

комплектації, реалізація за допомогою технології OpenCL більш ніж у десять разів пришвидшує обчислення таких задач.

1. Jaworski N., Farmaga I., Lobur M., Spiewak P. – *Research of composite materials optimal design task based on numerical simulation // Proc. of the 8th International Scientific and Technical Conference “Computer Sciences and Information Technologies” (CSIT’2013).* – P. 46–48, Lviv, 2013.
2. Нарусберг В., Тетерс Г. *Устойчивость и оптимизация оболочек из композитов.* – Рига: Зинатне, 1988.
3. Hashin Z. *The elastic moduli of heteroheneous materials // Journal of Applied Mechanics*, 29(1): 143-150, 1962.
4. Christinsen R. *Mechanics of composite materials // New-York: Wiley*, 1979.
5. Dunn M., Ledbetter H. *Elastic moduli of composites reinforced by multiphase particles // Journal of Applied Mechanics*, 62(4):1023–1028, 1995.
6. Odegard G., Clancy T., Gates T. *Modeling of the mechanical properties of nanoparticle/polymer composites // Polymer*, 46(2):553–562, 2005.
7. Дульнев Г., Заричняк Ю. *Теплопроводность смесей и композиционных материалов: справочная книга.* – Ленинград: Энергия, 1974.
8. Reiter T., Dvorak G., Tvergaard V. *Micromechanical Models for Graded Composite Materials // Journal of the Mechanics and Physics of Solids*, 45(8):1281–1302, 1997.
9. Ostoja-Starzewski M. *Random Field Models of Heterogeneous Materials // International Journal of Solids and Structures*, 35(19): 2429–2455, 1998.
10. Torquato S. *Random Heterogeneous Materials. Microstructure and Macroscopic Properties // New-York: Springer*, 2002.
11. Rahman S. *A random field model for generating synthetic microstructures of functionally graded materials // International Journal for Numerical Methods in Engineering*, 76(1):972–993, 2008.
12. Rahman S. *Multi-scale fracture of random heterogeneous materials // Ships and Offshore Structures*, 4(3):261–274, 2009.
13. Munshi A., Gaster B., Mattson T., Fung J., Ginsburg D. *OpenCL Programming Guide.* – New-York: Addison-Wesley, 2011.

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METHOD OF FORMING LATENT IMAGE TO PROTECT DOCUMENTS BASED ON THE EFFECT MOIRE

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Analysis of modern methods of information protection based on printed documents. It is shown that methods of protection from moiré effect provide reliable and effective protection by gaining new protection technology that is displayed in the optical acceleration motion layers and causes moire in fraud. Latent images can securely protect paper documents. Introduce a system of equations to calculate curvilinear patterns, where the optical formula of acceleration and periods moire stored in its simplest form. There is a need to create new types of protection of printed documents as the means and methods of fraud are becoming more common.

Key words: method of protection, securities, security printing.

Accession

With the development of computer technology forgery of documents is common. Manufacturing documents are easier to falsification consequence of that is becoming more development. In this regard, there is need for protection of electronic and paper documents in new ways. Computer industry and modern copiers developing rapidly. Modern computer systems and networks face different attacks, so now becoming urgent question of security of electronic documents. Given the variety of potential threats to information protection of electronic documents should be as high. To be effective protection it must meet

the criteria of reliability and efficiency. Effective protection should be simple in creation, but challenging and financially profitable during the fraud and visually noticeable when a copy of the document in elektrovanomu or printed form. In this work, a new type of document security based moire effects that satisfies the criteria of efficiency and reliability. The new method is based on an optical effect which causes moire.

Protection of printed and electronic documents appears as a strategic problem of state and international level. Data protection occupies an important place in the information security of the state, because there is a transfer of electronic and print media in the Internet space, mobile devices and the printed media. The subject involved and a number of leading research scientists and companies that want to provide protection as the information security of the state and each user separately. In this area many working as domestic and foreign researchers.

Problem

The analysis found that there are effective ways to protect and print documents that are based on the moire phenomem and satisfy the criteria of reliability and efficiency in defense. However, to increase the level of protection necessary to develop a new method that would take into account the technical characteristics of modern copying machines and did play falsified documents uneconomical. Designed protection does not require expensive equipment and special materials. The main objective of this work is to create a method of protection from hidden elements which are based will put moire effect. This model should provide high level safety information in printed or electronic form, thus providing for minimizing fraud.

