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An Alternative Digraph-Based Typing-Key Layout for Single-Finger or Stylus Input

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ABSTRACT

Recent research in the Boca Raton Design Center/Human Factors department (Lewis, Kennedy, and LaLomia, 1992) produced a key layout to improve typing speed for situations in which a user can type only with a single finger or a stylus on a reduced-size keyboard. Application of a path-analysis program to English-language digraphs provided information that led to the design of a key layout that minimizes the distance between commonly occurring pairs of English letters. Use of a computerized human-performance model provided an estimate that this layout is 27% better than the standard QWERTY layout. In an independent study, other researchers (Getschow, Rosen, and Goodenough-Trepagnier, 1986) used an assignment procedure to produce a similar layout for inividuals with special needs. The computerized human-performance model calculated that a modified Getschow/Rosen/Goodenough-Trepagnier layout would be 31% better than the standard QWERTY layout. Therefore, designers of hand-held computer products (such as pen-based systems) that offer typing-key layouts should consider the modified Getschow/Rosen/Goodenough-Trepagnier layout as a keyboard alternative, or, if maximizing typing speed is a design goal, as the default typing layout.

Introduction

With the advent of hand-held tablet and portable computers (including pen-based systems), it is important to evaluate the best arrangement of keys for typing layouts when users type with one finger or a stylus. Also, improved layouts for one-at-a-time character selection will help the population of computer users whose special needs limit them exclusively to this style of typing.

Lewis, Kennedy, and LaLomia (1992) developed a key layout to support this kind of typing. First, they developed a computerized human-performance model, based on Fitts' Law and the frequency matrix for English-language digraphs, for evaluating alternative layouts. Then they used a path-analysis program to help determine which letters should occupy which positions in a 5 x 5 matrix of letters so the distance between commonly occurring pairs of letters would be as small as possible. Table 1 shows the results of comparing several layouts to the conventional QWERTY layout. The value in the "Prediction" column is the value that the human-performance model returned, with smaller numbers being better. Figure 1 shows the Lewis/Kennedy/LaLomia digraph-based layout in a 5 x 5 matrix.

Table 1. Summary of Predictive Human-Performance Model Analyses (from Lewis et al., 1992)

Key Layout	Arrangement	Prediction	Improvement/Degradation Relative to QWERTY
Digraph-Based	Roughly 5 x 5	1699	+ 27%
Digraph-Based	Conventional	1802	+ 22
Alphabetic	Roughly 5 x 5	2006	+ 13
QWERTY	Conventional	2318	0
Alphabetic	Conventional	2389	- 3
Dvorak	Conventional	2777	- 20

Figure 1. The Lewis/Kennedy/LaLomia Digraph-Based Arrangement of Typing Keys in a 5 x 5 Layout

In 1986, in a relatively obscure conference proceedings, Getschow, Rosen, and Goodenough-Trepagnier reported work in which they used a variant of a simple assignment procedure (a "greedy algorithm") to develop a key layout for individuals with special needs. Figure 2 shows a slightly modified version of this layout. In the original version, the spacebar was the same size as the letter keys and, due to its relative frequency of use, occupied the central position in the letter matrix. The original version also included a period. In the modified version, the letter "E" occupies the central position. The spacebar would occupy an area of several letter widths below the letter matrix, and the period would be in an area dedicated to punctuation keys.

The purpose of this study was to use a human-performance model (Lewis et al., 1992) to determine whether the Lewis/Kennedy/LaLomia digraph-based key layout was worse than, equal to, or better than the Getschow/Rosen/Goodenough-Trepagnier digraph-based key layout.

Method

The first step in evaluating a key layout with the human-performance model is to determine the matrix of interkey distances. Table 2 shows the interkey-distance matrix for the modified Getschow/Rosen/Goodenough-Trepagnier digraph-based key layout. The human-performance model used this matrix to generate a number that represents the layout's relative goodness in terms of maximizing typing speed. (A lower number is better.)

Results and Discussion

The human-performance model returned a value of 1594 for the modified Getschow/Rosen/Goodenough-Trepagnier digraph-based key layout. This value is 6% better than the Lewis/Kennedy/LaLomia digraph-based key layout, and is 31% better than the conventional QWERTY layout.[1]

Although this difference is not great, the modified Getschow/Rosen/Goodenough-Trepagnier digraph-based key layout is better than the Lewis/Kennedy/LaLomia digraph-based key layout. Figure 3 shows a simple embodiment of the modified Getschow/Rosen/Goodenough-Trepagnier digraph-based key layout.

[1] The unmodified Getschow/Rosen/Goodenough-Trepagnier digraph-based key layout received a value of 1630, which was 4% better than the Lewis/Kennedy/LaLomia layout and 30% better than the conventional QWERTY layout.

