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Letter characters as screening elements in security graphics and design

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Abstract:

Use of typographic characters as screening elements is presented herewith. Each pixel of the picture is replaced with a letter character that corresponds with it as to coverage value. All letter characters that make up an alphabet are used. The overall picture can be screened with a single letter character or with many different elements. Quality screening is achieved with characters that have undergone measuring of the screening cell coverage, i.e. the quadrant where they are positioned. Continuous coverage increase within one and the same font is achieved in several iterations. There are no automatic possibilities, so corrections are carried out manually in programs for producing fonts. Characters that replace the screening elements depend on the graphic content that they reproduce. Generally known fonts are used for screening, as well as those found in the author's own font collection, providing thus for the uniqueness and originality of the reproduced pictures. Design possibilities are uncountable, especially if pictograms are used as screening elements.

Keywords:

screening elements, pixel coverage, security graphics, typographic design

1 Introduction

With traditional screening techniques the same elements are always used by repeating them and positioning them in a plane inside of which the screening dot surface sets the white or black parts (Ulichney,1987). The element is usually a round dot or rhombus or line. This has remained as described since the times of optomechanical procedures in graphics, and to date they are the most frequently used screening elements (Roth,1988). The same elements are found in the overall picture and in all the channels. Due to its form, the round dot has the smallest dot gain providing the best quality picture reproduction in flat printing. In the darkest tones the screening cell surface is completely covered, whereas the coverage value is less and less with lighter tones (Kipphan,2001). With the introduction of digital typography, there is possibility for mathematical definition of the screening cell. The methodology of creating different screening methods is shown, and the necessity for introducing the area of an „individualized design" is explained (Pap, Žiljak, 2001). A whole new group

of individualized screening elements has been disclosed (Pap, at al., 2008). Screening elements have been created that change form along with screening cell coverage altering. This is proven in many articles where different screening elements are described that transform from one form into another along with the cell coverage increase (Žiljak-Vujić, at al., 2009, Koren, at al., 2011). Screening elements do not need to be uniform in the overall picture area. Art screening is also described with the use of art screening elements where several different elements appear in one and the same black-and-white reproduction. Forms alternate depending on the picture detail that they display (Ostromoukhov, Hersch 1995). Algorithms are published that prove pixel form change (Stanić at al 2013). The pixel is not of a regular square form any longer, but a certain controlled deformation has been carried out. Individual action is taken for each pixel in the picture, so that each pixel has its own deformation controlled by the pseudo-random number generator.

Letter characters in the role of screening elements are introduced in the paper. All letter characters of a font or several fonts are used. It has been necessary to carry out certain preparations with the letter character screening elements in order to make good quality reproductions. Measurements have been made of letter character coverage for certain fonts as preparatory research work in creating fonts for picture screening. Coverage measuring is carried out with an algorithm controlling the width and area of the letter character section. It is carried out by transforming into a picture the letter characters intended to be measured. The resolution is such that each letter character is divided into pixels in the range from 100 to 500 pixels. In order to have the results as precise as possible, measurements are made repeatedly of the same few letters written in a row without spacing. Measurements are carried out in such a way that coverage is measured for all pixels: those that create a letter character and those that are in their vicinity. Coverage is the ratio of white pixels and black pixels and for such fonts can be measured with great precision.

Figure 1. The letters N and S

Several different font types with letter characters have been carried out in order to demonstrate in the best possible manner the wide and various possibilities of using such designs in security graphics. Covering capacities of some generally known fonts and of fonts from the personal data base were used and measured. All letter characters used for the experiments have been carried out in quadrants with the same width values. This is necessary for precise coverage measuring and positioning the letter characters in the place of pixels when creating the picture. All pixels are of equal size. The letter characters that will replace pixels must be of the same width size.

1.2 Fonts for picture screening

.The Courier font was designed by Howard Bud Kletter in 1955. The ordering party was IBM and the font was used for typing with mechanical typewriters. That is why all of its letter characters have equal width values, i.e. the same quadrant widths, regardless of the letter character width. IBM did not require exclusive rights in using that font, so Courier soon became the standard font for typewriters, and remained as such for several decades. Eventually, when electric typewriters were being produced, Adrian Frutiger redesigned Courier for the needs of IBM. Due to the equal width values of all letter characters Courier was repeatedly used in the digital era for texts that needed to have alignment to the full format. Different Courier versions are set today as one of the basic fonts in many computer operating systems. Some Courier versions have soft, curvy lines, whereas others have obtuse-angled end lines (Riggs, Grieshaber, 2009).

Table 1. displays measured coverage values of the generally well-known Courier font. The values of all letter characters have been measured, including digits and punctuation marks.

