STUDY OF HIGH SPEED PREDICTIVE TEXT ENTRY IN SMARTPHONES

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Abstract

In modern digital age, mobile networks have captured transmission of multimedia formats where along with sound and video, text messages between mobiles to mobiles and mobiles to PDA and other office equipments. The present study revolves around various methods for entering the text on keypads of mobiles especially push button and touch pad types using a comprehensive dictionary of words for disambiguation, however process in present study is similar to technology already licensed; it is further, studied with the convenience prevalent now a day, known as T9 dictionary and predictive texts with automatic word completion. This paper includes use of English Language as medium of communication and elaborates methods in making consistently accurate and faster methods of using various types of keypads available on mobile phones- an approach to increase efficiency of user under ambit of application layer of data communication networks. Examples of possible clashes with the actual words ease of dexterity and different keystroke level models of different input methods are part of this study. This paper present study of methods for predicting correct text entry rates for several input methods available on modern mobile phones utilizing finger and thumb movements based on Fitts' law coupled with linguistic aspects of English language based on digraph, or letter-pair, probabilities. Possible prediction in T9 method (disambiguating algorithm and single key press) are higher compared to multi press methods.

I. INTRODUCTION

As transmission and reception of text messages on mobile phones is increasing with exponential pace, text entry remains one of the most common challenges with the expectation of speed and accuracy. Till now so many methods have been proposed for text entry. Present study aims at reviewing most prevalent methods of text entries with physical keyboards and looking or future perfect touch screens and keypads.

Text entry on mobile phones is made possible using 12 physical keys available while T9 input method is based on the concept of *Text on 9 keys*. Variation in the patternsand types of keys and keypads, do not make a major difference in data input but the dexterity of thumb and fingers with the addition of linguistic knowledge are major parameters defining most popular data entry method.

II. GENERAL DESCRIPTION OF KEYPADS

General pattern of keypad is designed using 12 keys where English letters are distributed over keys 2-9 in alphabetic order(to encompass 26 letters, three or four characters are grouped on each key).Two additional keys (# and *)are provided for specific operations while 0-key is used as the SPACE character. This pattern is very common and based on an international standard.[1][2]