The main content

Moire - interference pattern created when you apply two mesh periodic drawings. The phenomenon is caused by the fact that elements of two objects that are repeated with varying frequency and overlap hidden form elements. Moiré effect is an optical phenomenon that occurs during the overlapping lines, grids, points, etc. It consists of a new visible object, which is clearly observed in some sites, although it is not included in any of the original structure [1].

The method of protection is to set up thin parallel lines of 0,25 mm width and repetition frequencies that are multiples of an integer frequency reproducing device and frequency different from copying / scanning at least 0,25mm moire interval value that can not be visually recognized without the use of special optical devices. Document with protective elements contains at least one protective image, which consists of many visible and separately published items which, in turn, are protective object formed from curves and fragments. The presence of moire elements distorts the appearance of the document leads to significant changes in forms or complete loss of picture elements on the copy that allows visually easy to distinguish a fake copy of the original. If the line frequency exceeds 0.7-0.8 mm, corresponding to a frequency of visual perception threshold, then the fragment visually perceived gray shades. Modern scanner and copy machines are characterized by relatively high reading frequencies or output image. Yes, most models of full color copiers has a resolution of 400 dpi. Current models of full color laser printers have a resolution of 600 dpi. The image resolution scanners is higher than 1200 dpi. Because the documents must have safety devices with limited upper spatial frequency, whose value is always less than the base frequency imaging or scanning devices. All models are copiers are divided into two types. For the first type of such frequencies - 100 dpi, 200 dpi, 400 dps, and for the second type - 150 dpi, 300 dpi, 600 dpi. Use at least two protection grids, where the frequency of a multiple of the first grid, and the frequency of the second - the second sequence achieves protection against copying on different types of copy or scanner technology. The basic idea of the protection method is that the protective elements form the displacement of lines moire half step value line. Moiré effect is a visual phenomenon resulting from inaccurate overlay two samples that contain a combination of transparent and opaque elements. Moire translated means flicker and created as a result of interference between two uniform structures. Mathematical representation moire effect is trivial and can be arbitrarily described.

Period moire lines is the distance from a point where the two layers of overlapping lines (at the bottom of the figure) for the next such point (top). Because $p_r < p_b$ for the same number of lines on which shifting base layer lines. Midway p_m distance base layer line. Identifying lines layer on half period ($p_r/2$) demonstration of line layer through which the line imposed form moire effect. At a distance p_m , base layer front line superimposed on a layer of bed lines full time p_r , so that lines intersecting layers again. Lines baseline p_m get the distance of the many lines (p_m/p_b), as the number of lines of demonstration (p_m/p_r) for the same distance. That is a basic layer we get a few objects that intersect in its axis, and parallel lines imposed certain that copy, on these sections provides moire lines, which can be determined by the formula:

$$p_m = \frac{p_b \cdot p_r}{p_b - p_r} \quad (1)$$

Mix of two layers containing parallel lines creates a visual effect and contains parallel lines with longer period. According to equation (1.1), the closer periods of two layers, the greater the rate of increase in moire, through the imposition of parallel lines in certain areas. If the number of objects p_m/p_b and p_m/p_r is relatively flat and core layer filled with the same number of objects in the zone lines both layers that overlap as shown in Figure 1. Layer lines will also great overlap in the centers of each other, depending on the quantity and options listed facilities. If p_m/p_b and p_m/p_r do not comply and are not the same in the base layer, the centers in areas of moire intersection of parallel lines, not necessarily coincide with the centers layered lines that give effect moire. In any case, the equation (1.1) shows the effect muaroutvorenniya a greater or lesser degree of reflection. The thickness of the lines in a layer affects the overall picture display protective image and Moire thickness of lines, but the period p_m does not depend on the thickness of lines. In the example, the base layer thickness lines $p_b/2$ equal to the thickness of lines in any newly created layer $p_r/2$, that all objects have the same line width in all layers. Consider the construction of two parallel and equally spaced vertical lines. Building two samples with vertical lines. Let the first building sample carry increments p (fig.1), and the second increments $p+\delta p$, where it choose δ within $0 < \delta < 1$. If the two samples lines impose alone on the left side of the figure, the shift between lines increases due to more repeat step (Figure 1). After a number of repetitions, vertical lines of the first pattern is opposite the second sample lines that are between the lines of the first sample. If we consider the design of overlapping samples from some distance, then there is complete filling areas where lines are superimposed (a gap between the white lines), and dark areas are where the line in the opposite direction. If two uniform structure, plastic impose on each angle, the moire is observed as a uniform grating with a certain step repeat (fig. 1). The middle of the first dark zone offset equal $p/2$. On the n second line pattern moves on np .

