Quantitative Assessment of Bitmap Fonts

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Abstract

The scale invariant index (irregularity) has been previously proposed to describe the spatial features of vector fonts. The index is sensitive to the shape of font characters that affects text legibility. In this work, we propose the idea of quantitative assessment of rasterized fonts based on fractal geometry. Fractal dimensions for some fonts are found. The correlation between the fractal dimension and the speed of reading is confirmed.

1 Introduction

Many studies in the field of text legibility and readability have been conducted in the last century. They are particularly important for the development of textual materials focused on the readers with evolving reading capacities. A major focus of the research conducted is being placed on fonts. The clarity, legibility and readability of different fonts as well as the influence of serifs, pattern and spatial characteristics in connection with content understanding and memorizing have been investigated by many researchers.

Artemov [1] proposed to divide the concepts of visibility and readability of the fonts. Readability is influenced by the reader's physiological characteristics, whereas visibility depends on the quality of font drawing and characteristics of a person's vision. Differences in type-face readability were investigated in studies [2, 3, 4]. Some fonts are marked as the most readable. The superiority of some small book fonts connected with their shapes and drawings is demonstrated. It was found that a thick font is read faster. At the same time, respondents preferred the other fonts.

The similar results were obtained in [5]. The studies have identified the subjective preferences of readers, as well as the objective differences in readability of fonts with various typeface designs. Various fonts features regarding their readability were analyzed in the review [6]. It also contains a large number of different, often conflicting views on the impact of serifs, size, and font style in the context of readability. Some common fonts readability measured by testing the speed of reading Russian texts is compared and presented in the results of study [7]. A higher reading speed for serif fonts is demonstrated. However, no explicit font characteristics affecting readability are identified. This work [8] provides an overview of current typography of textbooks identifying various contradictions of its present state in the connection with the font design and the rules of current technical regulations.

Many researchers consider the serif fonts more legible as their serifs add more information to the eyes [9] and enhance the legibility of text by helping the readers to distinguish the letters and words more easily [10]. Results in [11, 12] indicated serif fonts are believed to be read faster due to their invisible horizontal line made by the serifs. The results of study [13] are against the prominence of serif fonts. The space between letters in serif fonts is slightly reduced due to the ornaments that they have.

Consequently, as mentioned in [14], serifs act as a visual noise when the readers' eyes attempt to detect the letters and words. The reduction of the space leads to other problems, one is a problem of crowding, which is hindering of letter recognition when a letter is flanked by other letters (cited in [15]). Another problem is that the letter position coding may be hindered, which decreases the ability of word recognition [13]. The results of studies [15, 16] showed equal legibility and perception of both: serif and sans serif typefaces.

Almost equal numbers of studies have showed as advantages as disadvantages of serifs, as well as the preference of other text features. So far, there has been no consensus on the fonts features and their influence on the reading process. The preferences of specific font feature and size are varied widely. It can be predicted that legibility is more sensitive to some spatial font features combinations and user’s familiarity with the specified font. The best font to use has not been defined yet. The only thing on which all the scientists agree is the application of reading speed as the predictor of legibility and readability. The rest of the findings obtained are substantially contradictory. This is mainly due to the lack of an objective index, which could describe the typeface and allow different fonts to be compared. The aim of this work is to show how to assess spatial features of rasterized font using an objective scale invariant index based on the ideas of fractal geometry.

2 Suggested Approach

First of all, it’s quite challenging to evaluate visual characteristics of fonts. It is connected with different approaches to understanding what a set of visual characteristics is and what criteria to their assessment should be applied. Similarity of some graphic elements of letters in font and the letters themselves, as well as the font as a whole, provides the possibility of implementing the ideas of fractal geometry to conduct the assessment.