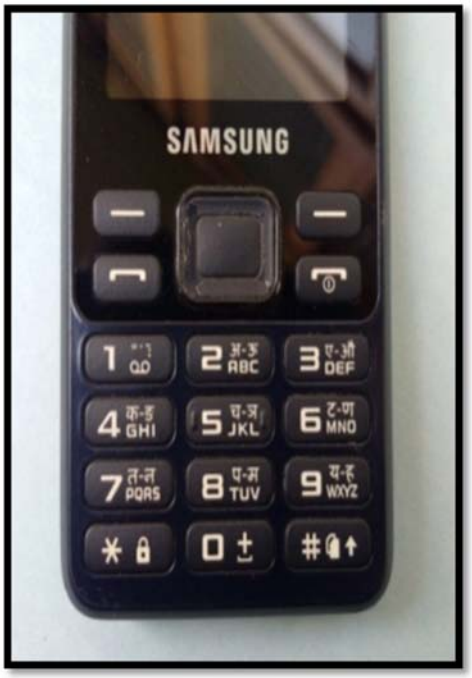


Fig: 1 Samsung DUOS physical Keypad

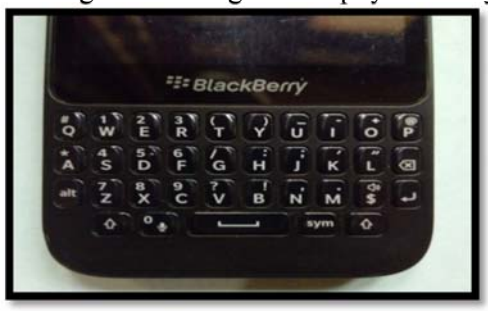


Fig 2. Blackberry Q5 Physical Keypad

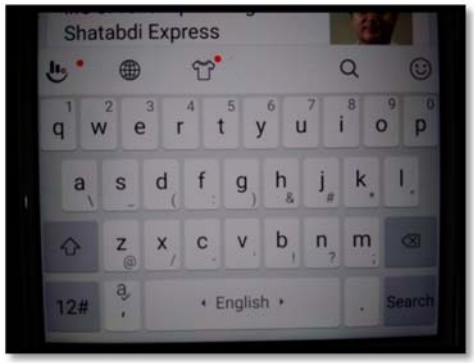


Fig 3. VIVO 3 Max Touch Screen Keypad

The grouping of three or four letters on a key is a method to encompass whole set of English alphabets which further becomes the reason for ambiguity in selecting the desired letter by way of key pressing. There must be some inherent system working in tandem which may select the letter or character user intends. There are many methods to rescue but present study revolves around multi-press, the two-key and the T9 methods for text or data entry.

III. TEXT ENTRY METHODS

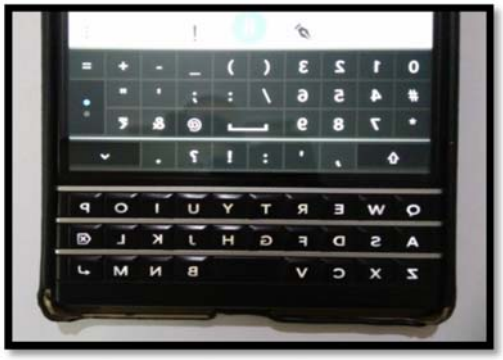


Fig. 4 Blackberry Passport Physical and Touch Screen (In extension to physical one) Keypads

Three most popular methods for text entry are explained below:

Multi-press method: In this method, user is to press a particular key many times to select the input character sequentially. For a key having three characters, one of the three presses in sequence, is required to select a specific characteristic. This method leads to problem of segmentation which was solved by allotting a specific timeout duration within which key pressing belongs to the same character. After timeout duration, next key press relates to the next character and so on for all characters on the same key. Another way to solve this problem of segmentation is to provide a special key to skip the timeout duration and next press allows next character for input. Generally a short duration of 1-1.5 sec is assigned as timeout duration.

Two-key method: Here, user presses two keys sequentially such that first press selects the required key, marked with specific character, and second press specifies the serial of character in question. For example, user must press 6th key and 2nd key to enter the character N.

T9 input method:T 9, which stands for Text on 9 keys is a predictive text technology for mobile phones generally contain 3x4 numeric keypad.This method requires single press for each key and dictionary is used as the basis of disambiguation to remove problem of segmentation. It combines the groups of characters on each key by predicting all words corresponding to the sequence of key presses and orders them by frequency of usage.After familiarization with the selection of words by the user, it speeds up the process by offering the most frequently used words first then lets the user access alternate words using some specified key operation.The 0-key or SPACE key is used to cancel disambiguation of the previous key. For example, to enter "INDIA", the user presses the keys in this sequence 4-6-3-4-2-0. T9 methodcompares the word possibilities to its dictionary database to "guess" the intended word; however, this method is not perfect in working as many words may have the same sequence of keys and T9 offers most common word as a default. If user wants some other word he may use specific key sequence (NEXT function key and * key) to select some other alternative word beyond 3-5% of most common words available. Modern Smartphone have touch screen version of T9 input method.

IV. MATHEMATICAL CONCEPT BEHIND TEXT ENTRY METHODS

Methods for text entry are generally based on Fitts' Law (A quantitative model to explain dexterity of thumb and index finger) and Linguistic model (using digraph probabilities particularly in English language). Let us have explanation in brief of these two concepts.

Fitts' Law:Psychologist Paul Fitts developed one empirical formula to study human psychomotor behavior, and proved that time required to move to a target is proportional to the distance to it and inversely proportional to the size of the target. [3]Thus, the longer the distance and the smaller the size of target, the longer it takes. Also fast movement and small targets result in increased error rate. The whole process of designing the keypads is to rely on this model which enables us to understand speed-accuracy tradeoff characteristics of human muscle movement with some analogy to Shannon's channel capacity theorem. That is why, in user experience (UX) and user interface (UI) designs, more interactive keys are made larger in size and kept as near as possible mutually compared to the general keys, as smaller keys are more difficult to click and require much more time locating for clicking. Today, with the advent of advanced and fluid graphical user interfaces, Fitts' Law is more in demand in human-computer-interaction.