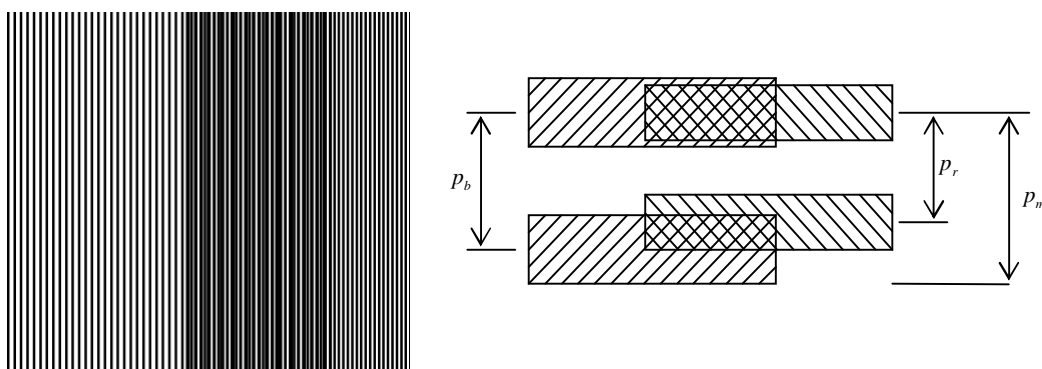


Fig. 1. Moire phenomenon at imposing uniform parallel lines

Moire phenomenon is created when the distance between lines of the first pattern p_b , and the distance between the lines of the second specimen p_m at imposing their relationship with distance equivalent to plus 1

$$\frac{p_m}{p_b} = \frac{p_m}{p_b} + 1 \quad (2)$$

A method of forming a latent image for defense documents using the moiré effect

Hide Picture Method for protection documents with the Moire effect is creating a grid of parallel lines with a given ratio of the width and the distance between successive lines. Describe the steps creating document security. Initially create the first layer of straight parallel lines, width l_0 and interval d_0 between them, with so determining factor r_0 , satisfying ratio $r_0 = l_0/d_0$.

