Inapplicability of the Fitts' law to the elderly

고령 사용자에 대한 Fitts 법칙의 적용에 관한 연구

정홍인
경성대학교 디지털디자인전문대학원

Cheng, Hong-In
Graduate School of Digital Design, Kyungsung University

맥스 바카에프
경성대학교 디지털디자인전문대학원

Maxim, Bakaev
Graduate School of Digital Design, Kyungsung University

• Key words: Fitts' Law, HCI, the elderly

1. Introduction

Population aging is a worldwide common feature (United Nations, 1997) and the year 1999 was declared as the International Year of Older Persons by the United Nations General Assembly. The aging of the world's population began at different times in different countries and is proceeding at varying rates; however, it's a worldwide tendency. Korean population ratio of the elderly is approximately 12.26% in 2003 and will be 23.3% in 2021 (Korea National Statistical Office, 2003). Figure 1 shows the forecast of population pyramid for South Korea in 2050 (US Census Bureau, 2005).

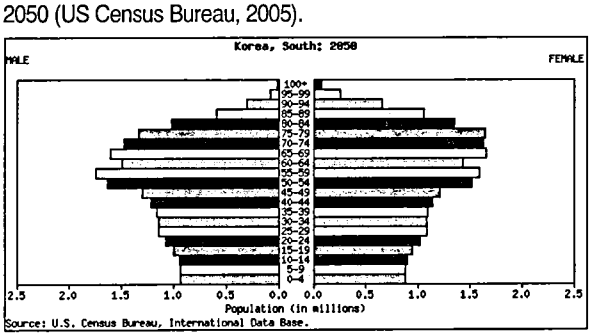

Figure 1. The population pyramid for South Korea, 2005.

Aging society will provoke many challenges and opportunities related to ensuring economic and social security of elder people. More IT products should be developed for the elderly in the near future to fulfill the demand of the aged consumers.

The upper limb movement is fundamental human body movement to interact with computers. The purpose of the study is to examine the upper limb motor behavior of elder persons and applicability of Fitts' law.

Fitts' law is one of the most important and widely recognized empirical findings in the field of human-computer interaction, and it predicts the movement time thusly (Fitts, 1954):

$$MT = a + b\log_2(2A/W) \cdots\cdots\cdots (1)$$

where MT is movement time, a and b are constants, A is distance to the target, W is width of the target, and the logarithmic element is the index of difficulty (ID). Many scientists have confirmed the law for a large variety of task conditions (Kerr, 1973; Jagacinski and Monk, 1985; Kantowitz and Elvers, 1988) and for humans as well as for animals (Brooks, 1979).

2. Method

2.1. Participants

Fifty-four elder subjects (35 male, 19 female) participated voluntarily in the experiment from a branch of Korean Elderly Association and paid for their participation. Their ages ranged from 60 to 79 (mean=60.6, SD=5.16; Table 1). All subjects had normal or corrected normal vision and no colordeficiency. Nine subjects reported having prior experience in using the mouse.

Table 1. Age distribution of the subjects

Age	Number of participants
60 ~ 65	11
66 ~ 70	16
71 ~ 75	14
76 ~ 80	13

2.2. Interfaces and apparatus

A web application was developed for the experiment and movement time and number of errors were captured by a JavaScript and stored into MySQL database. The time measurement unit was the millisecond (ms) with movement time measured from the clicking of the first target to the clicking of the second target.

Subjects performed selection mission by using a laptop computer with a regular mouse connected.

2.3. Experiment design and procedure

A partial within-subject repeated design was used for the experiment. All combinations of rectangle target sizes (1010, 2020, 4040, 6060, 8080,100100, and 120120 pixels) and randomly selected distance (less than 1,000 pixels) were given to each participant in random order three times. The control variables were the target sizes and the distancebetween the targets. The movement time and number of errors were measured during the experience. Errors were recorded when participants clicked out of the target.

Each subject was given a brief explanation of the experiment and informed consent was obtained. Vision and color deficiency were examined and general questions were then asked about their computer experience, age, etc.

Subjects were asked to click on a green and red target in sequence as fast as possible. Trial selections were repeated until subjects became familiar with the experiment. Targets were given when participants felt comfortable and the first clicking was performed by subjects' own decision.