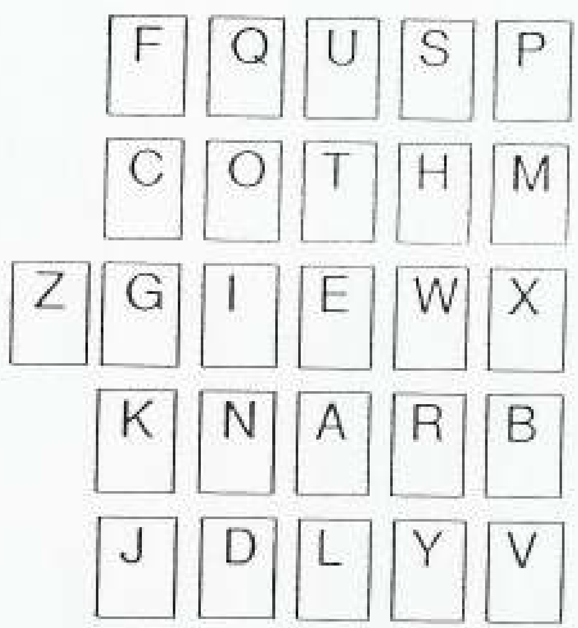

Figure 2. The Modified Getschow/Rosen/Goodenough-Trepagnier Digraph-Based Arrangement of Typing Keys

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Table 2. Distance Matrix for the Modified Getschow/Rosen/Goodenough-Trepagnier Key Layout

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A:	0	2	2	1	1	3	2	2	1	2	2	1	2	1	2	3	3	1	3	2	3	2	1	2	1	3
B:	2	0	4	3	2	4	4	2	3	4	4	2	2	3	3	3	3	1	3	2	3	1	1	1	1	5
C:	2	4	0	3	2	1	1	3	1	3	2	3	4	2	1	4	1	3	3	2	2	4	3	4	3	1
D:	1	3	3	0	2	4	2	3	2	1	1	1	3	1	3	4	4	2	4	3	4	3	2	3	2	2
E:	1	2	2	2	0	2	2	1	1	2	2	2	2	1	1	2	2	1	2	1	2	2	1	2	2	3
F:	3	4	1	4	2	0	2	3	2	4	3	4	4	3	1	4	1	3	3	2	2	4	3	4	4	2
G:	2	4	1	2	2	2	0	3	1	2	1	2	4	1	1	4	2	3	2	3	2	4	3	4	3	1
H:	2	2	3	3	1	3	3	0	2	3	3	3	1	2	2	1	2	2	1	1	1	3	1	1	3	4
I:	1	3	1	2	1	2	1	2	0	2	1	2	3	1	1	3	2	2	2	1	2	3	2	3	2	2
J:	2	4	3	1	2	4	2	3	2	0	1	2	4	1	3	4	4	3	4	3	4	4	4	4	3	2
K:	2	4	2	1	2	3	1	3	1	1	0	2	4	1	2	4	3	3	3	2	3	4	3	4	3	1
L:	1	2	3	1	2	4	2	3	2	2	2	0	3	1	3	4	4	1	4	3	4	2	2	2	1	3
M:	2	2	4	3	2	4	4	1	3	4	4	3	0	3	3	1	3	2	1	2	2	3	1	1	3	5
N:	1	3	2	1	1	3	1	2	1	1	1	1	3	0	2	3	3	2	3	2	3	3	2	3	2	2
O:	2	3	1	3	1	1	1	2	1	3	2	3	3	2	0	3	1	2	2	1	1	3	2	3	3	2
P:	3	3	4	4	2	4	4	1	3	4	4	4	1	3	3	0	3	3	1	2	3	4	2	2	4	5
Q:	3	3	1	4	2	1	2	2	2	4	3	4	3	3	1	3	0	3	2	1	1	4	2	3	4	2
R:	1	1	3	2	1	3	3	2	2	3	3	1	2	2	2	3	3	0	3	2	3	1	1	1	1	4
S:	3	3	3	4	2	3	3	1	2	4	3	4	1	3	2	1	2	3	0	1	1	4	2	2	4	4
T:	2	2	2	3	1	2	2	1	1	3	2	3	2	2	1	2	1	2	1	0	1	3	1	2	3	3
U:	3	3	2	4	2	2	2	1	2	4	3	4	2	3	1	3	1	3	1	1	0	4	2	2	4	3
V:	2	1	4	3	2	4	4	3	3	4	4	2	3	3	3	4	4	1	4	3	4	0	2	2	1	5
W:	1	1	3	2	1	3	3	1	2	4	3	2	1	2	2	2	2	1	2	1	2	2	0	1	2	4
X:	2	1	4	3	2	4	4	1	3	4	4	2	1	3	3	2	3	1	2	2	2	2	1	0	2	5
Y:	1	1	3	2	2	4	3	3	2	3	3	1	3	2	3	4	4	1	4	3	4	1	2	2	0	4
Z:	1	5	2	2	3	2	1	4	2	2	1	3	5	2	2	5	2	4	4	3	3	5	4	5	4	0