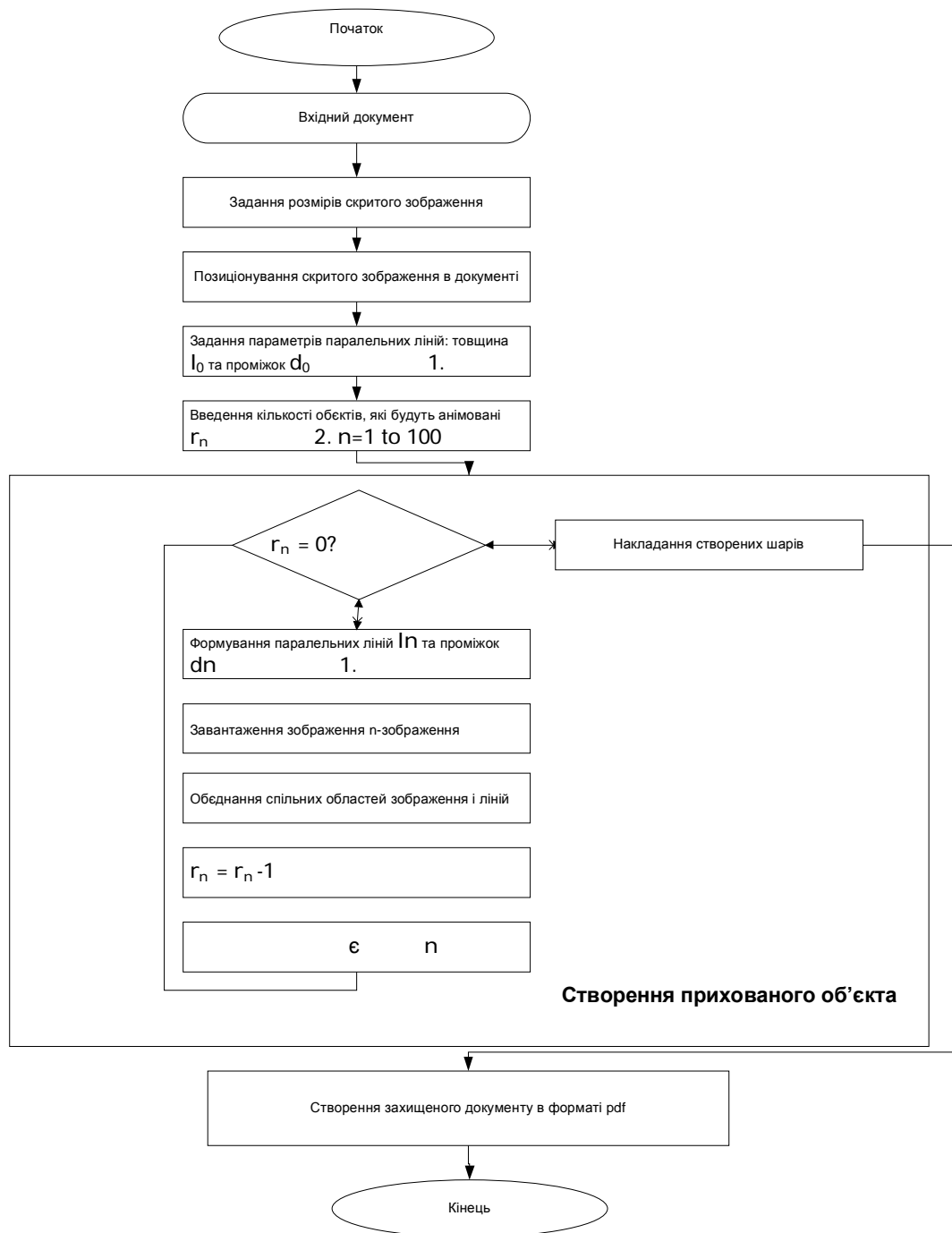


Fig. 2. A method of forming a latent image to protect documents using the moiré effect

Then change the distance between the two lines so that the interval between two consecutive lines d_{n+1} is equal to $d_n = d_0 + d_1 + \dots + d_n$ where by the parameter is a linear modulation period, where n - number of downloaded objects. Value line width and distance from one line to the next equal to a constant value r_0 , change line width l_n so that $l_n = l_0 + l_1 + \dots + l_n$, to value l_n/d_n is always r_0 . Then create the next layer of the loaded object and the pre-positioning images by selecting options in the document. The next step is to create layers where changing the width of the lines so that the ratio of the width l_n line and gap d_n between it and the next line would be one constant ratio $l_n/d_n = r_0$. Region all layers combined in value $r_n = r_0 + r_1 + \dots + r_n$.

Obviously, parameters such as l_0 , and i^λ may vary depending on the specifications. Content is visually distances between the lines and line widths gives a image, however, can not avoid moire effect when playing even when you change copier performance within range of values.

Distance modulated by the following formula $d_n = d_0 + i^\lambda (1 + \sin(2^\lambda h/N))$. In this case, N is the period of play lines. Thus, we get the facility where the distance between two successive lines varies not linear and sinusoidal. $l_n = l_0 + i^\lambda (1 + \sin(2^\lambda n/N))$ - the next phase modification is to change the form of lines in compliance with widths that formed lines in the form of waves or sinusoids that can be converted into concentric closed curves, following the line width. Form convert straight lines to closed curves is not limited and depends on the desired result. Thus formed screamo image. The more objects the harder play screamo image on copying technology. The algorithm method shown in Fig. 2.

In figure 3 and 4 show how the implemented protection protective element hidden in the image. Retrieved base layer, which is shown in Figure 4, which consists of parallel lines, and the main object of which is shown in Figure 3. main facility includes four superimposed layers are built using parallel lines shifted a certain period of the base layer. So get the object of several layers that intersect and overlap in certain proomizhkah object, there by moire get at these intersections, if there is forgery and screamo image will be clear from moire.

