Visual Saliency-Based Confidentiality Metric for Selective Crypto-Compressed JPEG Images

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INTRODUCTION

- For security reasons, more and more images are transferred or stored in encrypted domains by using selective format-compliant JPEG encryption methods.
- It is necessary to evaluate the confidentiality of the selective crypto-compressed JPEG images.
- Quality metrics, such as PSNR or SSIM, give a very **low** correlation with a mean opinion score (MOS) for low quality images.
- We propose an efficient confidentiality metric based on the visual saliency diffusion.
- We show experimentally that this metric is well correlated with a MOS and efficient to evaluate the **confidentiality** of selective crypto-compressed JPEG images.

SELECTIVE CRYPTO-COMPRESSION

- Crypto-compression targets JPEG images.
- We have several parameters to select:
  - Crypto-compression algorithm : FIBS or SJCC
  - Encryption of DC and/or AC
  - Encryption of Luminance and/or Chrominance

➡ 27 relevant combinations

- **FIBS**: full inter-block shuffle [1]. This method scrambles DC coefficients as well as same frequency AC coefficients.
- **SJCC**: a selective JPEG crypto-compression method [2]. This method encrypts the amplitude part of non null AC coefficients of each block and changes the DCT coefficients histogram.

200 images from the BSDS500 dataset as input images for a total of 5400 crypto-compressed images ***www.lirmm.fr/~wpuech/dataset***

EVALUATION OF THE CRYPTO-COMPRESSED JPEG IMAGES

- MOS: arithmetic mean of ratings given by humans for a particular stimulus.

➡ a single number, from 1 to 5, used to describe the quality of the current stimulus, where 5 is the best score and 1 is the worst.

- Evaluation on 41 different people, male and female from 17 to 53 years old:
- **1: The distortion is unbearable, nothing is visible**
- **2: The distortion is very annoying, I can barely make-out the content**
- **3: The distortion is annoying, but I can see the content**
- **4: The distortion is slightly annoying, but the content is clear**
- **5: The distortion is not annoying at all**

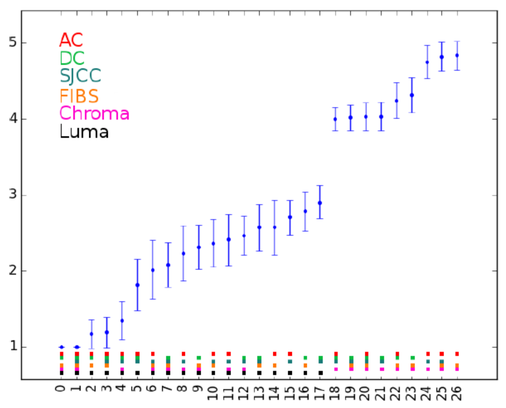
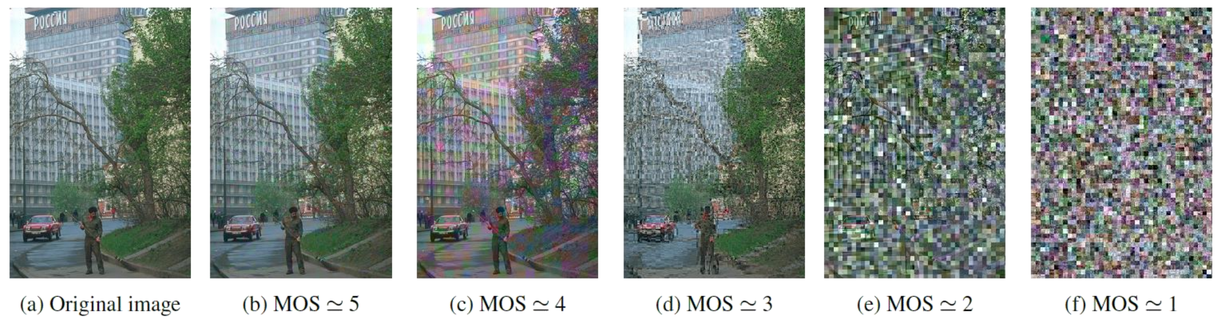


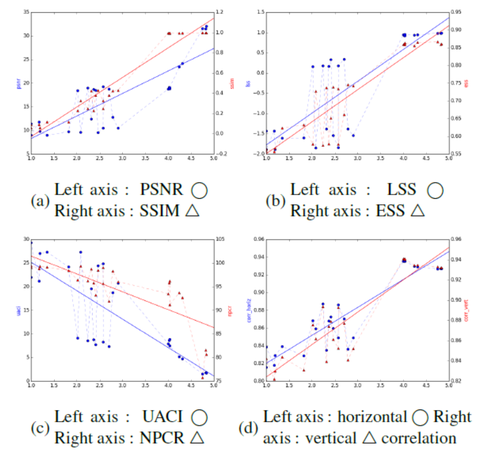
Fig. 2: MOS for the 27 distortions.



