



Ballistic movements on data-entry keypads

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ABSTRACT

Research to date on movement times on data-entry keypads has assumed that the movements are made under visual control [Drury, C.G., Hoffmann, E.R., 1992. A model for movement times on data-entry keyboards. *Ergonomics* 35, 129–147; Hoffmann, E.R., Tsang, K.T., Mu, A., 1995. Data-entry keyboard geometry and keying movement times. *Ergonomics* 38 (5), 940–950; Silfverberg, M., MacKenzie, I.S., Korhonen, P., 2000. Predicting text entry speed on mobile phones. In: Proceedings of the ACM Conference on Human Factors in Computing Systems – CHI 2000. ACM, New York, pp. 9–16]. This is often not the case; where the value of Fitts' Index of Difficulty is low, it is likely that movements will be made ballistically. A survey of commonly used keypads on devices such as mobile phones and ATMs shows that there is a need to study movement times when these ID values are less than those for which movements are likely to be made under visual control [Gan, K.-C., Hoffmann, E.R., 1988a. Geometrical conditions for ballistic and visually-controlled movements. *Ergonomics* 31, 829–839]. A series of experiments on simulated and real keypads indicates that the ballistic form of movement is generally valid and may be modelled by a modification of the ballistic movement time model of Hoffmann [1981. An ergonomics approach to predetermined motion time systems. In: Australian Institute of Industrial Engineers, Proceedings, Ninth National Conference, pp. 33–47] and of Gan and Hoffmann [1988a. Geometrical conditions for ballistic and visually-controlled movements. *Ergonomics* 31, 829–839]; 1988b. Sequential ballistic movement. *Ergonomics* 31 (10), 1421–1436]. A model is developed for the time to complete sequences of number entries containing up to 5 numbers. In this model, the movement times are related to the square-root of the sum of the movement amplitudes.

Relevance to industry: Many industrial applications require the use of keypads for data entry. Movements may be made ballistically or visually controlled, depending on the geometry of the keypad. As the time for data entry is dependent on geometry, a model for time taken is necessary for predicting human performance.

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1. Introduction

Many different devices use a numeric keypad for data input, such as ATMs, mobile phones and calculators. Most of these devices use a single finger as the input device, while on some of the smaller keypads, a pointed probe may be used. Early research in the use of such devices assumed that the common form of Fitts' law (Fitts, 1954) could be used to give an estimate of the movement time (Card et al., 1983). For example, if a finger was being moved a distance 'A' to a key of width 'W', the movement time (MT) was given as,

$$MT = a_1 + b_1 \log_2 \left[\frac{2A}{W} \right] = a_1 + b_1 (ID) \quad (1)$$

where a , b are empirical constants. In this work, the width of the finger pad in changing the available target width was not recognised. Drury (1975), showed that when making a movement with a probe of finite width, such as the finger, the available target width was approximately that of the target width 'W' plus that of the finger pad width 'F'. This change of available width has a very significant effect on the form of movement made, as the value of Fitts' Index of Difficulty (ID) is markedly reduced, as seen in equation (2).

$$MT = a_2 + b_2 \log_2 \left[\frac{2A}{W + kF} \right] \quad (2)$$

As shown by Gan and Hoffmann (1988a), the movement at these lower values of ID may be performed ballistically. The effect of these changes in available target width on Fitts' law has been demonstrated by Hoffmann and Sheikh (1991), where it was found necessary to add approximately 0.6 of the finger width ($k = 0.6$ in

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