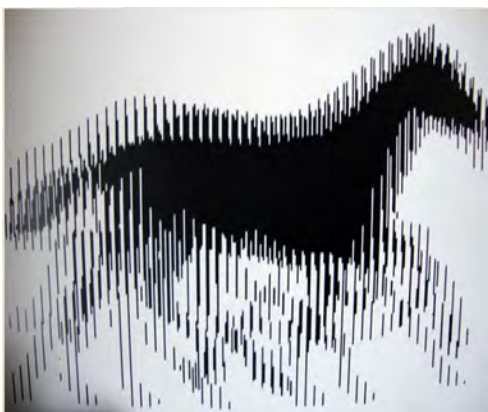


Fig. 3. Shows an example of moire image that "moves" in the overlay layer

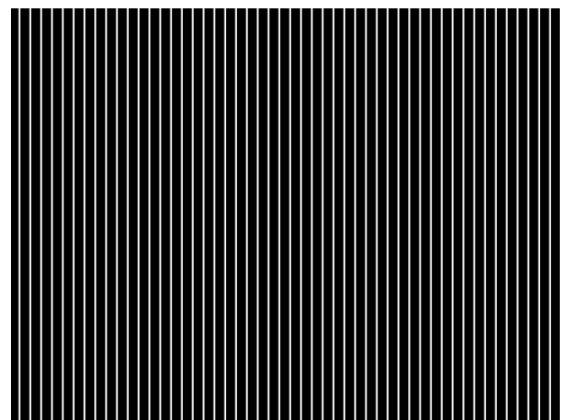


Fig. 4. Shows an example of performance base layer with the image on the surface of the periodic structure in the form of opaque and transparent parallel alternating bands

Method of forming Hide Picture for protection of documents with the effect Using Moire straight lines

Important and difficult for fraud is a method for creating moiré under certain corner forming lines, since copying is not possible to completely remove moire from raster structures. So in this way we will not choose well-known analog angles and deformed, such as 43° , 57° , 99° , and others. To create a hidden element inability to play without knowing the parameters of deformation lines at a certain angle.

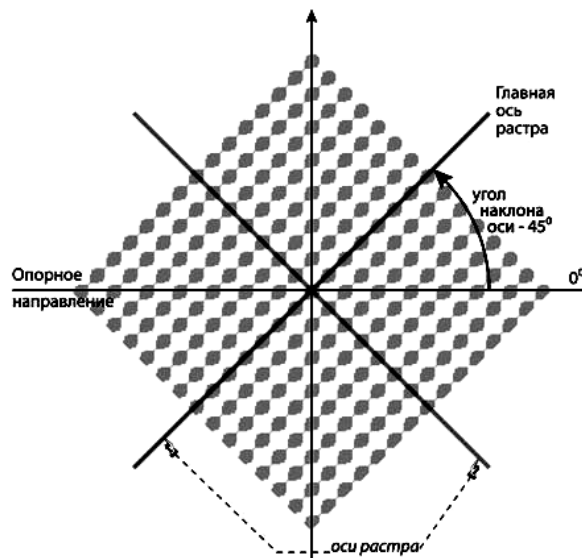


Fig. 5. The angle forming lines

Consider a few known variants forming elements from different angles, and how this affects of moire.

Moire occurs when imposing periodic raster structures, which results in another periodic structure. The formed structure has a period that is different from the periods of its constituent bodies, and, unfortunately, not downward.

In fact moire will be present on the printed copy image is always more or less degree visibility. It can be both distinct and almost imperceptible depending on the number of screening parameters and characteristics reproduced image.

For visual perception of great importance to the frequency or period moire structure. If its frequency is about 20-40 lines per centimeter or more, the probability of distinction when printing small. If the frequency moire low - less than 10 lines per centimeter, the printing will be clearly visible moire.

Moire occurs when the combination of periodic structures with equal spatial frequencies while turning lines at an angle. The fact that the rotation leads to a relative increase in its spatial frequency in the direction of the main axis of the other. The value of increasing the frequency of projection of the second layer will be the main axis of the spatial frequency, which produce a moire. At small angles of rotation raster screen frequency interference patterns - moire - as important and well-marked copy.

In the first case, the initial starting point is on the vertical axis and raster angle determined by the angle between the main axis and the axis of ordinates raster in the clockwise direction.

Essentially rotation angles to select a coordinate system is not essential. What matters is the only value or the difference between the angles of raster structures obtained as a result.

For different types of raster different intervals and permissible values of angles of rotation.

An example would be the angle of rotation are in the range from 0° to 180° , and regulated angle only for the main axis. If no main axis (screens with round and square dot) - from 0° to 90° , line raster - from 0° to 180° .

The greater the angle between two objects, the higher frequency is formed moire. Naturally, the best option in terms of minimizing moire is turn on 45° , but placement options with angles that differ by 45° , practically reduced by two working angles - $0-90^\circ$ and 45° .

Rotate 30° too visually unobtrusive and technologically acceptable for printing, and placement options for longer - three, for example $0-90$, $30-120$, $60-150^\circ$. The difference in angles of rotation 15° Printed in some circumstances lead to the formation of a noticeable moire well as use angles that differ by 15° , is essential.

Theoretically moire must fully displayed when the angle is much smaller and the smaller the angle the sharper moire is at falsification of documents.