Table 1. Courier font's coverage values

Name	*Courier*	*Coverage (%)*
Full stop	.	2,8
comma	,	3,6
Hyphen	–	4,1
Exclamation mark	!	4,7
Quotation marks	„	5,3
Semicolon	;	6,7
Question mark	?	7,2
Number 1	1	8,3
Equal sign	=	9,1
Caps C	C	9,7
Caps I	I	10,3
Caps J	J	11,2
Caps T	T	11,9
Number 6	6	12,2
Caps G	G	12,8
Caps S	S	13,1
Number 9	8	13,8
Caps F	F	14,1
Caps R	R	14,7
Caps A	A	15,2
Caps E	E	16,0
Caps Z	Z	16,8
Caps H	H	17,2
Numbersign	#	17,8
Caps N	N	18,5
Caps D	D	19,6
Caps B	B	20,2
Caps M	M	21,7

The table shows values for some characters only because certain characters have the same coverage level, and it is therefore, unnecessary to show all such characters. Programs for creating pictures with letter characters should have the widest range of coverage in order for the picture to be of the best quality, i.e. so that the widest range of tones could be displayed. Measurements for the Courier font have been carried out on basis of the original letter characters, without additional interventions. As the font is made of thin lines and all letters have the same width values, coverage range amounts to only 18,9%. This is not sufficient to display the wide range of gray tones, so the tone in the derived pictures is of a rather uniform quality. In order to obtain good-quality graphic designs it would be necessary to carry out more serious interventions when redesigning the font in question, so in this case the research was abandoned and other fonts were taken into consideration.

Table 2. Coverage of the Verdana and VerdanaNina Font Digits

Name	Verdana	VerdanaNina	Coverage (%) Verdana	Coverage (%) VerdanaNina
1.eps	1	1	8,5	9,1
2.eps	2	2	12,7	13,7
3.eps	3	3	17,9	18,9
4.eps	4	4	25,4	29,8
5.eps	5	5	28,9	36,6
7.eps	7	7	23,6	42,3
8.eps	8	8	31,2	53,0
6.eps	6	6	29,3	60,1
9.eps	9	9	29,3	65,4
0.eps	0	0	28,8	75,6

Table 2. shows results of the VerdanaNina font digits coverage. This font was produced by redesigning the existing well-known Verdana font. The font is without serifs. The coverage range of this font is much wider because this was targeted when redesigning certain letter characters. Some digits were distorted on purpose in order to achieve the targeted coverage. The letter character deformation of this font is in the limits of legibility, and each letter character is recognizable as displayed in the produced examples of picture screening with letter characters. Coverage range amounts to 66,5% with 10 different degrees. This means that 10 different gray tones can be displayed in these pictures. Although a relatively big coverage range has been achieved, there is a problem when making

reproductions with a large number of gray tone levels. All digits from this font can be arranged in such a manner as to cover only ten different gray tone levels. This means that certain tones will be lost in the reproduction, i.e. they will merge into one number that will replace several gray tone shades of the original. Results for digits have been displayed separately because individual application of digits in producing pictures in security graphics is also shown. It has been proven that digits alone are not sufficient in producing good-quality reproductions with screening because they cover an insufficient number of gray tone levels

Table 3. shows coverage results linked with VerdanaNina font's caps where redesigning resulted in providing a satisfactory coverage range for picture interpretation. The range here is 84,2% and it has been achieved for 15 different letters, i.e. 15 different coverage degrees. These reproductions will have improved quality in comparison to screening with digits because another 5 coverage degrees have been added. Too big is the spacing between screening elements of letters „P" and „K" : 13.3% and 31.5%. When the picture is reproduced, all the tones in this coverage range will correspond to the two mentioned letters. Some details are thus lost in the reproductions. The same can be said of

Table 3. Coverage of the Verdana and VerdanaNina

Name	Verdana	VerdanaNina	Coverage (%) Verdana	Coverage (%) VerdanaNina
GG.eps	G	G	9,2	9,6
FF.eps	F	F	9,8	10,4
PP.eps	P	P	12,7	13,3
KK.eps	K	K	19,3	31,5
CC.eps	C	C	18,1	36,5
JJ.eps	J	J	19,7	39,3
OO.eps	O	O	23,8	40,2
AA.eps	A	A	19,6	43,6
ZZ.eps	Z	Z	21,6	47,4
RR.eps	R	R	18,3	50,3
EE.eps	E	E	19,3	70,6
UU.eps	U	U	19,1	76,2
BB.eps	B	B	19,8	80,3
SS.eps	S	S	21,6	89,9
MM.eps	M	M	22,9	93,8

