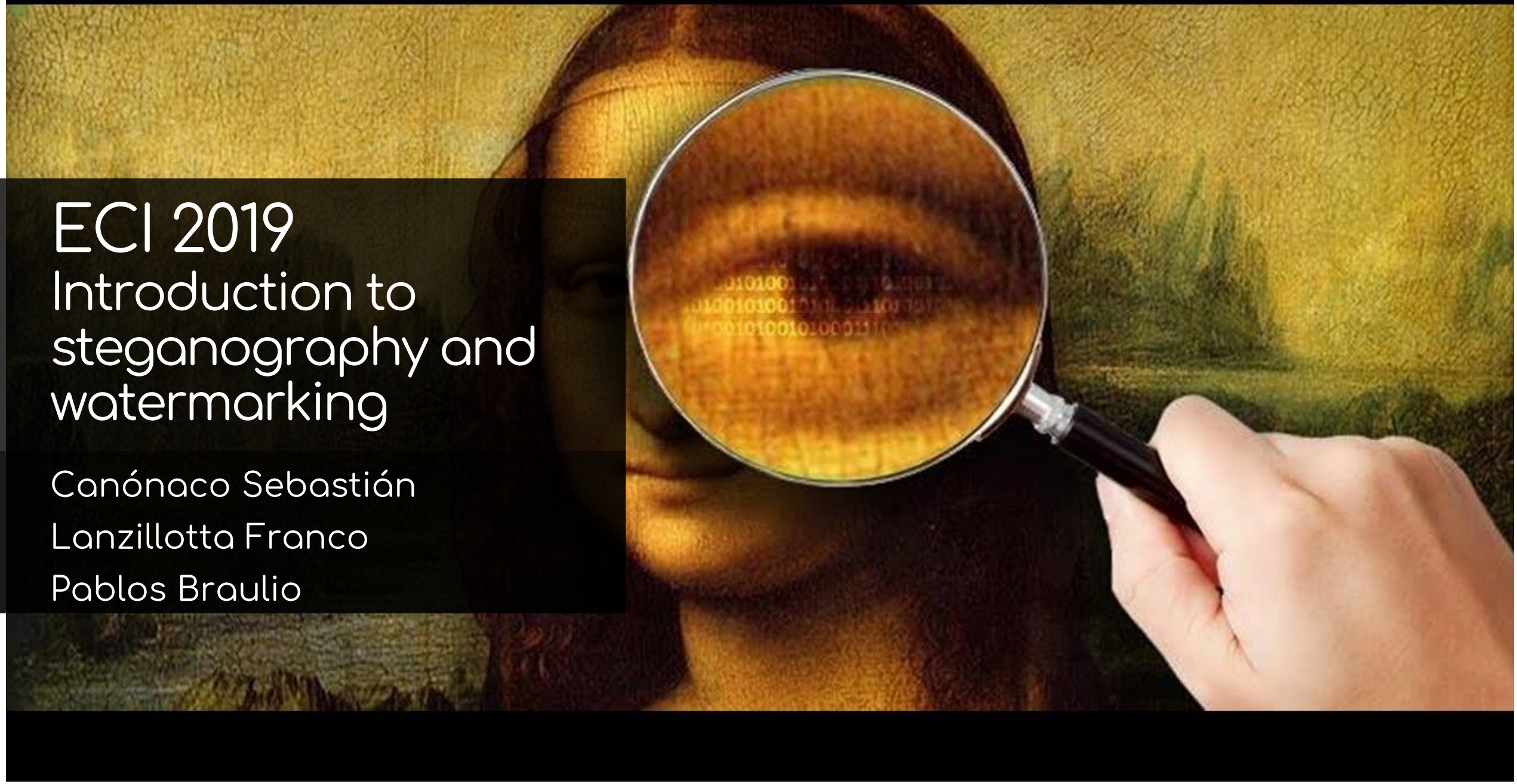

ECI 2019
Introduction to steganography and watermarking

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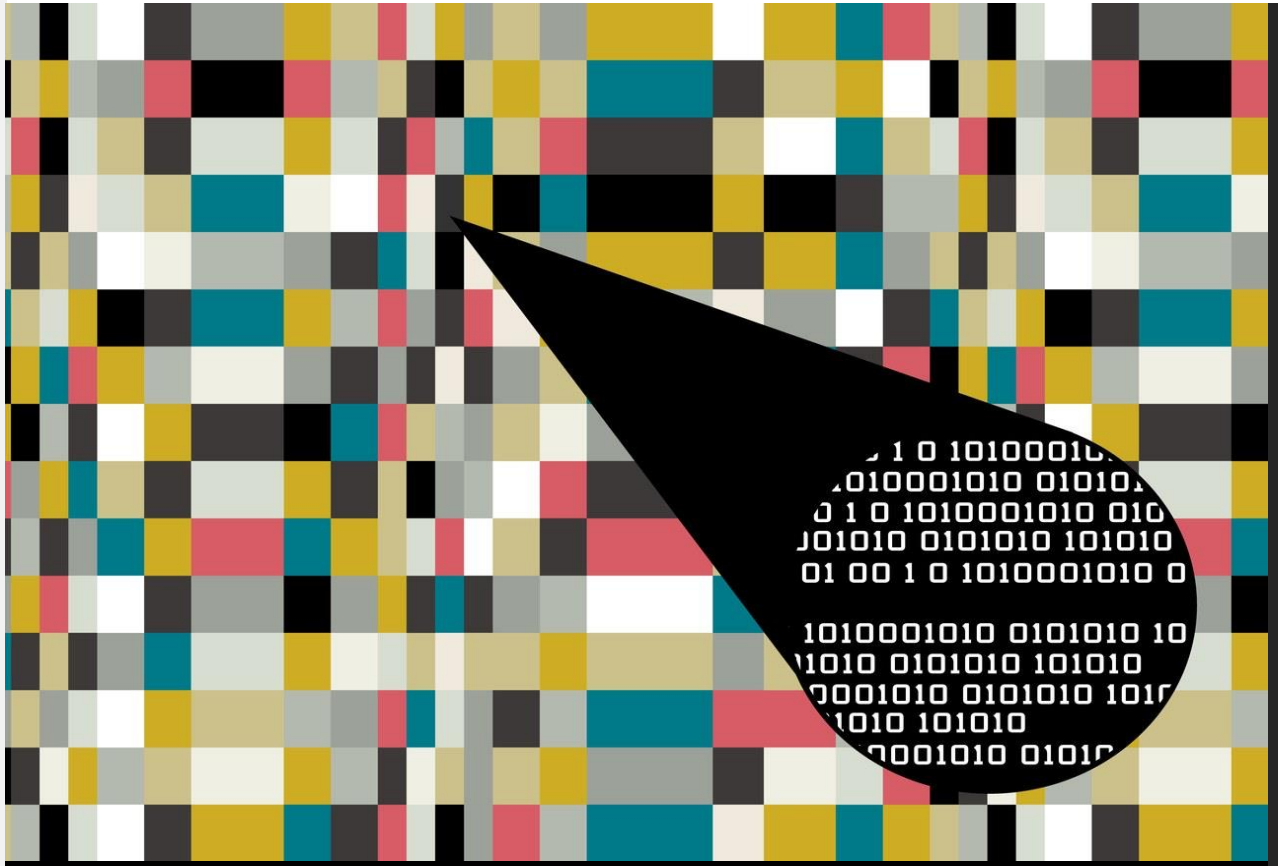


Steganography

Steganography is the study and application of techniques that allow to hide messages within other objects, establishing a cover channel that prevents the very act of communication from being noticed by external observers.

Where to apply stegranography?

