Irregularity as a Quantitative Assessment of Font Drawing and Its Effect on the Reading Speed

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Abstract. It is proposed to use irregularity, the scale invariant index based on the ideas of fractal geometry to assess the spatial features of font drawings. The index is sensitive to the shape of characters in the font, which affects text legibility. Preliminary results have shown promising application of the proposed index for classifying fonts by reading speeds.

Keywords. Font; Fractal; Scale invariance; Legibility; Typeface

1 Introduction

Research in the fields of legibility and readability are maintained for over a hundred years. They are particularly important for the development of textual materials intended for readers with emerging reading skills. A significant place in these studies takes fonts. Many researchers have investigated the clarity, legibility, readability of different fonts, the influence of serifs, the influence of the pattern and spatial characteristics of the font on the understanding and memorising the content of the text and some other factors. The obtained results are contradictory. So far there is no consensus on what fonts features and how affect the reading process. This is largely due to the lack of an objective index, which could describe the typeface, and allows comparing different fonts.

Artemov [1] proposed to divide the concepts of visibility and readability of the font. Readability is influenced by reader's physiological characteristics. Visibility depends on the quality of font drawing and vision features of the person. Differences in typeface readability investigated in [2-4]. Some fonts are marked as the most readable. The superiority of some small book fonts connected to their shapes and drawings is demonstrated. Thick font reads faster. At the same time, respondents preferred the other fonts. Similar results were obtained in [5]. Studies have shown the presence of subjective preferences of readers, as well as an objective difference in readability of fonts with different shapes. The review [6] analysed the various features of fonts with respect to their readability, but also contains a large number of different, often conflicting, views on the impact of serifs, size and font style for readability. Results of study [7] compares the readability of some common fonts by testing the reading speed

of texts in Russian. A higher reading speed for serif fonts is demonstrated. However, no explicit font characteristics affecting readability are identified. The work [8] provides an overview of the situation of modern typography of textbooks and considers contradictions of the current state with the font design to the rules of the current technical regulations. Lots of researchers consider serif fonts more legible and it is because of their serifs which add more information to the eyes [9] and enhance the legibility of a 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 serifs. Results of study [13] is 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 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]) and the other is that letter position coding may be hindered which decreases the ability of word recognition [13]. The results of studies [15], [16] showed out equal legibility and perception between serif typefaces and sans serif ones.

Thus, almost equal numbers of studies showed advantages and disadvantages of serifs, as well as a preference of other features of text. The preferences of specific font features and font size are highly dispersed, too. It can be suggested that legibility is more sensitive to some combinations of spatial features of text. No special type font is suggested to use. The point to pay attention to is the familiarity of the subjects with special typefaces and subjects' preferences. The aim of this work is to find the way to assess the spatial features of font drawings by using an objective scale invariant index.

2 Approach

An assessment of the visual characteristics of fonts represents certain difficulties associated with the difference in approaches to the understanding of what is a set of visual characteristics and what criteria should be used in their assessment. The similarity of some graphic elements of letters in font and the letters themselves, as well as the font as a whole, suggests the possibility of using the ideas of fractal geometry to make the assessment. A special case of the fractal dimension d is expressed by well-known formula that combines the number of objects n, with which the measurement is taken, and the geometric size of the object a:

$$d = \log n : \log a^{-1}. \tag{1}$$

Mandelbrot showed [17] that for fractal sets the expression relating the length of the perimeter of the object P and its area S is performed:

$$P^{1/d} : S^{1/2} = \text{const}, \tag{2}$$

which implies that $S \sim P^{2/d}$.

The fractal dimension can be understood as the degree of filling of the space by irregularly distributed substance. Thus, in either family of flat figures (like font), geometrically similar but having different linear dimensions, the ratio of the length of the shapes border to the square root of its area is a number that is completely determined by the general form for the family. The equivalence of different linear extensions in many cases is very useful [17]. The relation between abris' length (perimeter *P*) of the character or set of characters in the font and its area (*S*) can be used as a unique font index. Considering the font as a coherent geometric set, by analogy with the way proposed in [18], it is possible to apply the definition of compactness of the set *C* (3), circularity coefficient C_c (4) and irregularity C_n (5) which is proposed to use as such unique font index.

$$C = P^2 : S. \tag{3}$$

$$C_c = 4\pi S : P^2, \tag{4}$$

$$C_n = C_c^{-1} = \mathrm{C} : 4\pi = P^2 : 4\pi S \tag{5}$$

Vector graphics software having an intrinsic macro language based on *VBA* can helps to solve the task of index calculation. In the present work a public macro *CurveInfo* for *CorelDraw* package is used. The macro calculates perimeter (in mm) and area (in mm^2) of a coherent vector object.