(a) Original image (b) MOS ≃ 5 (c) MOS ≃ 4 (d) MOS ≃ 3 (e) MOS ≃ 2 (f) MOS ≃ 1

Fig. 1: An example of images using different selective crypto-compression methods with their corresponding MOS.

- PSNR: PSNR does not interact well with human judgment, The range is [0; +∞[, where identical images have a PSNR of + ∞.
- SSIM: (Structural Similarity Index Measure). A luminance, a contrast and a structure score are combined. The range is [0;1] where identical images have a score of 1.
- ESS [3]: (Edge Similarity Score). It uses non overlapping 8x8 block directions. With the range [0;1], a higher score reflects a less distorted image.
- LSS [3]: (Luminance Similarity Score). It uses non overlapping 8x8 block average luminance. With the range [-8.5; 1] for default parameters of = 0:1 and = 3, a higher score reflects a less distorted image.
- NPCR: the number of pixel changes between images. Its range is [0;100], where a fully encrypted image has a NPCR close to 100, where almost all the pixels have been changed.
- UACI: the unified averaged changed intensity. It is the average intensity difference between two images. Its range is [0;100], where a fully encrypted image has a value close to 33.



(a) Left axis : PSNR ◯ Right axis : SSIM △ (b) Left axis : LSS ◯ Right axis : ESS △ (c) Left axis : UACI ◯ Right axis : NPCR △ (d) Left axis : horizontal ◯ Right axis : vertical △ correlation

Fig. 3: Plots of different metrics with the MOS on the x-axis, a: PSNR and SSIM, b: LSS and ESS, c: UACI and NPCR, d: horizontal and vertical correlation.

VISUAL SALIENCY-BASED CONFIDENTIALITY METRIC

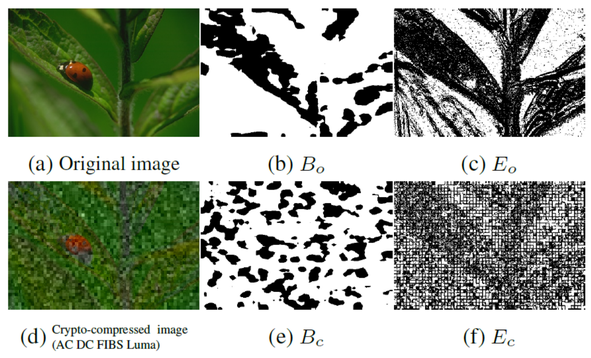
- Our proposed metric:
- Important information is located in salient areas: if no salient areas can be found, then the content is hidden.
- Let *Mo* be the saliency map of the original image and *Mc* be the saliency map of the crypto-compressed image.
- Two binary images are thus created, *Bo* from *Mo* (Fig. 4b) and *Bc* from *Mc* (Fig. 4e). The score based on the visual saliency is then:

$$v_{saliency} = \frac{\sum_{i=0}^{width}\sum_{j=0}^{height} B_o(i,j) \times B_c(i,j)}{\sum_{i=0}^{width}\sum_{j=0}^{height} B_o(i,j)}$$

- The results however are not as good for mid quality images, when the MOS is around 2 and 3.
- We introduce a second score, v_{edges}, based on the Sobel operator in an attempt to stabilize our first score $v_{saliency}$ (Fig. 4c and Fig. 4f).
- The final score is (with α = 0.6):

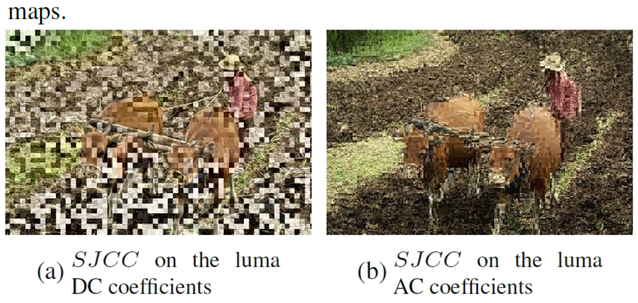
$$v = \alpha * v_{saliency} + (1-\alpha) * v_{edges}$$

- The euclidean distance of our metric to the MOS of all the distortions is 0:4323 for our metric and 0:5095 for SSIM and the euclidean distance of our metric to individual image rating is 0:6674 and 0:6699 for SSIM