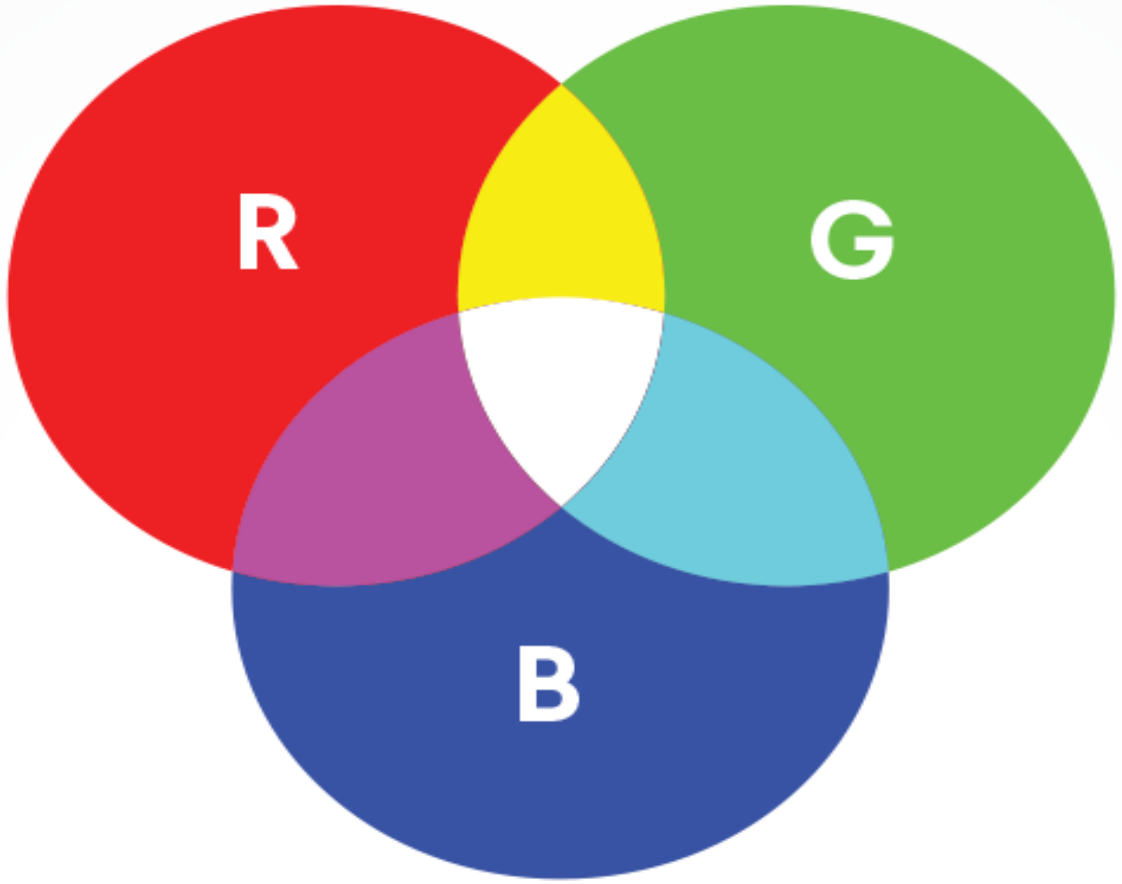
Audio

Images

Video

Other files

Images are commonly used as cover objects due to the relatively high amount of data they contain



BMP images
RGB format

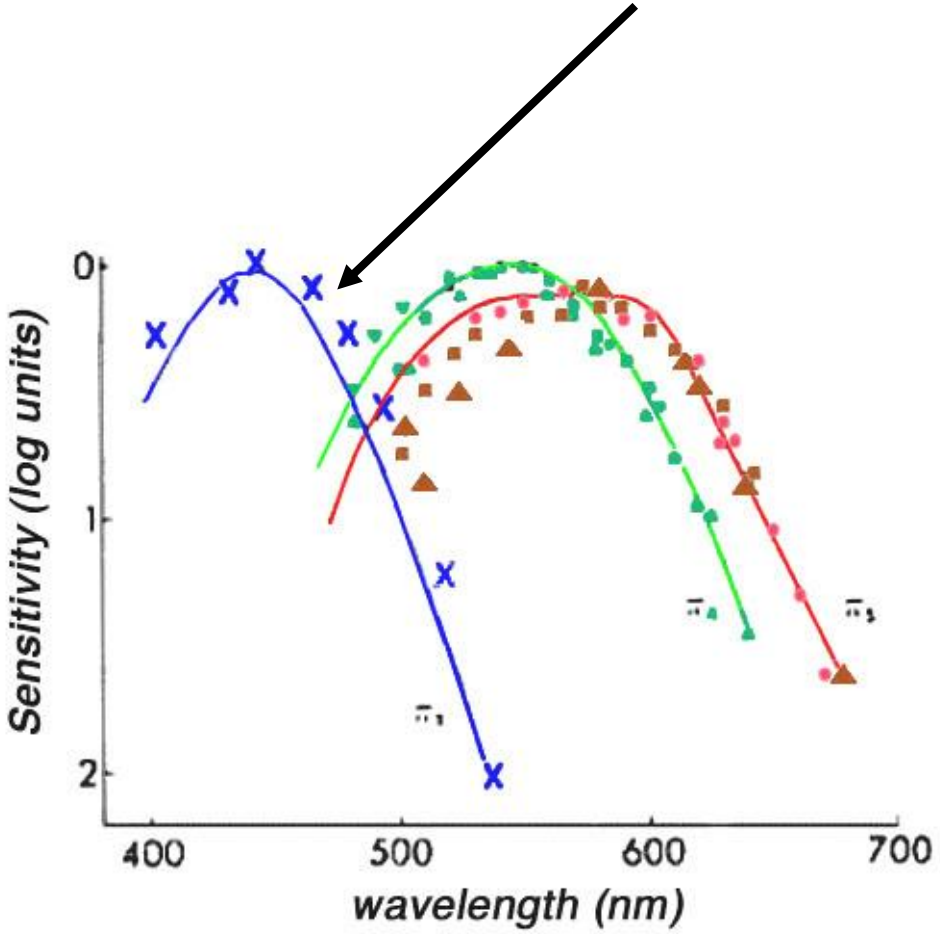
The image format chosen is BMP file format, which stores digital images as a bitmap.