Another option is to turn lines at an angle, for example, 45° creating, as a result, the contour image creating the effect of relief by breaking straight lines. We can change the width of lines depending on the density of gray geometric original image. If the equidistance line to change the angle, it can be seen as a moire grids that will change the slope. Here are pictures of the angles in 5° , 15° , 45° .

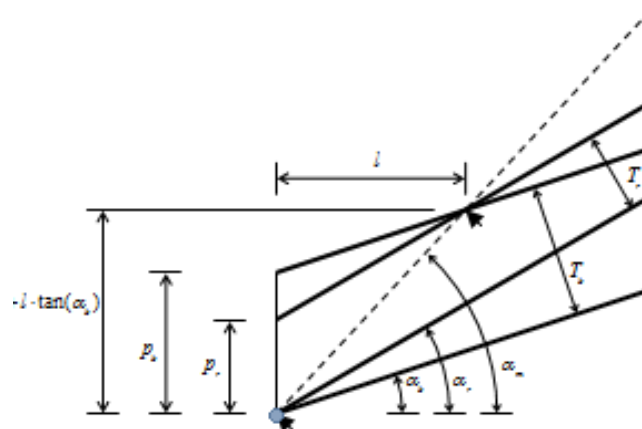


Fig. 6. Calculate the angle of inclination moire lines depending on the angles of the base layer, and detection of line

Figure 6 we obtain the following two equations [12]:

$$\begin{cases} \tan \alpha_m = \frac{p_b + l \cdot \tan \alpha_b}{l} \\ \tan \alpha_r = \frac{p_b - p_r + l \cdot \tan \alpha_b}{l} \end{cases} \quad (3)$$

From these equations we obtain the equation for calculating the tilt moire lines depending on the inclinations of the base layer and identify the lines of:

$$\tan \alpha_m = \frac{p_b \cdot \tan \alpha_r - p_r \cdot \tan \alpha_b}{p_b - p_r} \quad (4)$$

For the base layer attached to tilt 30 degrees, with the period of the base layer. Curve fig. 7 is the degree of inclination line moire detection layer depending on the slope of the line. Two other curves correspond to cases where the base layer inclination is 20 degrees and 40 degrees respectively.

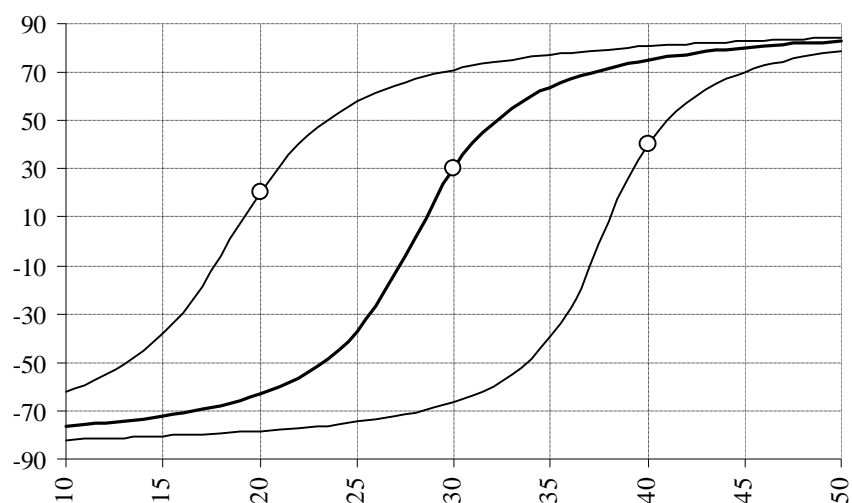


Fig. 7. Moire line of inclination for the basic lines of declination is 30 degrees

Used periods T_b , T_r , and T_m can be calculated by the following formulas (see. fig. 6):

$$\begin{aligned} T_b &= p_b \cdot \cos \alpha_b, \\ T_r &= p_r \cdot \cos \alpha_r, \\ T_m &= p_m \cdot \cos \alpha_m \end{aligned} \quad (5)$$

Using equation (4) formula to derive a certain angle moire lines:

$$\alpha_m = \arctan\left(\frac{T_b \cdot \sin \alpha_r - T_r \cdot \sin \alpha_b}{T_b \cdot \cos \alpha_r - T_r \cdot \cos \alpha_b}\right) \quad (6)$$