3. Results

Movement times due to the target size and distance are summarized in Table 2.

Table 2. Movement time due to the target size and distance(ms)

	0~199	200~399	400~599	600~799	800+
10	4665.31	4186.88	5484.59	4858.11	4416.56
20	3977.65	3691.94	4107.31	3867.36	4141.27
40	3250.20	3482.45	4148.13	3375.88	3753.83
60	2899.04	3443.89	3490.32	4003.80	2617.33
80	2567.18	3283.49	3220.47	3557.96	3287.50
100	2615.88	2763.35	2824.89	3583.05	3834.56
120	2543.88	2931.13	2567.94	4037.59	3784.29

ANOVA test showed that significant main effects of the size of target ($P < .001$) and amplitude of movement ($P < .001$) upon the movement time. No interaction was observed between the independent variables.

Many researchers have reported usually very high R2 statistics in Fitts'law model (MacKenzie and Buxton, 1992; Hinckley et al., 2002; Card et al., 1983). The empirical results from the experiment, however, show that movement time of elder subjects cannot be properly explained by Fitts' law. R2 of linear regression in Fitts' equation for elder subjects was less than 0.2 regardless of the ID variations.

A significant difference in number of errors was observed due to the size of target ($P < .001$). The movement distances and subjects' personal parameters, such as age, gender and experience did not significantly affect errors either.

4. Conclusions

The Fitts' law has been empirically proven highly applicable and robust in human-computer interaction (HCI). Upper limb movement time and selection error were measured to investigate the applicability of Fitts'law. It was concluded that Fitts' law is inappropriate to predict the movement time of the elderly even though the size of target and movement distance affect their movement times.

Another potentially useful finding is that the size of the targets is the only significant variable among considered independent ones (target distance, person's age, gender and experience in using a mouse) for elderly users in terms of erroneous when making a selection. Small sized targets (10 and 20 pixels) caused much more errors.

This study found a case where Fitts' law was not suitably applied. Further study is required to prepare the aging society and understand the features of the elderly. More effective and efficient user interfaces for various users including children, seniors, disabilities, and adults should be developed for the aging society.

5. Acknowledgements

This research was partially supported by Universal Design Research Center at Kyungsung University under contract of Ministry of Commerce Industry and Energy.

References

- Brooks, V. B. (1979). Motor programs revisited. In: R. E. Talbott and D. R. Humphrey (Eds.), *Posture and movement: Perspective for intergrading sensory and motor research on the mammalian nervous system* (pp. 13-49). New York Raven Press.
- Card, K. S, Moran, P. T., & Newell, A. (1983). *The psychology of human -computer interaction*, Lawrence Erlbaum Associates, Publishers, London.
- Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology*, 47 (6), 381391.
- Hinckley, K., Cutrell, E., Bathiche, S., & Muss, T. (2002). Quantitative analysis of scrolling techniques, In *Human Factors in Computing Systems: Proceedings of CHI2002*, 4(1), 65-72.
- Kantowitz, B. H., & Elvers, G. C. (1988). Fitts' law with an isometric controller: Effects of order of control and control-display gain. *Journal of Motor Behavior*, 20, 53-66.
- Kerr, R. (1973). Movement time in an underwater environment. *Journal of Motor Behavior*, 5, 175-178.
- Mackenzie, I. S. (2003). Motor behavior models for human-computer interaction, In M. J. Carroll (Eds.), *HCI models, theories and frameworks: toward a multidisciplinary science*, Morgan Kaufmann Publishers.
- MacKenzie, I. S. & Buxton, W. (1992). Extending Fitts' law to two dimensional tasks, In *Human Factors in Computing Systems: Proceedings of CHI92*, 219-226.
- Soukoreff, R.W. & MacKenzie, I. S. (2004). Towards a standard for pointing device evaluation, perspectives on 27 years of Fitts' law research in HCI. *International Journal of Human-Computer Studies*, 61, 751789.
- United Nations, 1997. The sex and age distribution of the world populations: The 1996 revisions. United Nations, Department for Economics and Social affair, Population Division, New York.
- US Census Bureau (http://www.census.gov).
- World Health Organization. (2000). Social Development and Ageing: Crisis or Opportunity? *Special panel at Geneva 2000.*