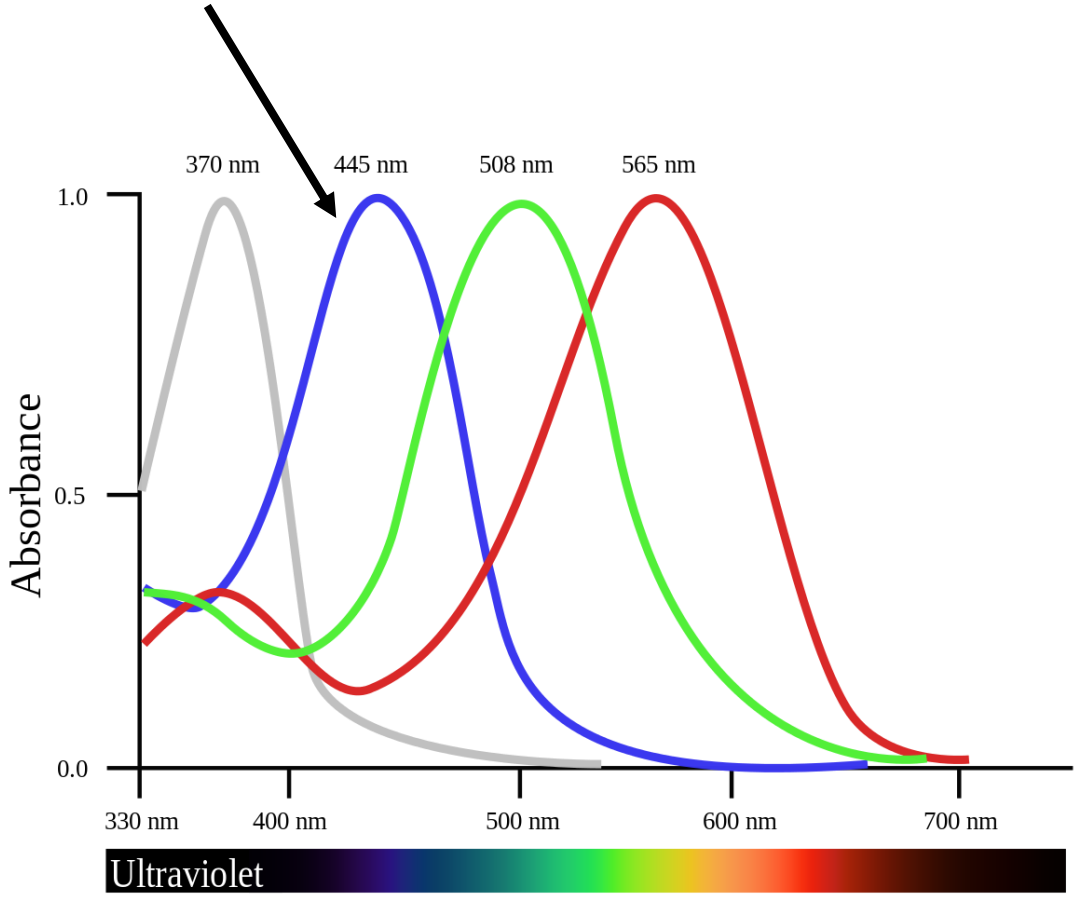
Each pixel is represented by a fixed number of bits (may it be 1, 2, 4, 8, 16, 24, 32 or more).

