Modeling fonts in context of counteraction of electromagnetic eavesdropping process

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Abstract. Computer fonts can be one of solutions supporting a protection of information against electromagnetic penetration. This solution is called „Soft TEMPEST”. However, not every font has features which counteract the process of electromagnetic infiltration. The distinctive features of characters of font determine it. This article presents two sets of new computer fonts. These fonts are fully usable in everyday work. Simultaneously they make it impossible to obtain information using the non-invasive method. Names of these fonts are directly related to the shapes of the characters. Each character of these fonts is built only with vertical and horizontal lines. The differences between them consist in the different widths of the vertical lines. The Symmetrical Safe font is built from vertical lines with the same widths. The Asymmetrical Safe font is built from vertical lines with two different widths of lines. However, the appropriate proportions of the widths of the lines and clearances of each character of the safe font have to be met.

Keywords: computer fonts, graphics, image processing, protection of text information

1. INTRODUCTION

An important element of daily processing of text information is an use of computers and computer fonts. There are many different computer fonts for a variety of applications. Most often, however, fonts are used to process text information, which is displayed on computer screens and printed by laser printers. The most popular fonts are Arial and Times New Roman. With their use, almost every text document is processed. The characters of these fonts have decorative elements such as: an ear, a bowl, an eye, a serif, a tail, a terminal, a bracket, a loop, etc. [1]. The characters are oval and also angles between the individual components are different than 90°. In addition, the widths of lines building characters are variable [2], especially for the Times New Roman font.

During the processing of text, each character of font has its representation in the form of electrical signal. This signal is transmitted from a computer to a screen or to a laser printer. In this case, this signal become a source of electromagnetic emissions which have characteristics of this signal [3, 4, 5]. This phenomenon makes it possible to reconstruct every processed character and thus all text displayed on the screen or printed on the laser printer.

Side Channel Attack (SCA) plays an important role in this process. SCA is created between the source of emission (electrical signal transmitted by e.g. video cables in VGA (still very popular in non-public information systems, where first of all the text information is processed), DVI (HDMI) or DisplayPort standards) and antenna which receives such emissions (Fig.1). These emissions are called revealing (sensitive) emissions [6, 7, 8].
vertical and diagonal edges (rising edges and falling edges of pulses of electrical video signals) are visible on reconstructed images. There are no visible horizontal edges. In the case of the analog VGA standard, the reconstructed characters of the fonts are marked by their vertical and diagonal edges. For the digital DVI (HDMI) standard, due to the nature of the TMDS coding algorithm, there appear fills of characters. This phenomenon is related to the bit character (0 and 1) of the electrical signal and it may result in the loss of processed information (Fig.2) [9, 10].

![Fig.2. Examples of possibilities acquisition of information from sensitive emissions for text data and VGA and DVI (HDMI) standards: (a) Arial and VGA standard, (b) Times New Roman and VGA standard, (c) Arial and DVI (HDMI) standard, (d) Times New Roman and DVI (HDMI) standard.](image)

Another feature of the computer fonts is the possibility of transferring the paper form of a text document to an electronic version (editable e.g. in MS Word), using Optical Character Recognition (OCR) programs. Not every document should be moved to an editable form. Appropriate characters of fonts should counteract this process.

Sang Mun tried to design such fonts. He created three sets such fonts: Flower, Noise and Cross (Fig.3). Each font fulfills its role and counteracts optical characters recognition process. We also can find a font which has similar features as safe fonts. It is Null Pointer font (Fig.3d). Characters of this font have not diagonal lines but they have distinctive features. These features (different widths of vertical and horizontal lines) allow to recognize each character during the electromagnetic penetration process.

![Fig.3. Sang Mun’s fonts: (a) Flower, (b) Noise, (c) Cross and Null Pointer font.](image)
The safe fonts have both features. They are resistant to electromagnetic infiltration process \cite{11, 12} as well as optical characters recognition process.

2. CONSTRUCTION OF CHARACTERS OF SAFE FONTS

2.1. Symmetrical Safe font

The Symmetrical Safe font is one of two computer fonts which was designed according to safety criterias \cite{13, 14}. This font could be used in printing process and computer techniques. It is a typical font which is used in the processing of text data (technical documentation, scientific documentation, advertising banners), in particular of classified data. The font characters are devoid of decorative and diagonal elements. The lines building the characters intersect at a right angle. The general contour of characters of Symmetrical Safe font has a rectangle shape. Each character is built from lines about two widths. Wider lines are vertical lines of the character, thinner lines are horizontal lines of the character. Simultaneously the right proportions of the line width and the clearance of each character of the font are maintained. The corresponding characters have ascender and descender. There aren’t unnecessary decorative elements. This makes font characters of font are similar each other with high values of correlation coefficient between characters. Examples of lowercase and digits are shown in Fig.4.

