ERGONOMICS DESIGN OF COMPUTER KEYBOARD LAYOUT

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ABSTRACT

For the past six decades there has been tremendous development in computer technology. The computer keyboard basically is the main input device of a computer and the way we communicate with the computer has not changed. The "QWERTY" keyboard is considered to be the standard, even though the constraints that heavily influence the adoption have changed. From the ergonomics perspective, it has been proven that it inhibit speed and difficult to learn. It is the aim of this paper to design an optimum layout that maximise speed, improve comfort, minimize error and easy to learn using heuristic of ergonomics principles.

Keywords: Ergonomics, computer keyboard, QWERTY, Heuristic, speed

INTRODUCTION

The keyboard is the main input peripheral used by all computers. The keyboard allows for user input and action with the computer. Much like many typewriter, the keyboard has all the letters of the alphabet, numbers 0 – 9 and additional special operational keys. The history of the typewriter dates back to the year 1714 when Henry Mill obtain the first patent for a contraception that can be recognized as typewriter. In 1808, Pallegrim Turin typewriter was invented. This happens to be the oldest working machine. This machine also enables a blind person to write letters to a sighted person. Between 1829 and 1876 inventors in Europe and the US patented numerous writing machines with a wide range of design. One of those machines, Charles Thurber's 1843 – 45 called Chirographer. Thurber's design was much more compact. It was described on the patent as "artificial" machine or method for impressing or transcribing letter singly or progressively one after another.

In 1856, the Bruce typewriter was invented it carried the universal typing bar that we are familiar with today. The first practical typewriter was invented by Christopher Latham Sholes in 1868 and was marketed by Remington Arms Company in 1873. The typewriter in his initial design was very sluggish and tended to jam frequently. In 1878, Remington No 2 was introduced. The major improvement was the possibility of printing both upper and lower case using a shift key. The previous design only printed in upper case. One of the greatest limitations was that it was an upstroke typewriter. In order word actual printing was done at the back of the paper.

During the first decade of the 20th centuries, the standard for the office typewriter changed from the upstroke to the front strike typewriter (Victor, 1999). With this, the typist could see what she had typed because the machine printed on the front of the plate. In 1889, Blinkerdafar machine that was more efficient than Sholes design was produced, but for unknown reason, fails to challenge Sholes design. It was in 1920 that ergonomics experts Frank Gilbert performed time and motion studies. Gilbert addressed the flaws in Sholes design by allocating letter among keyboard rows, among fingers and between right and left hand. Inspired by Gilbert Findings, in 1930, DVORAK and his colleagues worked on better arrangement of the keys in 1936, He Patented his DVORAK simplified keyboard .His experiment that claim the new layout to have far superior performers to the old layout was published in |(DVORAK et al 1936).

Since that time till date, there has been strong argument between proponent of QWERTY and DVORAK keyboard in terms of efficiency. (Liebowitz and Margolis, 1990) in his fable of the keys questioned the veracity of the claim of DVORAK. (David, 1996) an economist and a proponent of DVORAK posited that QWERTY was adopted before there was any strong competition. Between 1940 till date, there has been tremendous research in the field of ergonomics as regards the best possible arrangement of keys that will enhance speed, little has been done to upstage QWERTY as the universal standard for keyboard. This paper seeks to design an optimum layout that will enhance efficiency in terms of speed, improve comfort, minimize error and easy to learn using heuristic of ergonomics principles.

GENERAL MODEL OF INFORMATION FLOW

There are five stages in the process of typing (Zipp, 1983).
The first stage is character recognition, when the symbol at the input has to be processed. The human eyes reads ahead about 1 second largely irrespective of typing speed (Butsch, 1932) (Fuller, 1943) in (Zipp, 1983) found the mean eye-hand span of 100 trained typewriter student to be 0.32 seconds.

The second phase concerns the storage Buffer. This is where the information from the eye is stored. Since the eye reads ahead between four and eight letters, this has to be store in a short term memory. It appears that eight letters is the maximum look ahead range. The age long believe that advance typist distinguished themselves by larger reading span was experimentally refuted by (Butsch, 1932) and (Fuller, 1943).

The third stage is the major program. (Shafer, 1946) in (Zipp,1983) observed that the inter stroke (the time between successive keystroke) are very low when the keys are at different hand. The inter key stroke interval was measured to be under the neutral transmission time for a signal to go from the hand to the brain and back again to the other hand. It was shown by (Genther, 1983) that the movement of the hand not only depend on the current character to type, but also on the following letter.

The fourth stage is the keystroke strange. It should be noted that computer keyboard differs from the typewriters in that the keyboard need much less effort to be depressed. The mechanical structure of the typewriter demands a greater keystroke interval (time between first touching the key and finally the release), which can often been neglected in computer keyboard.

The sensory feedback stage is the final stage .This is concern with error detection. One way this is done is through visual feedback while the second feedback is through kinesthetic feedback.

ERGONOMICS CONSIDERATION

The most recent studies of the relative merits of keyboard are found in ergonomics literature. These studies provide evidence of the advantage of the DVORAK over QWERTY is either small or non existence. A lot of the studies concluded after their experiment that no other layout has shown significant advantage over QWERTY for general purpose typing.These ergonomics studies are particularly interesting because the claim of different keyboard layout has been historically hinge on the advantage it offer ergonomically. Even DVORAK explanation is hinge on ergonomics advantage of reduce finger movement (Zipp et al, 1983) discover clues to why DVORAK does not provide as much of an advantage as its proponents have claimed. According to them, there are three factors that play a role in speed optimization:

a. The load on the right and left hands are equalized
b. The load on the home row is maximized
c. The frequency of alternating hand sequences is maximized and the frequency of same finger typing is minimized.