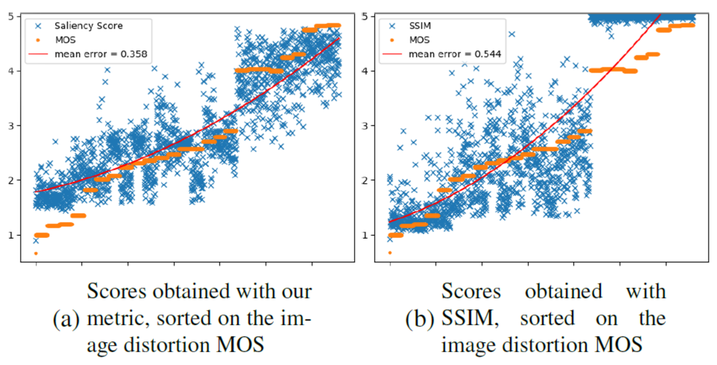
(a) Original image (b) B_o (c) E_o (d) Crypto-compressed image (AC DC FIBS Luma) (e) B_c (f) E_c

Fig. 4: Maps obtained for an original image a), a crypto-compressed image d), b) and e) saliency maps, c) and f) edge maps.



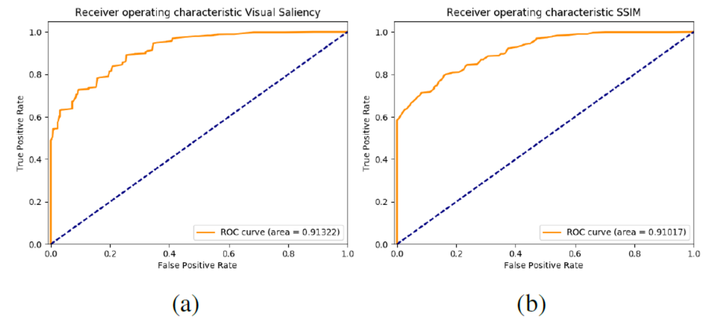
(a) $SJCC$ on the luma DC coefficients (b) $SJCC$ on the luma AC coefficients

Fig. 5: Global noise caused by a $SJCC$ on DCT coefficients.



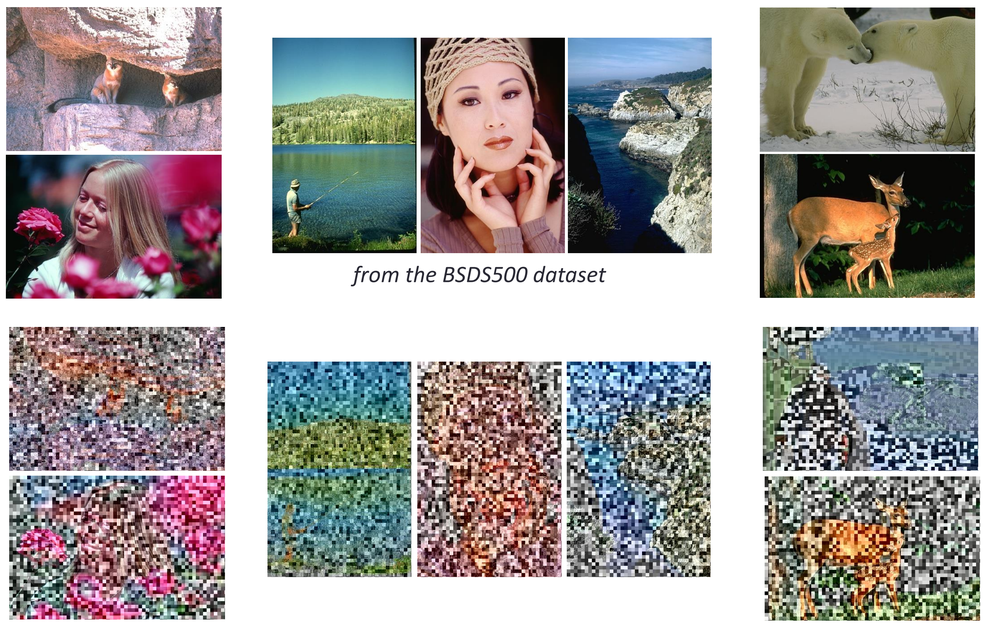
(a) Scores obtained with our metric, sorted on the image distortion MOS (b) Scores obtained with SSIM, sorted on the image distortion MOS

Fig. 6: Comparison of results for our metric and SSIM.



(a) (b)

Fig. 7: ROC curves of: a) Our metric, b) SSIM.



from the BSDS500 dataset

CONCLUSION

- We proposed a dataset composed of selective crypto-compressed images for image quality assessment.
- The images were rated by human observers to obtain a mean opinion score.
- We introduced a new confidentiality metric based on visual saliency.
- We evaluated our metric and noticed that we obtained better results compared to quality metrics such as SSIM.
- Future work:
  - A more in depth analysis of our dataset and each of its 27 distortions,
  - A more refined metric based on visual saliency, which shows great potential.

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