Fig.4. Characters of Symmetrical Safe font

The construction of characters, for ensure the counteracting properties of the electromagnetic eavesdropping process, has to meet appropriate assumptions. They concern the proportions of width of lines, clearance and the position of middle horizontal line. Such the line appears, for example, in the letters „e”, „s” and „z” (Fig. 7). Details of construction of the characters of font are shown in Fig.5 and 6. They contain basic data regarding the width of characters, their height, as well as the ascender and descender. An important element of construction, affecting the readability of signs, is also appropriate space between the lines.

Fig.5. Construction of lowercases of Symmetrical Safe font
The characters of the font are constructed with the required proportions of the width of the lines to the clearances and the appropriate position of the middle horizontal lines for characters which have such lines. This applies to both lowercase and capital letters and also digits (Fig.7).

Construction parameters of characters of Symmetrical Safe font:

a) height of lowercase:
\[ h_1 = 13p, \]  
(1)

b) height character with ascender or descender (height of digits and capital letters):
\[ h_2 = 18p, \]  
(2)

c) width of lowercase, capital letters and digits (with the exception of „m” character):
\[ c_1 = 9p, \]  
(3)

d) width of „m” character (lowercase and capital letter):
\[ c_2 = 15p, \]  
(4)

e) width of vertical line and clearance between vertical lines:
\[ d = 3p, \]  
(5)

f) width of horizontal line:
\[ k = p, \]  
(6)
g) ascender and descender: \[ w = 5p. \] (7)

2.2. Asymmetrical Safe font

The Asymmetrical Safe font [13, 14] is the second new computer. As the Symmetrical Safe font this font could be used in printing process and computer techniques. The characters of the font are devoid of decorative and diagonal elements. The lines building the characters intersect at a right angle. The general contour of characters of the Symmetrical Safe font has a rectangle shape. Each character is also built from lines about two widths. However, the location of the lines in the characters is different than for the Symmetrical Safe font. Wider lines are vertical lines but only as a left part of the character. Thinner lines appear as horizontal lines of the character and a right element of the character (Fig.8). Simultaneously the right proportions of width of the lines and the clearance of each character of font are maintained. The corresponding characters have ascender and descender. There haven’t necessary decorative elements. This makes that characters of font are similar each other with high values of correlation coefficient between characters. Examples of lowercase and digits are shown in Fig.8.

Fig.8. Characters of Asymmetrical Safe font

Similarly to the Symmetrical Safe font, the construction of characters of the Asymmetrical Safe font has to meet the appropriate assumptions (Fig.9 and 10) to ensure the protection against the electromagnetic eavesdropping process. They concern the proportions of width of lines, clearance and the horizontal position of the middle line. Such the line appears, for example, in the letters „ε”, „ς” and „ζ” (Fig.11).

Fig.9. Construction of lowercase of Asymmetrical Safe font
The characters of font are constructed with the required proportions of the width of the lines to the clearances and the appropriate position of the middle horizontal line for characters which have such line. This applies to both lowercase and capital letters and also digits (Fig.11).

Construction parameters of characters of Asymmetrical Safe font:

a) height of lowercase:

\[ h_1 = 13p, \]  

(8)

b) height character with ascender or descender (height of digits and capital letters):

\[ h_2 = 18p, \]  

(9)

c) width of lowercase, capital letters and digits (with the exception of „m” character):

\[ a_1 = 10p, \]  

(10)

d) width of „m” character (lowercase and capital letter):

\[ a_2 = 15p, \]  

(11)

e) width of vertical lines and clearance between vertical lines:

\[ d_1 = 5p, \quad d_2 = p \]  

(12)
f) width of horizontal lines:

\[ k = p, \quad (13) \]

g) ascender and descender:

\[ w = \frac{1}{2} a_1 = 5p. \quad (14) \]

3. ELECTROMAGNETIC PROTECTION AS AN APPLICATION OF SAFE FONTS

The construction of characters of Symmetrical and Asymmetrical Safe fonts has an effect on high level of similarity between the characters. Because SCA, due to its properties, additionally eliminates some construction elements of characters, an attempt of identification of characters becomes impossible. In reconstructed images from sensitive emissions, almost all characters (depends on the degree of similarity and correlation coefficient value) are identified as one and the same [15, 16, 17]. In this situation the reading of text data makes impossible (Fig.12, 13 and 14). This makes that safe fonts are useful not only in the typical processing of text data. These fonts effectively counteract the process of electromagnetic infiltration.