Fitts' Law is an essential principle of Human-Computer Interaction theory that is used to define movement of thumb and index finger quantitatively.Fitts' Law is also useful to calculate possible text entry speed of expert hand on keypads of mobile devices. However, this law is the basis for the quantitative measurement of natural rapid and aimed movements of thumb and fingers.[4]Fitts' Law considered following factors into account to propose empirical formula in a way to quantify human psychomotor behavior

Time required to move to target in question.

The movement vector from home position to the target

Size (width) of the target

Extending the analogy of Shannon's channel capacity theorem, he proposed that the time required (MT) to move and point to a target of width (W) and at a distance (A) is a logarithmic function of the spatial relative error (A/W), that is

$$MT = a + b \log_2 (2A/W)$$

In fact, Fitts' Law is a linear regression model, where

The term log2 (2A/W) also known as Index of Difficulty (ID) expressing the order of dexterity in terms of bits

The term 1/b is called Index of Performance (IP) expressing the order of information capacity of human motor reaction in terms of bits per second. Devices with higher IP value would be faster and accurate.

Comparing with equation of straight line, a andb are the intercept and slope of the regression line between MT and ID, respectively. However, these constants can be determined using a regression analysis on the movement time data. Constant a does depend on device and learning curve of input methods.

For speed and accuracy, bigger keys at closer distances are preferred

In general, Fitts' Law simply remains a comparative tool which can differentiate devices, tasks and human computer interactions.Fitts' Law is very useful in dealing various issues related to the design of high density (ppi) screens, as higher ppi values lead to smaller menu buttons. Advantage of higher ppi value bounces back to user as smaller keys would extend time of movement in hitting the keys accurately. The objective of keypad designing is to reduce required movement distances among keys, repositioning the cursor and reorganization of keys and menusso that frequently used keys are placed at closer positions to increase performance.Fitts' law is a useful method for quantitative modeling of user performance in rapid, aimed movements and enables in the design of high performing and user adaptive Graphic User interfaces. As Fitts' Law was originally proposed for one-dimensional approach for movement and measuring the width of the target, dimensional extension of Fitts' Law for two dimensional keypads was suggested by MacKenzie& Buxton.

Table 1 Measurement of Keypad Parameters

S. No.	Brand	Size of Keypad (cm)	Distance between Keys (cm)	Max Movement (cm)
1	Samsung DUOS	4.3 x 2.5	1.5 (H), 0.6 (V)	3.5 (3-*)
2	Blackberry Q5	6.1 x 2.8	0.6 (H), 0.8 (V)	5.8 (P-alt)
3	Blackberry Passport	8.0 x 2.1	0.8 (H), 0.7 (V)	7.4 (P-Z)
4	VIVO V3 max	6.8 x 4.0	0.9 (H), 1.0 (V)	6.8 (abc->)

Dimensions of key are smaller than the distances between the keys.

V. TIME REQUIRED FOR INPUTS

In the simple cases of text input method through mobile keypads, each letter or character is entered with one or more key touches involving many rapid movements with different movement times. [6]Hence, total time required to enter one character through n movements is

$MT = \Sigma MTn$

In case of T9 input method, each key is pressed only once (perfect disambiguation), time required for inputting any character is defined as

$MT = MT0$

Probability Based Linguistic Method

This model of inputting characters or words is based on linguistics (English Language) where one SPACE key is put together with 26 characters of English language to form a 27x27 matrix of letter-pair (digraph). Each letter-pair (p-q) is assigned a probability (Ppq) of occurrence as most common word in usage. This method may be applied to other languages also after appropriate modification in probabilities.Considering all digraphs, average time for character input is the weighted average of character input times for complete matrix of digraphs. Reciprocal of this average time is

known as the input rate as number of characters per second.

