**4,6875**
25.	Burn 1	3	3	3	3	2	3	4	4	4	4	2	2	3	4	3	3	**3,125**
26.	Burn 2	3	3	4	4	2	3	3	4	4	4	3	3	4	4	4	4	**3,5**
27.	Burn 3	1	1	2	2	1	1	2	2	2	1	1	1	1	1	1	1	**1,3125**
28.	Los Gigantes	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
29.	Los Gigantes 1	3	3	4	4	4	3	4	5	3	4	2	3	4	4	3	3	**3,5**
30.	Los Gigantes 2	3	3	3	3	2	4	3	3	3	4	2	2	4	3	3	3	**3**
31.	Los Gigantes 3	3	2	2	3	2	1	3	3	3	3	3	2	3	2	3	3	**2,5625**
32.	Bridge	5	4	4	4	5	5	4	5	5	5	5	5	5	5	5	4	**4,6875**
33.	Bridge 1	5	4	4	5	5	5	4	5	5	5	5	5	5	4	4	5	**4,6875**
34.	Bridge 2	4	3	3	3	2	2	4	4	4	3	3	4	4	3	3	2	**3,1875**
35.	Palma de Mallorca	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
36.	Palma de Mallorca 1	4	4	4	4	3	3	4	4	4	4	4	5	4	4	4	4	**3,9375**
37.	Palma de Mallorca 2	3	3	3	3	2	3	4	4	3	4	2	4	4	4	4	2	**3,25**
38.	Palma de Mallorca 3	1	2	2	2	1	1	3	2	2	3	1	3	2	3	2	1	**1,9375**
39.	Ship	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
40.	Ship 1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
41.	Ship 2	4	2	4	4	5	4	4	4	4	4	3	4	4	4	4	3	**3,8125**
42.	Ship 3	2	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	**1,875**
43.	Valencia	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
44.	Valencia 1	3	4	4	4	3	3	3	3	4	3	3	2	4	4	3	2	**3,25**
45.	Valencia 2	3	3	3	3	2	2	2	3	3	4	2	4	4	4	3	3	**3**
46.	Valencia 3	2	2	2	3	1	1	1	2	2	3	1	2	3	2	1	1	**1,8125**
47.	Nature	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	**5**
48.	Nature 1	3	3	3	2	2	2	3	4	4	4	2	2	3	3	3	2	**2,8125**
49.	Nature 2	2	2	2	2	1	1	2	3	3	2	1	1	2	2	2	1	**1,8125**
50.	Nature 3	1	2	2	2	1	1	1	2	3	1	1	1	1	1	1	1	**1,375**

Results: DSCQS method

Nb.	Image	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Results
1.	Port 3	29	25	26	15	10	8	9	45	65	57	21	29	15	48	21	33	**28,5**
2.	Port 1	56	58	70	37	40	80	55	55	69	70	63	45	60	78	75	57	**60,5**
3.	Port 4	20	17	17	15	2	4	28	35	29	15	16	8	3	39	5	11	**16,5**
4.	Port 2	51	69	65	43	38	30	38	42	46	36	37	19	31	78	60	29	**44,5**
5.	**Port**	84	92	95	94	100	100	85	96	100	95	86	96	89	100	100	97	**94,3125**
6.	Garden 2	68	85	66	44	48	33	71	97	68	78	47	12	60	78	85	66	**62,875**
7.	Garden 3	60	77	69	44	49	50	37	83	60	57	43	28	70	80	81	52	**58,75**
8.	Garden 4	13	20	8	5	2	10	1	17	2	3	10	1	8	30	18	7	**9,6875**
9.	**Garden**	94	88	77	93	99	90	85	93	82	98	82	88	90	100	100	94	**90,8125**
10.	Garden 1	73	37	74	44	69	50	35	56	53	67	44	27	41	77	43	55	**52,8125**
11.	Calblanque 3	45	36	47	24	55	30	43	50	43	45	36	35	49	60	45	41	**42,75**
12.	Calblanque 2	49	32	57	21	65	50	32	37	44	57	35	28	37	70	38	29	**42,5625**
13.	Calblanque 4	26	19	24	10	26	10	15	25	37	33	17	8	44	58	14	22	**24,25**
14.	**Calblanque**	83	70	90	83	99	70	89	92	100	90	64	67	71	83	86	71	**81,75**
15.	Calblanque 1	25	24	17	31	11	9	35	78	40	29	12	26	21	42	10	23	**27,0625**
16.	Pyramid 3	28	30	13	10	20	10	8	18	30	12	17	6	30	45	22	16	**19,6875**
17.	Pyramid 1	83	71	94	94	80	89	75	85	98	88	64	90	68	82	90	86	**83,5625**
18.	Pyramid 2	44	52	56	45	60	50	30	57	57	57	57	26	50	79	58	55	**52,0625**
19.	**Pyramid**	84	95	98	73	100	100	76	93	80	95	84	87	95	99	100	94	**90,8125**
20.	FER 3	81	76	78	66	80	100	96	85	90	96	71	68	73	80	80	77	**81,0625**
21.	FER 2	54	51	50	33	27	77	54	73	58	38	42	79	58	75	55	48	**54,5**
22.	**FER**	98	93	95	95	99	100	100	99	100	85	82	100	91	100	100	97	**95,875**
23.	FER 1	60	78	70	63	61	50	36	82	60	49	51	50	50	82	70	61	**60,8125**
24.	Burn 3	26	15	5	6	1	9	10	4	35	15	17	4	10	31	7	13	**13**
25.	Burn 1	58	46	33	35	20	29	25	68	78	50	32	23	28	38	65	33	**41,3125**