Using trigonometry derive the following formula:

$$\begin{aligned} \cos \alpha &= \frac{1}{\sqrt{1 + \tan^2 \alpha}} \\ \cos(\alpha_1 - \alpha_2) &= \cos \alpha_1 \cdot \cos \alpha_2 + \sin \alpha_1 \cdot \sin \alpha_2 \end{aligned} \quad (7)$$

From equations (6) and (7) we have:

$$\cos \alpha_m = \frac{T_b \cdot \cos \alpha_r - T_r \cdot \cos \alpha_b}{\sqrt{T_b^2 + T_r^2 - 2 \cdot T_b \cdot T_r \cdot \cos(\alpha_r - \alpha_b)}} \quad (8)$$

From equations (2) and (5) we get:

$$T_m = \frac{T_b \cdot T_r}{T_b \cdot \cos \alpha_r - T_r \cdot \cos \alpha_b} \cdot \cos \alpha_m \quad (9)$$

From equations (8) and (9) we derive a formula for the second period known Moire lines:

$$T_m = \frac{T_b \cdot T_r}{\sqrt{T_b^2 + T_r^2 - 2 \cdot T_b \cdot T_r \cdot \cos(\alpha_r - \alpha_b)}} \quad (10)$$

With trigonometry follows that:

$$T_m = \frac{T}{2 \cdot \sin\left(\frac{\alpha_r - \alpha_b}{2}\right)} \quad (11)$$

We can assume that all angles relative to the base layer level line and the equation (6) is as follows:

$$\alpha'_m = \arctan\left(\frac{\sin \alpha'_r}{\cos \alpha'_r - 1}\right) \quad (12)$$

With trigonometry follows that:

$$\tan \frac{\alpha}{2} = \frac{1 - \cos \alpha}{\sin \alpha} \quad (13)$$

$$\tan(90^\circ + \alpha) = -\frac{1}{\tan \alpha}$$

And the formulas (12) and (13):

$$\alpha'_m = 90^\circ + \frac{\alpha'_r}{2} \quad (14)$$

Equation (6) and (10) is the general case formula, known in the literature, equation (12) and (14) is a formula for the rotation of the same models with parallel lines ([11], [12] [13] [14]).

The developed software realizes the possibility of modifying the image by entering different distances between the lines, uneven line thickness, and various size distortions in the formation relief. There is also the possibility of thickening the line in places imposition of the picture. The resulting protective image with a new form and can be programmatically imposed on any text or graphical information while maintaining high quality printing products and protecting it against counterfeiting. This way you can produce documents of identification, travel documents, postage payment instruments that serve currency, and others that require printing of protection with a resolution of 2500 - 5000 dpi or higher (due to resolution of the output device)

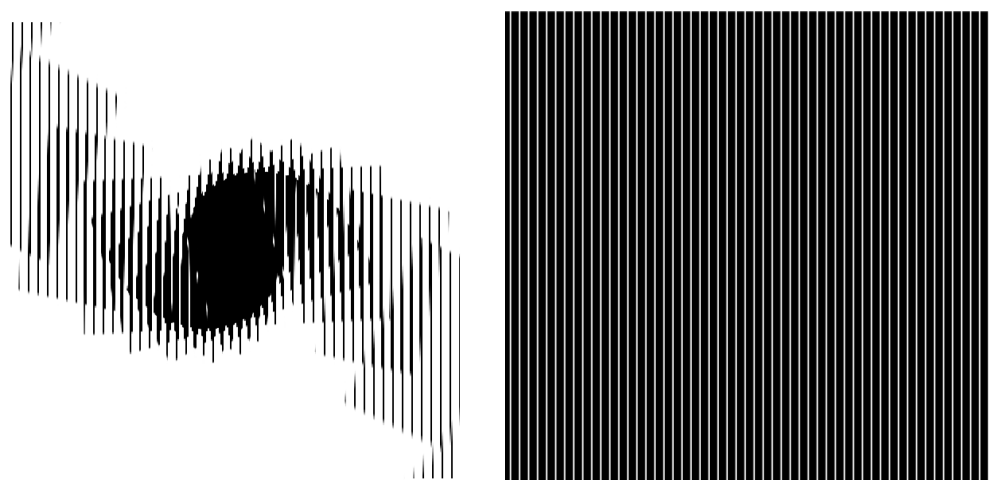


Fig. 8. Shows an example of basic and performance base layer with the image angle

Selecting protect documents on the basis of the criterion of efficiency to prevent threats Copies quality protection for printed documents determined by optical density, clarity of reproduction, distribution some paint on the elements of protection and reproduction, which can be determined using densitometer. Dot gain, zbilshennya area printing elements offset printing defined to 40-80 microns. When copying a document from the application of the principle of reprography image formed of charged particles transfer of toner to zadrukovuvalnyy and recorded material resulting toner adhesion to paper when heated. By increasing the thickness of the line toner adhere to empty areas and the formation of two strokes to 40 microns and 20 microns emptiness obtained solid line 2. According to this principle protection built hidden element that allowed to increase the level of protection from the threat of photocopying documents based on the separation lines. Subject to individual graphics elements are built, and then he built a hidden message by changing the thickness of the line. The method of implementing the change line thickness for building the hidden message. The present document consists of a large number of repetitive lines that provide reliable and effective protection from fraud.