Table 4. Coverage of the NNN font

Courier	I iteration	Coverage (%)	II iteration	Coverage (%)	III iteration	Coverage (%)	IV iteration	Coverage (%)
.	N	1,8	N	0,8	N	0,8	N	0,8
,	N	1,2	N	2,2	N	3,2	N	4,1
–	N	3,1	N	5,1	N	7,1	N	7,8
!	N	4,5	N	6,5	N	9,5	N	11,5
„	N	6,4	N	7,4	N	12,4	N	14,9
;	N	7,8	N	10,8	N	17,8	N	18,3
?	N	10,1	N	14,1	N	19,1	N	21,7
1	N	13,8	N	15,8	N	20,8	N	25,1
=	N	15,6	N	15,6	N	25,6	N	28,5
C	N	18,4	N	21,4	N	26,4	N	31,9
I	N	21,2	N	22,9	N	29,2	N	35,2
J	N	21	N	24	N	33	N	38,8
T	N	23,2	N	27,2	N	38,2	N	42,2
6	N	47,9	N	39,3	N	48	N	45,9
G	N	51,2	N	48,2	N	47,8	N	49,2
S	N	55,9	N	47,6	N	51,2	N	52,9
8	N	58,1	N	49,7	N	58,6	N	56,1
F	N	63,6	N	59,1	N	61,2	N	59,6
R	N	65,9	N	61,5	N	63,8	N	62,9
A	N	68,8	N	57,8	N	67,2	N	66,8
E	N	71,1	N	63,1	N	66,1	N	70,1
Z	N	77,3	N	61,3	N	68,3	N	74,3
H	N	78,2	N	68,6	N	71,6	N	78,2
#	N	62,9	N	62,9	N	72,6	N	81,7
N	N	64,7	N	74,7	N	79,7	N	85,1
D	N	82,7	N	83,7	N	81,7	N	88,7
B	N	84,9	N	88,9	N	88,9	N	92,3
M	N	82,2	N	85,2	N	93,2	N	95,7

the exceeding coverage range with screening elements of letter characters „R“ and „E“ amounting to 50.3% and 70.6%. With this coverage range once again all of the said tones will be lost.

Shown fonts Verdana and Courier as an example coverage of characters. Their range of coverage is a maximum of 18.9%, which requested rule readability. The coverage of a screen elements requires range from 0 to 100%. Due to the rules of legibility none font could satisfy the conditions of quality screening. The original font characters occupy a coverage ratio of the darkest to lightest. This table is used for PostScript font in order to control coverage. Font NNN and VerdanaNina with Courier used this sequence:/str1 (MBDN#HZEARF 8SG6TJIC =1?;“!-,.)def % through PostScript commands in the program shown in Table 5.

Table 4. shows the NNN font that has been derived from only a single handwritten capital letter character. The letter N has been taken as the Initial letter of the author's name. The coverage range is 94.9%. This font consists of 28 different capital letters „N“. The letter deformations made in the program for producing fonts were such that a difference amounting to 2 – 3% was evident after coverage measuring of every following letter. Certain letter characters with extremely high blackening values have been distorted until illegible in order to get a high coverage value and the best possible display of dark tones in the pictures. In this manner a sufficiently wide range of coverage was achieved and a continuous transition from lighter to darker tones.

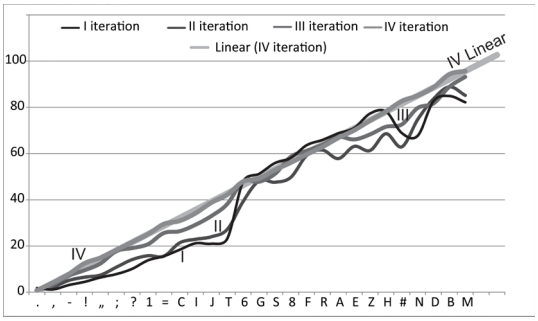

Figure 2. Coverage of the NNN font

Figure 2. Displays measured values of the NNN font letter character coverage. This font was produced by first creating the letter character „N“ that is found in the hexadecimal code 004E in the program for creating fonts, according to UNICODE (Pap, et al., 1998). Letter characters were further made with program tools that decrease the letter character size by 20 em relative units. On the other hand, characters were developed that were increased by 20 em relative units. On basis of Graph 1 it is evident that with such an automatic procedure it is not possible to achieve a continuous letter character coverage increase. Soon it was observed that letter characters required additional manual processing. Automatic tools increase or decrease the letter characters horizontally or vertically in a proportional rate, and it is not desirable in this case. Based on personal estimates, a relatively continuous coverage increase has been achieved with this font after producing a large number of fonts with manual post processing. The entire process is conducted in several iterations. Some letters have gone to disproportionately bold while some went to lightening. Achieved is the continuous increase in coverage that meets the requirements for high-quality rasterization images with letter characters.