In the previous work [17] we offered to use the irregularity Cn by formula (1) (which includes the perimeter P and the area S) as the scale invariant index for the vector fonts. The fonts were represented by the set of 66 Russian uppercase and lowercase letters as shown in Fig.1. Statistical analysis has revealed a strong negative correlation between the reading speed (obtained as a result of previous experiments) and the index of irregularity (correlation coefficient is –0.69, $p<0.05$) for five selected fonts (see Table 1 and Fig. 2).

$$C_n = \rho^2/(4\pi S) \quad (1)$$

Figure 1: Set of 66 font letters and their division

Table 1: Irregularity C_n and reading speed for different fonts

№	Font	Feature	Mean reading speed, chars per sec	C_n
1	Arial	sans-serif	43.2	481
2	Futuris	sans-serif	35.5	605
3	Times New Roman	serif	33.6	675
4	Classic Russian	serif	31.4	796
5	Art Script	script	28.5	1717

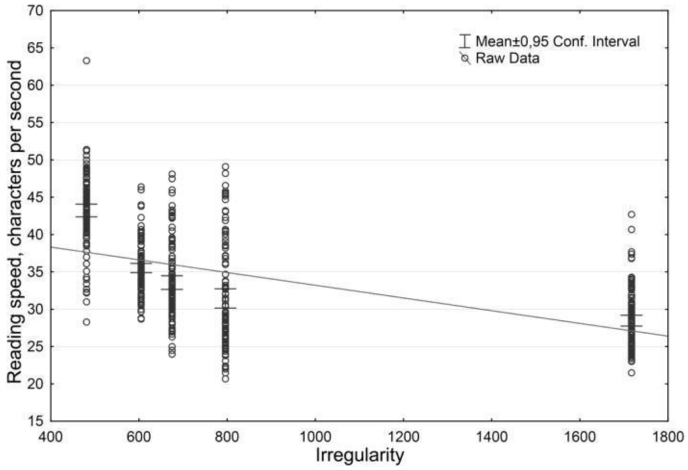

Figure 2: Reading speed vs irregularity

However, the rasterized fonts can barely be assessed in this way because there are no methods for a quick calculation of the perimeter and the area of irregularly distributed substance in the 2D Euclidean space. We assumed that the irregularity can be estimated by the fractal dimension of the font's border. A special case of the fractal dimension d (Minkowski dimension or box-counting dimension) is expressed by a well-known expression (2) that combines the number of objects N(ε) the measurement is taken, and the size of the "box" ε:

$$d = lim_{\varepsilon \to 0} \frac{logN(\varepsilon)}{log\varepsilon^{-1}} \qquad (2)$$

While working with the printed fonts or rasterized onscreen fonts it is important to take into account the resolution of the font being observed. The pixel size in various resolutions is equal to ε in Minkowski's fractal dimension (the geometric size of "box"). Thus, the Minkowski's dimension can be calculated by seeing how the number of "boxes" changes as the grid (resolution) is becoming finer.

The same set of 24 points fonts (see Table 1) and the same representation of each selected font (66 Russian letters) are used in the experiment. All fonts are converted into 2-colour (black and white) .BMP files with different resolutions: 75, 150, 300, 600, 1200, and 2400 dpi (see Fig. 3). The 1-pixel border of each font in the set and for each resolution is marked in the CorelDraw package and then also saved as .BMP files (see Fig. 4). Calculation of pixels ("boxes") is performed in the MatLab package. The fractal dimension (2) is calculated for each font border.

Figure 3: Set of 66 font letters, Arial, 150 dpi

Figure 4: Set of 66 font letters border, Arial, 150 dpi

3 Results and Discussion

The number of black pixels related to the border of font characters in each .BMP file is presented in Table 2. Actually, the number of black pixels is equal to the area of the border calculated in units of ε. Dependence of the number of black pixels on the value of ε-1 is shown in Fig. 3. Figure 4 shows the same dependence in the logarithmic coordinates.

Actually, the area of the fonts borders in the ε units is the area of the border, i.e. its fractal parameter. Tangent of slope of the regression line in Fig. 4 shows the fractal dimension for each font. Figure 5 shows the dependence of reading speed (based on the previous experiments) on the fractal dimension of font border. The statistical analysis has showed the correlation between reading speed and fractal dimension of the font border (correlation coefficient is –0.53, $p<0.05$).