The effectiveness of safe fonts in the process of protection of information is confirmed by very large values of Character Error Rate (Tab.1), which was counted according to below equation:

\[ ZSB = \frac{m + k}{q} = \frac{m + (u - n)}{q}, \quad (15) \]

where:

- \( u \) – the number of characters looked for in analysed image,
- \( m \) – the number of characters incorrectly recognized,
- \( n \) – the number of characters correctly recognized,
- \( k \) – the number of unrecognized but looked for characters in analysed image \((k = u - n)\),
- \( q \) – the number of all characters existing in analysed image.

This means that during reconstruction of characters of letters and digits there are made a lot of mistakes [18, 19]. This applies to both lowercase and capital letters and also digits (Fig.12, 13 and 14).
Fig. 12. (a) Example of reconstructed image with text data for four different fonts (from the top: Symmetrical Safe, Arial, Asymmetrical Safe, Times New Roman) and magnifications of parts of the image: (b) Symmetrical Safe, (c) Arial, (d) Asymmetrical Safe, (e) Times New Roman (frequency of appearing of reveal emission: \( f_0 = 740 \text{ MHz} \), \( BW = 50 \text{ MHz} \), size of characters: 14 p., VGA standard was a source of reveal emission)
Fig. 13. Examples of reconstructed images with text data: (a) Symmetrical Safe, (c) Arial, and magnifications of parts of these images ((b) and (d)) (frequency of appearing of reveal emission: $f_0 = 1730$ MHz, $BW = 100$ MHz, size of characters: 14 p., DVI (HDMI) standard was a source of reveal emission)

Table 1. Values of Character Error Rate for traditional and safe fonts [21]

| Character | Arial font | Times New Roman font | Symmetrical Safe font | Asymmetrical Safe font |
|-----------|------------|-----------------------|-----------------------|-----------------------|
|           |            |                       |                       |                       |
| **VGA standard** | | | | |
| a         | 1          | 2                     | 1                     | 4                     |
| c         | 3          | 5                     | 7                     | 350                   |
| h         | 51         | 0                     | 310                   | 6                     |
| n         | 31         | 39                    | 283                   | 183                   |
| s         | 1          | 3                     | 40                    | 204                   |
| **DVI (HDMI) standard** | | | | |
| a         | 1          | 4                     | 91                    | 21                    |
| c         | 3          | 11                    | 97                    | 509                   |
| h         | 3          | 4                     | 50                    | 60                    |
| n         | 7          | 6                     | 431                   | 80                    |
| s         | 1          | 1                     | 156                   | 70                    |
| **Laser printer (double diode system, resolution: 600 dpi × 600 dpi)** | | | | |
| a         | 3          | 5                     | 3                     | 122                   |
| c         | 0          | 5                     | 19                    | 98                    |
| h         | 5          | 0                     | 20                    | 95                    |
| n         | 3          | 10                    | 73                    | 104                   |
| s         | 2          | 3                     | 3                     | 75                    |
Fig. 14. Example of reconstructed image with text data for four different fonts: (a) Times New Roman, (b) Arial, (c) Asymmetrical Safe, (d) Symmetrical Safe (frequency of appearing of reveal emission: $f_0 = 750$ MHz, $BW = 30$ MHz, printing resolution (size of characters: 14 p.): 600 dpi × 600 dpi, laser printer was a source of reveal emission)

4. CONCLUSIONS

The safe fonts are fully functional computer fonts and they can be used to process text information. A feature which distinguishes these fonts from traditional Arial or Times New Roman fonts is the high level of similarity between the characters of font. This property was achieved by eliminating decorative elements and diagonal lines, building characters of fonts. This means that characters of safe fonts have unique shapes which aren’t similar to other existing characters of computer fonts.

The safe fonts via their unique characters are characterized by significant features related to protection against electromagnetic penetration process. In reconstructed images from sensitive emissions, there is difficult to indicate a specific character, in contrast to traditional fonts. This applies to sources of unwanted emissions in the form of analogue and digital graphic standards [22]. Additionally, the safe fonts are resistant to optical character recognition. Software of this type can not correctly recognize of letters and digits.

5. PATTERNS AND INDUSTRIAL DESIGNS

Symmetrical Safe and Asymmetrical Safe fonts are new computer fonts. Due to their universality of the use and acceptance of potential users, the works on improvement of the shapes of characters are still being continued. Despite of the high level of similarity between the characters of font, each safe font could be used in the secure processing of information. These fonts obtained protection of the Polish Office Pattern in the form of Industrial Design (No. 24487) [13] and Pattern (No. P.408372) [14].

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