2 Experimental part

Producing of fonts and measuring their coverage values is followed by the next screening process phase. It is necessary to find the connection in the hexadecimal code with each pixel of the picture and the letter character that will fall into the place of individual pixels. An auxiliary program for picture screening has been enclosed for such purposes.

Table 5. Program for picture screening with typographic elements

```
xx yy translate
/Nx XXX def /Ny YYY def % picture size in pixels
/HF 8 def % letter height
/F {/Courier findfont HF scalefont setfont} bind def F
/DX HF 0.81 mul def % pixel size per x axis
/str1 (MBDN#HZEARF8SG6TJIC=1?;“!-,.)def % letters arranged
according to coverage
str1 length /N exch def
/tekst 3 string def /znak 1 string def
/CITAJ {  Nina i get  } def
/i 0 def /y Ny HF mul 200 add def
Ny {/x 20 def
Nx{ CITAJ % taking decimal values from the pixel graphic at
the position point i
/POK exch def  /P POK N mul  255 div cvi def % decimal values
from 0 to N
x y moveto /x x DX add def  /Poz P 1 sub def
Poz 0 lt {/Poz 0 def} if
str1 Poz 1 getinterval /znak exch def
znak show
/i i 1 add def } repeat
/y y DX sub def } repeat

Showpage
```

The program enabling picture pixel transformation into a letter character picture is in PostScript. In order for the program to work, it is first necessary to transform the picture into an EPS format so

as to obtain hexadecimal values for individual picture pixel coverage. The values of individual pixels become legible, and recognizable for the program that transforms the picture into letter characters. The program operates in such a manner that in the place of each pixel comes a letter character of a certain font that corresponds with its coverage value. The picture size, pixel size, and the letter character size are all set in the program. The relation /str1 (MBDN#HZEARF8SG6TJIC=1?;"!-„)def contains in itself letters arranged in accordance with their coverage level.

Figure 3. The original picture of fish

The experiments that were carried out show the reproduction of one and the same picture. Figure 3 shows the original that was reproduced in such a way that it is screened with fonts whose letter character coverage had been measured earlier. The picture of a fish has been taken with continuous transition of the gray color in the background. Such sections provide special accent as to the reproduction quality. All the examples have been blown up to such extent that the screening structure of the picture can be observed with the naked eye. Details have been shown separately so that each screening element of the picture can be observed clearly. Black-and-white pictures are displayed in this paper.

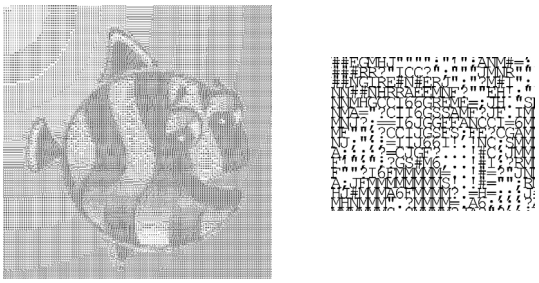

Figure 4. Fish and detail screened with the Courier font

Figure 4. Shows a fish screened with the 120 x 111 pixel Courier font. All letter characters whose coverage values have been measured and described in Table 1 are used for screening. As the measured coverage range with this font is rather narrow, there is proportionally around 17% not having distinct contrast between color tones. The derived screened picture has a very low level of gray tones. In comparison to the original, the reproduction carried out with these screening elements is much lighter in tone. This is due to the fact that the original Courier font and its darkest character have a coverage of only 19.7% of the quadrant and this is sufficient only for displaying lighter tones with low coverage.

This example carried out with the Courier font is shown so that it could be evident that with a relatively small coverage range there could not be high quality picture reproduction. This kind of picture production can be applied on concert, theater tickets or lottery tickets. It is used as a background with a reduced brightness onto which all other data concerning the event for which they have been designed is printed. Detail has been blown up so it would be obvious that the picture is composed of various letter characters. With this font the letter characters have the same line width and the coverage degrees depend on the quantity of lines. Simple characters such as „ i, !, 1, l, L, V, -, /, ." that are composed of only one or two lines have a small coverage area in the quadrant, and so the value of the measured coverage is also low.