This array of bits is most commonly arranged in RGB format, establishing the beginning bits for red, the middle ones for green and the last ones for blue value.

Visual perception

The blue color is the least noticeable by the human eye





Development

The idea is to change the least significant bits of the blue color so that the information is less detectable

Least significant bit

10111001

Algorithm

The algorithm is pretty simple: the bits of the character are taken in chunks of k bits, which are then stored in the k least significant bits of some consecutive pixels.

If the last chunk is of a size less than k then only the needed less significant bits of the next pixel will be used.

Before inserting the next character, there is the possibility of a pseudo-random padding being introduced.

First, for adding a padding at all the binary exclusive or (xor) operation between the amount of pixels left available for padding (its total is calculated at the beginning of the hiding algorithm) and the last pixel used for steganography must result in a 1 in the least significant bit. If this condition is fulfilled, then the jump is calculated as follows:

$$jump = ((padding\_left \text{ xor } prev\_pixel) \% (char\ size * k) + 1) \% (padding\ left + 1)$$

% representing the calculation of the remainder of a division between integer numbers and the char size equalling 8, as ASCII is used as the encoding.

Algorithm

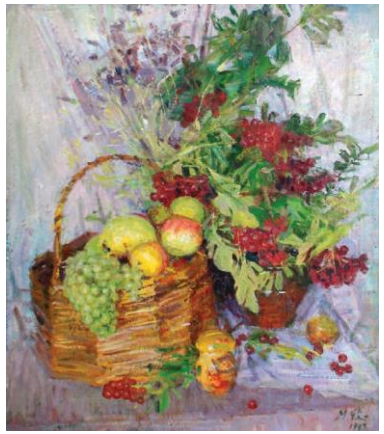
The procedure for recovering the hidden message is straightforward: after extracting k and the text size from within the first pixels of the image the reverse algorithm for inserting a character must be applied. Also, the calculation of the padding jumps is executed in the very same manner. This results in that the recipient of the message only needs to know this algorithm for recovering it, as the original image has no more porpurse after the text has been hidden.

Procediment

Open nature

Portrait

Procediment



Still life

Text

A varied career

Chloe Kelling, a successful model and singer-songwriter, now has a new venture

I arrive for my interview with Chloe Kelling and I'm asked to wait in the garden. I hardly have time to start looking round at the carefully tended flowerbeds when Chloe appears. Every bit as tall and striking as I'd expected, Chloe emerges from the house wearing an oversized man's jacket, a delicately patterned top and jeans. Chloe is known for her slightly quirky sense of fashion and, of course, she looks great as she makes her way towards me through the flowerbeds.

'Let's talk in my office,' she says, leading the way not back to the house, but instead to an ancient caravan parked up next to it. As we climb inside the compact little van, the smell of fresh baking greets us. A tiny table is piled high with cupcakes, each iced in a different colour. Chloe's been busy, and there's a real sense of playing tea parties in a secret den! But what else should I have expected from a woman with such a varied and interesting career?

Chloe originally trained as a make-up artist, having left her home in the country at nineteen to try and make her name as a model in London, and soon got work in adverts and the fashion business. 'I went to Japan to work for a short period, but felt very homesick at first,' she recalls. 'It was very demanding work and, though I met loads of nice people, it was too much to take in at nineteen. If I'd stayed longer, I might have settled in better.'

Alongside the modelling, Chloe was also beginning to make contacts in the music business. 'I'd been the typical kid, singing with a hairbrush in front of the mirror, dreaming of being a star one day,' she laughs. She joined a girl band which 'broke up before we got anywhere', before becoming the lead singer with the band Whoosh, which features on a best-selling clubbing album. Unusually though, Chloe also sings with two other bands, one based in Sweden and another in London, and each of these has a distinct style.

It was her work with Whoosh that originally led to Chloe's link with Sweden. She was offered a song-writing job there with a team that was responsible for songs for some major stars, but gradually became more involved in writing music for her own band.

Although she now divides her time between London and Sweden, her first stay there turned out to be much longer than she'd bargained for. 'The rooms are very tall over there and so people have these rather high beds that you climb up to,' she explains. 'I fell as I climbed up the ladder and cracked three ribs. Although the people at the hospital were very kind, I was stuck there for a while, which was very frustrating. Sneezing and laughing were so painful at first, let alone singing!' It was while recovering from her injuries that Chloe hit upon the idea of staging what she calls vintage fairs.