26.	Burn 2	59	58	75	56	61	50	56	82	78	67	60	50	68	78	75	59	**64,5**
27.	**Burn**	80	71	92	95	99	90	86	96	100	100	90	96	84	100	85	78	**90,125**
28.	Los Gigantes 3	40	58	48	42	41	23	43	55	70	45	44	24	37	63	78	45	**47,25**
29.	Los Gigantes 1	37	68	58	35	20	30	53	58	75	68	34	44	49	66	60	58	**50,8125**
30.	**Los Gigantes**	84	97	93	94	100	89	85	98	100	95	100	96	96	99	100	99	**95,3125**
31.	Los Gigantes 2	42	57	63	34	29	60	50	78	84	55	25	28	57	58	50	53	**51,4375**
32.	Bridge 1	84	90	83	77	100	89	69	95	96	100	77	100	84	82	90	87	**87,6875**
33.	**Bridge**	84	97	96	95	100	90	87	95	100	89	85	100	90	99	100	99	**94,125**
34.	Bridge 2	52	54	57	30	25	50	50	75	77	39	30	45	54	45	40	45	**48**
35.	Palma de Mallorca 2	63	58	65	67	68	60	50	67	57	76	39	43	48	57	72	49	**58,6875**
36.	Palma de Mallorca 3	18	14	26	47	10	40	25	16	10	36	16	25	43	38	35	60	**28,6875**
37.	**Palma de Mallorca**	97	94	96	95	100	100	88	96	100	98	93	100	89	100	100	99	**96,5625**
38.	Palma de Mallorca 1	58	58	85	71	80	80	70	77	65	75	52	59	69	78	61	74	**69,5**
39.	Ship 2	76	60	75	63	80	90	69	95	70	65	44	97	63	78	72	73	**73,125**
40.	Ship 1	89	84	97	95	100	100	95	96	79	88	84	93	92	98	100	99	**93,0625**
41.	Ship 3	38	30	17	30	15	30	25	16	38	24	29	23	33	38	20	27	**27,0625**
42.	**Ship**	83	84	98	91	100	89	92	94	90	83	85	83	95	99	100	99	**91,5625**
43.	Valencia 2	43	50	73	38	19	80	58	59	56	67	43	27	50	78	42	50	**52,0625**
44.	Valencia 1	47	67	78	53	30	50	41	42	65	47	57	26	56	72	49	47	**51,6875**
45.	Valencia 3	26	28	33	27	16	13	22	26	38	30	30	11	15	42	17	28	**25,125**
46.	**Valencia**	98	97	95	96	99	100	86	98	100	99	97	98	96	99	100	99	**97,3125**
47.	Nature 2	20	49	12	22	9	20	18	37	18	25	35	6	7	41	40	27	**24,125**
48.	Nature 1	31	64	58	45	30	30	42	35	30	55	42	11	49	69	39	41	**41,9375**
49.	**Nature**	100	91	94	96	99	90	90	98	100	95	97	92	93	99	100	99	**95,8125**
50.	Nature 3	6	29	7	8	1	10	15	18	22	34	16	3	16	36	10	14	**15,3125**