The last factor informed why Sholes design has competed favourably with other more ergonomical keyboard afterward. His design was based on factor(c). He did this to avoid frequently used letters pairs (Digraph) far apart. It seems that this mechanical rationale accidentally resulted in a fast keyboard. The explanation of (Zipp and Rummelhart, 1983) of factor(c) is that during a keystroke, the idle hand prepares for its next keystroke; Thus Shole's decision to solve a mechanical problem through careful keyboard arrangement may have inadvertently satisfied an important requirement for efficient typing.This paper will attempt to make a bold step by harmonizing the three factors for optimal typing speed using ergonomics principles.

ERGONOMICS CONSIDERATION OF COMPUTER KEYBOARD LAYOUT

The optimization technique of keyboard layout is going to follow three basic ergonomics research theory. They are

i. The load on the left and right hand are equalized
ii. The load on the home row is maximized
iii. Alternate hand frequency is maximized and the frequency of same finger typing is minimized

Load on the left and right hand are equalized

The techniques adopt sharing load among the fingers in relation of their relative strength. In line with this techniques monograph frequency usage was used to allocate alphabet to the various fingers.

The load on the home row is maximized. According to Maynzer and Tresselt
Table of single letter and digraph frequency count

E	=	13%	R	=	8%	L	=	3%	G	=	2%
T	=	10%	N	=	7%	F	=	3%	P	=	2%
A	=	8%	S	=	7%	M	=	3%	W	=	2%
1	=	8%	H	=	4%	C	=	3%	Y	=	2%
O	=	8%	D	=	4%	U	=	2%	B	=	1%

K = 1% V = 1% X = 0.3% J = 0.1% Q = 0.1%

Table1:Maynzer and Tresselt table of single letter and diagraph frequency count

A,O,E,T,I,D,H,R,N,S letters combine to form more than 70% of keystrokes.

Since the first ten letters in the ranking order form more then 70% of keystrokes. It is natural to allow the first ten letters to take the home row

Left Hand					**Right Hand**				
A	O	E	T	I	D	H	R	N	S

Hand Alternation

This ergonomics technique highlights the fact that comfortable typing is assured if keys are to be struck on opposite sides of the keyboard. This third technique is the overriding factor as far as typing speed is concerned in computer keyboarding. According to (McQueen et al, 1995) transition time between successive keystroke in milliseconds is shown below. The 26 alphabets and four punctuation signs making 30 characters was divided into three groups in the left and right hand. The transition time was calculated between groups and rows.

Left Hand					**Right Hand**				
0	0	0	0	0	1	1	1	1	1
2	2	2	2	2	3	3	3	3	3
4	4	4	4	4	5	5	5	5	5

Time in Milliseconds

0	1	2	3	4	5	
0	403	198	311	351	547	236
1	271	193	157	237	614	320
2	287	119	159	134	409	123
3	263	415	140	180	418	152
4	499	524	334	495	629	175
5	159	245	168	307	268	318

Table 2: Transition time in seconds by McQueen et al

Sequence statistic table is shown below

Key pairs		H	L	M	N	R	S	T	V	Y
A	66	41	30	92	46	49	64	22	24	
E	117	41	50	66	162	57	65	59	10	
I	35	34	15	88	22	53	72	13	__	
O	20	18	33	44	65	29	85	7	56	
U	2	14	7	12	44	27	28	__	__	

Table 3: Sequence statistical table

Calculation from table 3, table 4 was derived

ER 4.9%	TH 4.5%	EH 3.5%	OU 2.9%
AN 2.8%	IN 2.7%	OT 2.6%	IT 2.2%
AH 2.0%	EM 2.0%	OR 2.0%	ET 2.0%
AT 2.0%	EV 1.8%	OY 1.7%	ES 1.7%

Calculation procedure

Key pair frequency is shown relative to a total value of 3320. The occurrence of EH or HE for example is shown as 117. In the use of English HE or EH is calculated thus:

$$\frac{117}{3320} \times \frac{100}{1} = 3.5\%$$

From the above calculation in table 4, 16 diagraphs of the total 676 forms 40% key struck consecutively in English language.Another considering factor in the course of designing the final keyboard layout is what ergonomics call Hit direction. Ergonomics research has revealed that for diagraph typed using one hand; only the preferred hit direction is from the little finger to the thumb. Since diagraph typed using one hand cannot be completely eliminated, it can be arranged in such a way that one hand successive keystroke can be maximized using the rule: little finger to the thumb.

CONCLUSION

From the analysis of the ergonomic optimization techniques, the final arrangement of the keyboard layout was designed thus:

:	Q	J	Z	Y	F	W	L	C	G
A	O	E	T	I	D	H	R	N	S
,	,	.	P	Y	K	V	W	B	M

FIG 1: Final arrangement of the design keyboard layout

The ergonomic keyboard was carefully designed using ergonomics theory.

(1) The designed keyboard layout produces less error because of hand alternation that was maximized.

(2) The arrangement was also easy to learn because it was orderly arranged.

(3) The design keyboard was very effective in terms of comfort as 70% of the whole typing is done without generally leaving the home row, which is the natural rest position of the hand at rest.

RECOMMENDATION

It is expedient to note that the entire design is still susceptible to modification. The Author intend to further extend this work by approaching the design using scientific optimization techniques like genetic algorithm, salesman algorithm and ant colony optimization to arrive at the best optimal layout.

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