Technological advances in technology photocopiers and scanners led to the fact that the appearance of photocopying machines with very high performance arose task of creating zones that give watered effect of digital copy, for example, using photocopiers for copying documents. This watered effect distorts the original picture and indicates that it is a copy.

Moire effect appears when reading information broken and distorted original image, in particular, are changing uneven shades and colors. The appearance of such moire effects difficult to predict because it depends on the characteristics and regulation used for reproduction equipment.

Conclusion

A method that provides reliable security of electronic information and print documents. The method consists in the development of printing elements of protection, namely security elements based moire in hidden elements. The method of document protection that improves the efficiency of protection based on moire effect.

Since the introduction and implementation of the method does not require large financial costs, then the method can be widely used to protect valuable documents and documents for public protection.

This work is important as scientific and technological development in the field of printing data protection. The results can be used to develop securities, documents and publications that provide effective protection and identification.

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1. Kronover R. *Fractals and chaos in dynamic systems [Text] / R. Kronover. - M. : Technosphere, 2006. – 488 p.* 2. *Fractal analysis of the processes, structures and signals [Text] / Ed. RE Pashchenko. – Kharkov: EkoPerspektiva, 2006. – 348 p.* 3. *Introducing the New Cybersecurity Coordinator: <http://www.whitehouse.gov/blog/2009/12/22/introducing-new-cybersecurity-coordinator>.* 4. Kipphan G. *Encyclopedia of print media. Technologies and production methods / Translated from the German – M.: MGUP, 2003. – 1280 p.* 5. B. Mandelbrot, *Fractals, cases and finances / B. Mandelbrot. – Moscow-Izhevsk: Regular and Chaotic Dynamics, 2004. – 256 p.* 6. ISO 4163-2003. *State unified documentation system. Unified system of organizational and administrative documentation. Requirements oformlyuvannya documents.* 7. <http://dsaua.org/index.php?option=comcontent&view=article&id=182%3A2013-04-14-21-54-53&catid=66%3A2010-12-13-08-48-53&Itemid=90&lang=uk>. 8. Barannik V. V. *Coding transformed images in the information systems [Text] / V.V. Barannik, V.P. Polyakov. – H.: Hoops, 2010. – 234.* 9. Luck M. M. *Digital technologies Printing. : monogram. / M. Luck – Lviv: Eng. Acad. Printing, 2012. – 488 p.* 10. C. A. Sciammarella and A. J. Durelli, “Moiré fringes as a means of analyzing strains”, *American Society of Civil Engineers, Vol. 127, Part I, 1962, pp. 582-587.* 11. Isaac Amidror, “Glass patterns in the superposition of random line gratings”, *Journal of Optics A: Pure and Applied Optics, 28 March 2003, pp. 205-215.* 12. Amidror I and Hersch R D 2001 *Method and apparatus for authentication of documents by using the intensity profile of moire patterns US Patent No. 6,249,588.* 13. Chosson S 2006 *Synthse d’Images Moir’e (Ph.D. Thesis No. 3434: EPFL, Lausanne);* 14. Hersch R D and Chosson S 2006 *Model-based synthesis of band moire images for authenticating security documents and valuable products Published US Patent Application No. 2006/0003295;* 15. Shlomchak G. G., Mamuzic I., Mironenko N. A. *Development of the technique for the plastometric experiment of the rheologically complex metals // Metallurgija, vol.42, Zagreb. – 2003. – Br.4. – S.257–259.* 16. Nazarkevych M. A. *The development of software for the protection of printed documents / M. Nazarkevych, O. Troyan // Proceedings of the international scientific-practical. Conf. ITSEC;* 17. Nazarkevych M. A. *Analysis of modern methods and software items with graphic printed documents protection / Maria Nazarkevych Oksana Trojan // Technical news. – 2013. № 1 (37). – S. 42–44.*