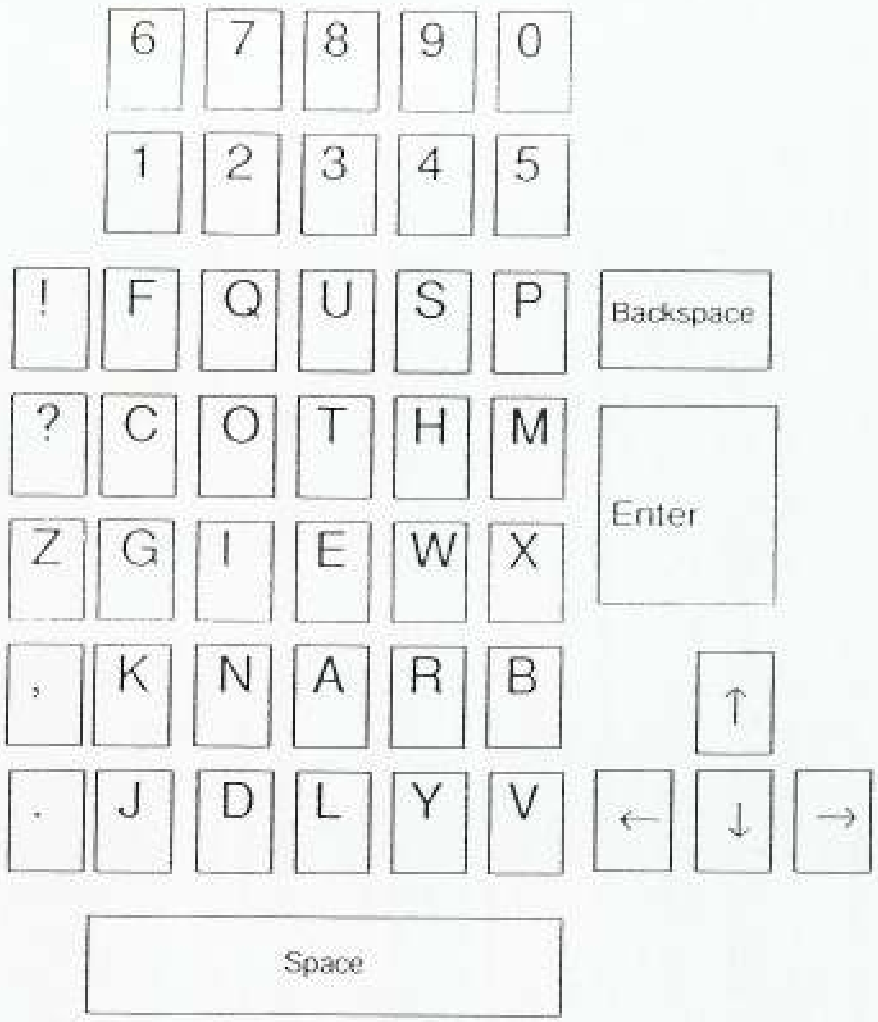

Figure 3. A Simple Embodiment of the Modified Getschow/Rosen/ Goodenough-Trepagnier Digraph-Based Arrangement of Typing Keys

Recommendations

Hand-held computer products (such as pen-based systems) that offer typing-key layouts on touch- or stylus-sensitive screens should offer the appropriate alternative layouts depending on the needs of the users and their applications.

If the user will benefit in the long run by having the layout that supports the fastest possible typing speed, the default typing screen should use a 5 x 5 digraph-based layout (either the Getschow/Rosen/Goodenough-Trepagnier or the Lewis/Kennedy/LaLomia typing layout).

If the user does not require a layout that maximizes throughput, the default typing screen should use the 5 x 5 alphabetic typing layout (see Lewis et al., 1992).

In addition to the default layout, designers should offer other layouts (if possible), depending on users' previous experience. For example, if users have experience with conventional computer keyboards, the system should offer the QWERTY layout as an alternative.

References

Getschow, C. O., Rosen, M. J., and Goodenough-Trepagnier, C. (1986). A systematic approach to design of a minimum distance alphabetical keyboard. In Proceedings of the RESNA 9th Annual Conference (pp. 396-398). Minneapolis, MN: RESNA.

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