'It was snowing in Sweden and I wanted something nice to look forward to.' Chloe had always loved vintage clothes, particularly from the 1950s, and decided to stage an event for others who shared her passion for these. Finally back in England, she began turning her plans into reality.

The first fair was held in her home village and featured stalls selling all sorts of clothes and crafts dating back to the 1950s. It was a huge hit, with 300 people turning up. 'When I had the idea of the first fair, it was only meant to be a one-off, but we had so many compliments, I decided to go ahead with more,' says Chloe. 'There's something for all ages and people find old things have more character than stuff you buy in modern shops. It also fits perfectly with the idea of recycling.' Looking round Chloe's caravan, I can see what she means.

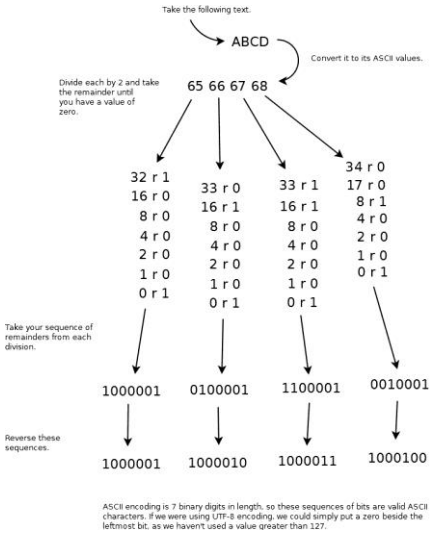


Table 5: Regression Results

	Dependent variable:	
	Overall Rating	
	(1)	(2)
Handling of Complaints	0.692*** (0.447, 0.937)	0.682*** (0.470, 0.894)
No Special Privileges	−0.104 (−0.325, 0.118)	−0.103 (−0.316, 0.109)
Opportunity to Learn	0.249 (−0.013, 0.512)	0.238* (0.009, 0.467)
Performance-Based Raises	−0.033 (−0.366, 0.299)	
Too Critical	0.015 (−0.227, 0.258)	
Advancement	11.011 (−8.240, 30.262)	11.258 (−0.779, 23.296)
Observations	30	30
R^2	0.715	0.715
Adjusted R^2	0.656	0.682
Note:		*p<0.1; **p<0.05; ***p<0.01

Results

Each picture was used to hide messages, varying the k parameter and the length of the text to hide.

For each time, it was calculated three values that represent the effectiveness of the algorithm hiding the given text. These are: the mean squared error (MSE), the peak signal-to-noise ratio (PSNR) and the structural similarity (SSIM).

$$\mathrm{MSE} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left(X(i,j)-X'(i,j)\right)^2$$

where m and n denote the size of the image, X(i,j) is the value of a pixel in the original image and X'(i,j) is its value in the stego image

$$\mathrm{PSNR} = 10\log\frac{\mathrm{MAX}_i^2}{\mathrm{MSE}}$$

where MAXi is the maximum among the pixels

$$\mathrm{SSIM} = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)}$$

where μ, σ , and σ_{xy}(represent mean, variance and covariance; C_1, C_2 constant

Results

Table 1: *Open nature images worst values*

#	MSE	PSNR	SSIM
1	13329	103.25	0.999994
2	3147	109.51	0.999999
3	3640	157.05	0.999998

Table 2: *Portrait images worst values*

#	MSE	PSNR	SSIM
1	92615	94.79	0.999957
2	9794	104.58	0.999995
3	5541	107.06	0.999997

Table 3: *Still life images worst values*

#	MSE	PSNR	SSIM
1	6180	106.59	0.999997
2	5353	107.21	0.999998
3	23310	100.14	0.999989

Table 3: *Text images worst values*

#	MSE	PSNR	SSIM
1	3541	109.00	0.999998
2	3	139.72	0.999999
3	14638	102.84	0.999993

Conclusions

- Every message hidden correctly in an image was properly recovered.
- The pseudo-random padding generates localized jumps, the spaces between adulterated pixels are relatively small. This results in the text been hidden in the lower border of the screen, as the pixels are actually counted starting from the bottom left corner of the picture.
- The values of SSIM obtained were really good. This could be caused due to the small length of the text hidden in comparison to the size of the images used
- A possible modification to be made in the future is to increment the amount of bits used to store the length of the text from 8 to 16 (2 bytes or characters), which would allow messages of up to 65536 characters.


Thanks
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