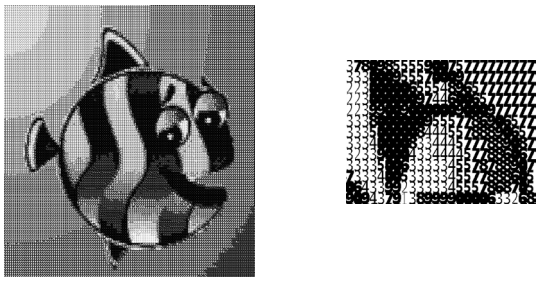

Figure 5. Picture 4.Fish and details screened with the Digit VerdanaNina font

The screened picture shows ten gray tone levels. Six levels of gray are shown in the background. The smallest coverage value amounts to 9.1% so that all lighter tones of the original will be reproduced at this coverage value. The maximum coverage value with this font amounts to 75.6%, and this means that all darker tones will be reproduced

at just that coverage value. The overall coverage range is significantly higher than with the Courier font and therefore, the transitions from the darkest to the lowest color tones are more pronounced. The reproduction is recognizable and may be used for carrying out some simpler examples in security graphics. Letter characters or punctuation marks are added when producing such designs in order to extend the coverage range and to raise the screening quality to a higher level. Individual designs are made for personal documents by combining digits and letter characters. The picture is screened with digits that mark a person's date of birth and with letters that are the name and surname of a person. This provides security against document counterfeiting.

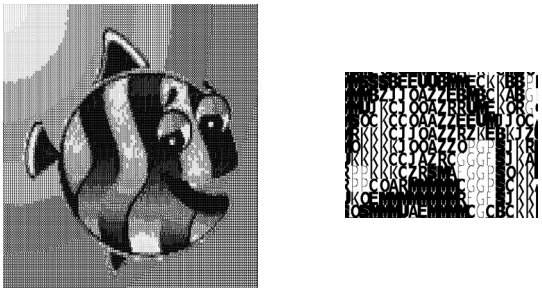

Figure 6. Picture 4.Fish and details screened with the Digit VerdanaNina font

Figure 6. was screened with the VerdanaNina font. Downsides of this font may be observed when comparing the original and the screened picture. Many details have been lost with the screening, i.e. the half-tones. Although the overall blackening range is satisfactory, the coverage value increase between the characters is too high to have good quality with screening. The detail of the screened picture shows an excessive difference in coverage between screening elements – letter characters „P", „K", and „C". This is evident in the graphic display of measured coverage values of the whole font. By using this font for screening purposes sudden transitions in the levels of gray are created, and the tones between screening elements are lost. There are only 8 levels of gray shown in the picture's background. For better quality reproduction this font is additionally processed in the sense that new characters will be created to decrease the differences between the measured coverage values of neighboring characters.

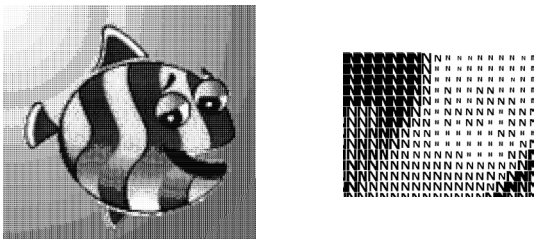

Figure 7. Fish and details screened with the NNN font

Figure 7. Fish screened with the NNN font. The same photograph has been taken on purpose in order to stress the advantage in the quality of screening pictures with fonts that have a high coverage value range. Many more details are observed here than in the other examples. The change of coverage value when there is continuous transition from the lightest upper left corner diagonally down to the right towards the darker tones is especially stressed. If observed with the naked eyes only, 16 levels of gray can be counted in the picture's background. This is something that is not visible in the other reproductions. The best quality reproduction has been achieved with the NNN font because it has the highest overall coverage value range, and the lowest range between two characters. The detail of the picture has been blown up so that the screening elements, i.e. the letter characters that replace them could be observed with the naked eye.

3 Conclusion

The paper is targeted at extending the limits of designing and to improve new ways of protecting documents and securities. The letter character is introduced as a screening element containing a meaning in respect to the reproduced contents. Including fonts from one's own collection shown in the displayed examples is a way to make it impossible to repeat the processes without knowing the picture screening program used and without possessing certain fonts. Several fonts with obvious distinct differences have been used in the described experiments. According to classification, these fonts come from completely different families and therefore, they have clearly obvious differences in letter cut and stroke width. The originality and uniqueness of such designs contributes to extending the field of their application from the

security printing area into the area of design. Interesting reproductions can be offered when printing huge size advertisements where from a certain distance the picture of the advertized product will be seen, but at close range the screening structure will be observed and it might contain a certain message about the product. The letter character cut replaces the screening cell for the purpose of achieving a new personal touch in graphic design.

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