Fig. 1. Set of font letters and its division

As a representation of a font the full set of 66 uppercase and lowercase letters (for Russian language) of each font is used (see Fig. 1). To obtain information about the perimeter of a particular letter the perimeter of the external abris of a letter (P_{out}) must be added to (if available) of the internal perimeter of the letter space (P_{in}). The perimeter of the full set of 66 letters (*P*) equals the sum of the perimeters of all letters (6). To obtain an area of a letter it must subtract the internal area of the letter space (S_{in}) from the general area bounded by the outer abris of the letter (S_{out}). The area of the full set of 66 letters (*S*) is equal to the sum of the areas of all the letters (7).

$$P = \Sigma\,(P_{out} + P_{in}) \tag{6}$$

$$S = \Sigma\,(S_{out} - S_{in}) \tag{7}$$

3 Results and discussion

For the measurement 21 fonts (straight light drawing, sizes 12 and 18 pt) were selected: 9 sans serif fonts, 11 serif fonts and a script font. For the selected set of fonts the described procedures and formulas were applied. By the distribution of the values of irregularity C_n for groups of serif and sans-serif fonts the mapping is undertaken.

Also, 5 fonts among the full set are used to test their reading speeds. Participants of the experiment are 10 students. They read text samples with different font layout and count the reading speed. The correlation between reading speeds and irregularities is assessed. The results of calculations by formula (5) and reading speed measures for 5 fonts are given in Table 1. As it can be seen from Table 1, a irregularity has almost constant values for each font. It indicates the objective nature of the scale invariant index proposed that is useful for research. A small variation of the index for some fonts can be explained by features of font scaling. Figure 2 shows the distribution of irregularity for groups of serif and sans-serif fonts by peer review. Serif fonts are read slightly faster than sans serif ones, on average. Script fonts have a low reading speed but extremely high irregularity. Figure 3 shows the distribution of reading speeds and its dependence from irregularity for 5 selected fonts, regression and confidence intervals. Statistical analysis reveals strong negative correlation between reading speed and irregularity (correlation coefficient –0,69, $p<0,05$).

Table 1. Irregularities and reading speeds.

No	Font	Feature	Reading speed, chars per sec	C_n, 12 pt	C_n, 18 pt
1	Vanta	sans-serif		305	305
2	Text Book	sans-serif		418	418
3	Comic Sans	sans-serif		439	416
4	Verdana	sans-serif		459	464
5	Avantgard	sans-serif		470	470
6	Arial	sans-serif	43,2	481	469
7	Century Gothic	sans-serif		575	575
8	Futuris	sans-serif	35,5	605	605
9	Futura	sans-serif		825	825
10	Bruskovaya	serif		472	472
11	Antiqua	serif		585	585
12	Mysl Narrow	serif		653	653
13	Times New Roman	serif	33,6	675	655
14	Baskerville	serif		682	682
15	Journal	serif		703	704
16	Book Antiqua	serif		714	714
17	Baltica	serif		778	792
18	Classic Russian	serif	31,4	796	796
19	Garamond	serif		875	875
20	Literaturnaya	serif		880	802
21	*Art Script*	script	28,5	1717	1651

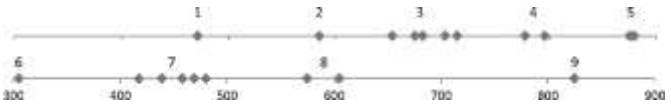

Fig. 2. Distribution of irregularity for groups (numbers) of serif (above) and sans-serif (below) fonts by peer review

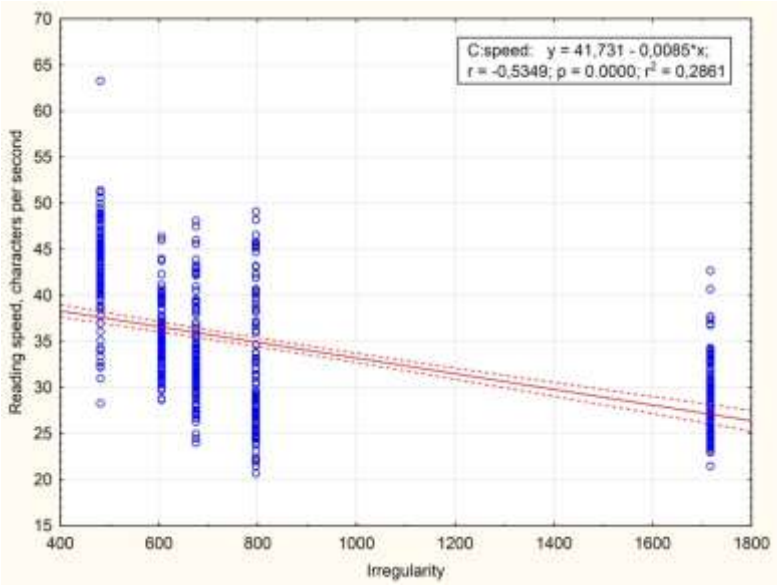

Fig. 3. Distribution of reading speeds and its dependence from irregularity for 5 fonts, regression and confidence intervals (drops).

4 Conclusion

Although there are massive bodies of analysis considering typography and font features, there is no agreement among researchers regarding legibility factors in print. One of the most complicated issue is accounting for the effect of font drawing on legibility. The work offers a solution to this problem. The scale invariant index to assess the spatial features of font drawing is proposed. Accounting for the index in research of reading (e.g. [19]) might help to identify predictors of reading speed, as well as quality of assimilation not only for paper, but also for electronic texts. In any case, the scale invariance of the proposed index allows to accumulate experimental results without any subsequent processing or conversion, which is convenient.

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