Image hiding based on angular time-averaging moiré Proceedings

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Image hiding based on optical time-averaging moiré technique is presented in this paper. It is a new visual decoding scheme when the secret image is embedded into a circular moiré grating and can be interpreted by a naked eye only when the image is harmonically oscillated in an angular direction around a predefined axial point. The encoded secret image is not shared into components; this a one image method. The secret image is visualized at a strictly defined amplitude of angular oscillations. Computational examples are used to demonstrate the functionality of the method.

In our encoding procedure we use time-averaging geometric moiré optical technique [1]. Time-average geometric moiré is an optical experimental method when the moiré grating is formed on the surface of an oscillating structure and time averaging techniques are used for the registration of time averaged patterns of fringes. Moiré grating in the constructed image is formed as a set of concentric circles around internal image point (x_0, y_0). It is not necessary that the center of moiré grating would be a central point in the encoded image. Each concentric circle is created as a set of grayscale pixel's formed according to $M(\varphi) = \frac{1}{2}\left(1 + \cos\left(\frac{2\pi}{\lambda}\varphi\right)\right)$, where φ is the angular coordinate, λ is the pitch of the angular grating.

Now we are ready to construct digital time averaged images. We calculate integral sum instead of calculating indefinite integral. Thus, time averaged one-dimensional image becomes (the amplitude a is constant in the area of the whole image):

$$M_T(x, y) = \lim_{n\to\infty} \frac{1}{n} \sum_{k=0}^{n-1} \frac{1}{2} \left(1 + \cos\left(\frac{2\pi}{\lambda}\left(\varphi_0 + a \sin\left(\frac{2\pi k}{n}\right)\right)\right)\right) \quad (1)$$

where a is the amplitude of angular oscillations, φ_0 is the angular coordinate of the point (x_0, y_0) in respect to the axial point of angular oscillations.

In practice that means that we calculate averages of many frames turned about strictly predefined internal point where every frame represents the original static image deflected from the state of equilibrium by a certain magnitude defined by (eq. (1)).

There are no 2 or n shares to superpose in our method [2] , we use only one image. We oscillate that image in order to produce time-averaged moiré fringes. Numerical construction of a time-averaged image when the original image performs unidirectional oscillations about strictly predefined internal point can be interpreted as a calculation of the integral sum when the number of nodes in the time axis tends to infinity (eq. (1)).

We select such discrete amplitudes of angular oscillation that moiré pattern would be transformed into gray fringes in the time-averaged image and use a stochastic phase deflection algorithm [3] to encrypt the digital image.

The functionality of the method is illustrated in the following figures. Secret text “1234” is encoded into a circular moiré pattern in figure 1. The embedded text “1234” is visible as a pattern of gray fringes (at appropriate amplitude a) but the moiré grating in the background is not transformed into gray zone in a time averaged image in figure 2, but incorrect amplitude of oscillations does not reveal the hidden information figure 4. Though the secret text can be observed by a naked eye in figure 2 we enhance the contrast [4] for better interpretability in figure 3.

The encoded secret image is not shared into components; this is a one image method. The secret image is embedded into the background circular moiré

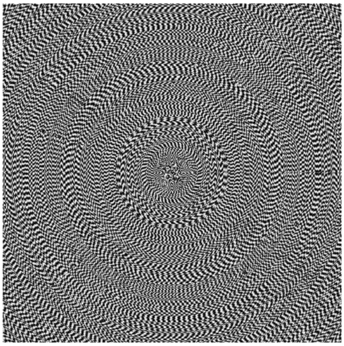

Figure 1: Stochastic phase deflection adapted for encryption of the secret text “1234”

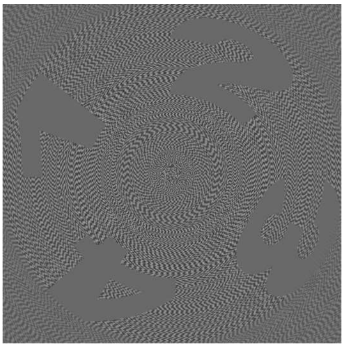

Figure 2: Computational decryption of the encrypted text at the amplitude of oscillations $a = 0.0383$

grating. Stochastic initial phase deflection of circular moiré gratings help to construct an encoded digital image which cannot be interpreted by a naked eye.

The decoding is performed by vibrating the encoded image in an angular direction around predefined axial point. The decoding process exploits the property of the human visual system to average fast dynamical processes being not able to follow rapid oscillatory motions.

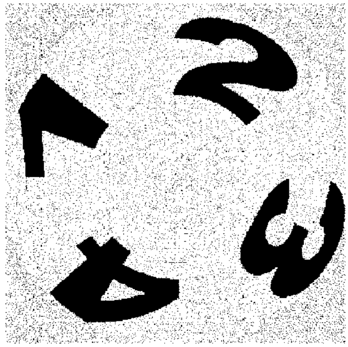

Figure 3: Computational decryption of the encrypted text at the amplitude of angular oscillations $a = 0.0383$ with applied contrast enhancement procedure

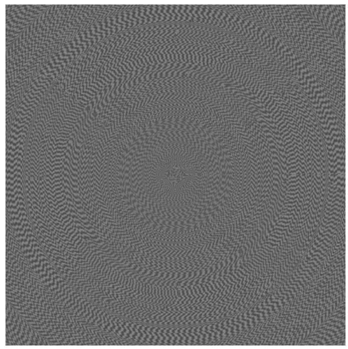

Figure 4: Decryption is not possible when the amplitude is incorrect

References

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