VI. GENERAL DESCRIPTIONS OF KEYPADS AND SCREENS

Various photographs with dimension are inserted in the present paper to enable the reader to calculate input times of text entries. Constants appearing in Fitts' Law may be determined, with specific operations on keypads, using regression analysis. First hand analysis shows-
Index finger is faster than the thumb.

Acceptable predictions are highest in T9 methods than other input methods. Text entry rate more than 40wpm may be achieved in T9 method which is much higher than in other methods.

Prediction for T9 methods are very generous, initial word predicted is the one with highest probability as per linguistics, more than 90% of words appear naturally as default and uniquely disambiguated.

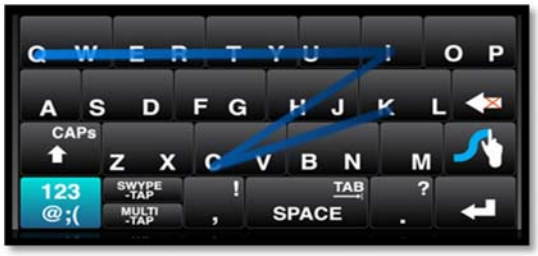
Modern smartphones have screen sizes approximately from 3.5 inch to 6.2 inch with rotation facility (vertical and horizontal viewing). There are varying types of keypads, all deem fit to Fitts' Law in operation. Interaction with the thumb is very common and essential nowadays. It is desirable to approach full screen with the thumb (Fitts' Law applies to one pointing variable) but as screen sizes increases, user requires finger (adds an additional variable) that increases movement time. Particular brands (Apple and Blackberry) with smaller screen sizes provide enhance usability where the average thumb can reach every portion of the screen; menus are also placed at the bottom of the screen within the reach of natural position of thumb. Top corner opposite to the thumb position require extra effort and stretching the thumb. In such cases, user has to use finger which increases the movement time and loses the fluidity of movement.[7] In smaller screens, some key positions meant for important actions like DELETE or CLOSE are not provided along with other routine menus, but actions like swiping left or right are used to avoid accidental targeting of these important tasks.

Phones with Android systems, generally with larger screens, have operating system menus at the bottom side of the screen while routine menus are placed near the top line of the screen to avoid problem mentioned above.

In the cases of larger and rectangular screens held at horizontal orientation, user has to input text using both the hands simultaneously in two separated zones of screen (example of Fitts' Law applicable in different zones concurrently) which has the advantage of reducing user time. But due to elongated rectangular shape of the screen, middle vertical zone of the screen in horizontal orientation, is difficult to approach from top to bottom, hence, reserved for sparingly used actions.

VII. ABOUT NEW TECHNOLOGY

Nuance Communications, Inc. developed enhanced versions of T9 family of input methods (T9 Write and XT9) suitable for touch screens and pen based devices that features multi-touch gestures and multi-modal input technology that allows users to choose the input method. [8] Using T9 Write method along with multi-touch gestures, user can edit text by swiping the fingers across on the keypad. This predictive text technology is for both QWERTY and touch screen keypads.



Cliff Kushler, inventor behind the T9 method developed a new input method for touchpads/screens known as "SWYPE" where user is to trace a route over the on screen keypad (or physical keypads on Blackberry Passport) for the word they would like to type. The word is

complete once the finger is removed from the screen, and accuracy of the input is assured by built-in predictive text feature.

VIII. CONCLUSION

Fitts' Law leads us in understanding following obvious principles in designing any keypads- Movements repeated more often should be assigned larger keys Movements repeated more often should be closer to the home position of cursor.

Keypads should be well organized and full available area of keypad should be targetable by the user with ease. Fitts' Law, in spite of foremost study in human computer interaction does not address cases of using both the hands in a way to divide the task of acquiring target, however, Fitts' Law seems to accept concept of ambidextrous hands naturally which may not be practically possible.[9]Modern human computer interactions include trajectory based input activities (SWYPE) rather than aimed movement for targets, and virtual reality environment where Fitts' Law should be studied for optimization. The appearance of any pop-up menu nearest to the cursor position, justifying fastest acquisition time of target, is one of the striking examples of the application of Fitts' Law.

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