DSCQS difference results

Nb.	Image	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Results
1.	Port 3	55	67	69	79	90	92	76	51	35	38	65	67	74	52	79	64	**65,8125**
2.	Port 1	28	34	25	57	60	20	30	41	31	25	23	51	29	22	25	40	**33,8125**
3.	Port 4	64	75	78	79	98	96	57	61	71	80	70	88	86	61	95	86	**77,8125**
4.	Port 2	33	23	30	51	62	70	47	54	54	59	49	77	58	22	40	68	**49,8125**
5.	**Port**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
6.	Garden 2	26	3	11	49	51	57	14	-4	14	20	35	76	30	22	15	28	**27,9375**
7.	Garden 3	34	11	8	49	50	40	48	10	22	41	39	60	20	20	19	42	**32,0625**
8.	Garden 4	81	68	69	88	97	80	84	76	80	95	72	87	82	70	82	87	**81,125**
9.	**Garden**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
10.	Garden 1	21	51	3	49	30	40	50	37	29	31	38	61	49	23	57	39	**38**
11.	Calblanque 3	38	34	43	59	44	40	46	42	57	45	28	32	22	23	41	30	**39**
12.	Calblanque 2	34	38	33	62	34	20	57	55	56	33	29	39	34	13	48	42	**39,1875**
13.	Calblanque 4	57	51	66	73	73	60	74	67	63	57	47	59	27	25	72	49	**57,5**
14.	**Calblanque**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
15.	Calblanque 1	58	46	73	52	88	61	54	14	60	61	52	41	50	41	76	48	**54,6875**
16.	Pyramid 3	56	65	85	85	80	90	68	75	68	83	67	86	65	54	78	78	**73,9375**
17.	Pyramid 1	1	24	4	14	20	11	1	8	10	7	20	3	27	17	10	8	**11,5625**
18.	Pyramid 2	40	43	42	50	40	50	46	36	41	38	27	66	45	20	42	39	**41,5625**
19.	**Pyramid**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
20.	FER 3	17	17	17	29	19	0	4	14	10	4	11	32	18	20	20	20	**15,75**
21.	FER 2	44	42	45	62	72	23	46	26	42	54	40	21	33	25	45	49	**41,8125**
22.	**FER**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
23.	FER 1	38	15	25	32	38	50	64	17	40	43	31	50	41	18	30	36	**35,5**
24.	Burn 3	54	56	87	89	98	81	76	92	65	85	73	92	74	69	78	65	**77,125**
25.	Burn 1	22	25	59	60	79	61	61	28	22	50	58	73	56	62	20	45	**48,8125**

26.	Burn 2	21	13	17	39	38	40	30	14	22	33	30	46	16	22	10	19	**25,625**
27.	**Burn**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
28.	Los Gigantes 3	44	39	45	52	59	66	42	43	30	50	56	72	59	36	22	54	**48,0625**
29.	Los Gigantes 1	47	29	35	59	80	59	32	40	25	27	66	52	47	33	40	41	**44,5**
30.	**Los Gigantes**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
31.	Los Gigantes 2	42	40	30	60	71	29	35	20	16	40	75	68	39	41	50	46	**43,875**
32.	Bridge 1	0	7	13	18	0	1	18	0	4	0	8	0	6	17	10	12	**7,125**
33.	**Bridge**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
34.	Bridge 2	32	43	39	65	75	40	37	20	23	61	55	55	36	54	60	54	**46,8125**
35.	Palma de Mallorca 2	34	36	31	28	32	40	38	29	43	22	54	57	41	43	28	50	**37,875**
36.	Palma de Mallorca 3	79	80	70	48	90	60	63	80	90	62	77	75	46	62	65	39	**67,875**
37.	**Palma de Mallorca**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
38.	Palma de Mallorca 1	39	36	11	24	20	20	18	19	35	23	41	41	20	22	39	25	**27,0625**
39.	Ship 2	13	24	23	28	20	7	23	0	20	25	41	0	32	21	28	26	**20,6875**
40.	Ship 1	0	0	1	-4	0	-3	-3	-1	11	2	1	4	3	1	0	0	**0,75**
41.	Ship 3	51	54	81	61	85	67	67	79	52	66	56	74	62	61	80	72	**66,75**
42.	**Ship**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
43.	Valencia 2	55	47	22	58	80	20	28	39	44	32	54	71	46	21	58	49	**45,25**
44.	Valencia 1	51	30	17	43	69	50	45	56	35	52	40	72	40	27	51	52	**45,625**
45.	Valencia 3	72	69	62	69	83	87	64	72	62	69	67	87	81	57	83	71	**72,1875**
46.	**Valencia**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
47.	Nature 2	80	42	82	74	90	70	72	61	82	70	62	86	86	58	60	72	**71,6875**
48.	Nature 1	69	27	36	51	69	60	48	63	70	40	55	81	44	30	61	58	**53,875**
49.	**Nature**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
50.	Nature 3	94	62	87	88	98	80	75	80	78	61	81	89	77	63	90	85	**80,5**