Table 2: The number of black pixels in fonts borders for different resolutions

№	Resolution	Arial	Futuris	Times New Roman	Classic Russian	Art Script
1	75 dpi	5640	2787	4846	4205	4348
2	150 dpi	13708	10886	13079	10347	11957
3	300 dpi	27321	25009	29163	25841	28066
4	600 dpi	53845	50404	58474	53132	72376
5	1200 dpi	110538	100621	116849	106748	152790
6	2400 dpi	221336	202501	234472	213516	306809

Table 3: The fractal dimension d for different fonts

№	Font	d (font border)
1	Arial	1.04
2	Futuris	1.19
3	Times New Roman	1.10
4	Classic Russian	1.13
5	Art Script	1.23

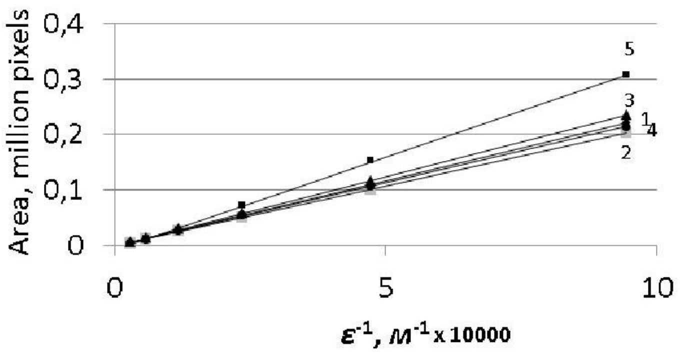

Figure 5: Assessment of font border area vs value of ε-1 (1. Arial, 2. Futuris, 3. Times, 4. Classic Russian, 5. Art Script)

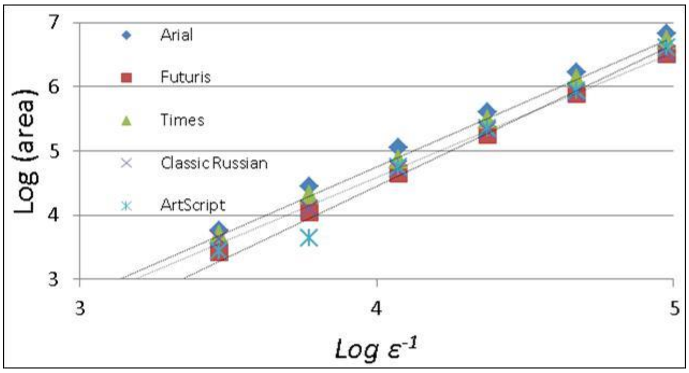

Figure 6: Assessment of log (font border area) vs value of log ε-1

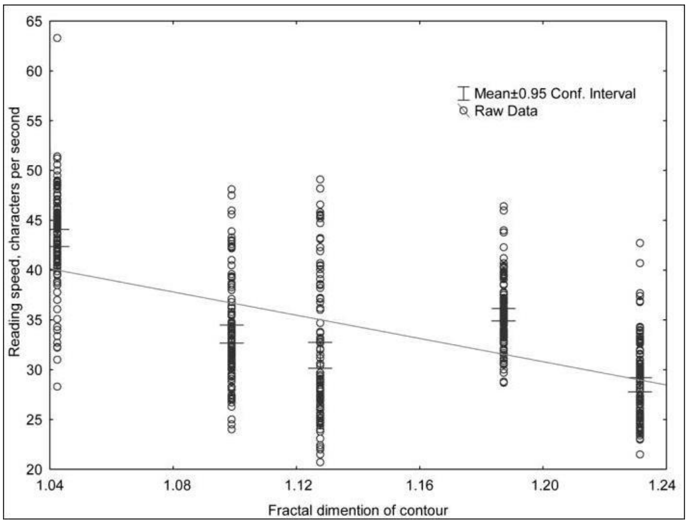

Figure 7: Reading speed vs fractal dimension (for the font's borders)

4 Conclusion

Although there is a wealth of studies considering typography and font features, there is no agreement among the researchers regarding legibility factors in printing and onscreen presentation of textual materials. One of the most complicated issues is numerical accounting of how the font's drawing influences on text legibility. This work develops the previous results and offers a solution to this problem.

It is suggested the fractal dimension of the font to be used in order to assess the spatial features of font in rasterized form. The statistical analysis has showed the correlation between the reading speed and fractal dimension of font border. The application of index in the research of reading might help to identify predictors of reading speed, as well as the quality of assimilation not only for printed materials, but also for onscreen texts.

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