Objective methods

There have been used several objective methods to evaluate the same images from database. For all methods it was used the same software ‘Image comparator’. It works on the principle of comparison two images which are present in it. Then, software gives the results of different methods. Each objective method has a specific form of the result.

- ***Mean Squared Error (MSE)*** measures the average ‘error’ of the squares in the image. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. In image evaluation it measures difference in pixel values between the original and impaired image.

- ***Peak Signal to Noise Ratio (PSNR)*** puts in a ratio the maximum possible power of a signal and the power of corrupting noise that disturbs the signal. PSNR is usually expressed in logarithm decibel scale. The most commonly PSNR is used in image compression. The signal represents original data while the noise is error introduced by compression. This metric is valid only when is used to compare results from the same codec. Otherwise, some results measured with human eye may appear better, even though they have lower PSNR. Image fidelity is an indication about the similarity between the reference and distorted images and measures pixel-by-pixel. The PSNR is the most commonly used fidelity metric. MSE and PSNR measure similarity between two images and they are Reduce Reference (RR) methods. These metrics don’t recognize different distortion types and also can not recognize if only the part of image is distorted.

- ***SSIM*** is a method for measuring similarity between two images. It is a full-reference metric, based on measuring structural distortions in images by comparing luminance, contrast, and structures of objects in a scene. The final outcome of the comparison, the SSIM index, quantifies the structural similarity between the reference and the distorted image. SSIM index have values between -1 and 1, if two images are identical then the value would be 1.

Comparison with objective methods

As it has already been stated, correlation of both subjective methods is evident. Results are similar and we can consider that the whole process of subjective evaluation was very successful. On the other side, all results of the objective methods have a different view of presentation. Even then it is quite possible to notice that some results match together. Therefore there is a correlation between the results of objective methods as well. For example, there is a similarity between MSE and PSNR objective methods. They both compare images pixel-by-pixel. They are sensitive on *luminance masking* which is represented like the change in brightness or variation of colors in the image. SSIM method is bit different because it is trying to find similarities between the objects and structures of two images which are compared. SSIM method does not care if the luminance on some image is slightly different in comparison with the original image. It is more important that the objects are recognizable and have the same shape as on the original image. Therefore the SSIM scores for this kind of distortion are more or less good and more similar with subjective scores than MSE and PSNR methods.

Subjective methods take more time to perform and cost more as well. Results of subjective methods are irreplaceable because there is no mathematical model who can predict them. The results of each method are specific and important. That is why it is important to perform both methods to assess image quality on the most professional level.

Conclusion

There is no referent score of image which makes you able to evaluate the success or effectiveness of objective or subjective method. The results of each method are very important and it is not possible to say which is more correct or wrong. Sometimes it seems like the whole image is distorted because the computer program can not find the similarities with the original image, but subjective method shows how real observer perceive different. Results of both methods may vary but they both play important rule in overall assessment of image quality. If it is necessary to evaluate the data or binary information, it’s logical how objective method can give the most accurate result.

For high quality distribution of TV signal it is important to adjust all the components of radio-communication channel to eliminate all distortions. Success of this performance is measured with methods for evaluation of image/video quality. Therefore objective and subjective methods for quality assessment are equally necessary.

Summary

In this project was created a simulation of a radio-communication channel in Simulink (Matlab). It is a graphical tool that allows modeling, simulation and analysis of dynamic systems. The radio-communication channel includes: JPEG coder and decoder, BPSK modulator and demodulator, AWGN channel and some additional boxes to adjust the flow of data. Group of images have been sent through the channel and while changing the parameters of each box the image distortion changes. There were used two subjective methods for image evaluation: DSIS and DSCQS. The methods correlate well. Correlation with the objective methods depended on each method and a type of image distortion. Subjective and objective methods are both equally important for evaluation of image quality.

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