MOKSLAS – LIETUVOS ATEITIS
SCIENCE – FUTURE OF LITHUANIA
ISSN 2029-2341 / eISSN 2029-2252
http://www.mla.vgtu.lt

ELEKTRONIKA IR ELEKTROTECHNIKA
ELECTRONICS AND ELECTRICAL ENGINEERING

2017 9(3): 345–348

https://doi.org/10.3846/mla.2017.1038

THE STUDY OF ROAD CONDITIONS THAT AFFECT TILT-BASED TEXT INPUT FOR MOBILE DEVICES

Darius MINIOTAS[1], Andrius KATKEVIČIUS[2], Darius PLONIS[3]
Vilnius Gediminas Technical University, Vilnius, Lithuania
E-mails: [1]darius.miniotas@vgtu.lt; [2]andrius.katkevicius@vgtu.lt; [3]darius.plonis@vgtu.lt

Abstract. With the rapid advances in technology of mobile devices, their application areas expand continuously as well. Given the growth of the market share for mobile devices, one of the main issues that arise is the need for new and convenient techniques for data input and output suitable for various settings. Tilt-based text input is one of the alternatives that attract attention of current researchers. This study investigates the potential of using tilt-based interaction to enter text while sitting as a passenger in a moving vehicle. In addition, the investigation focused on the characteristics of the road as well as driving conditions that affect tilt-based text input. The study manipulated the following factors: keyboard size 10×4 and road unevenness (small, moderate, and large). 14 participants, aged 25 to 50, took part in the user study. The best performance and the shortest task completion time equal to 24.5 seconds was observed when the vehicle was moving at a constant speed on a straight road with small unevenness. The task completion time increased by 15% in moderate unevenness road and by almost 20 % in large unevenness road. Error rate and movement efficiency were investigated additionally in order to find out the cause of such times.

Keywords: mobile text input, tilt-input, keyboard size, road unevenness.

Introduction

Development of mobile devices makes human-computer interaction an issue of increasing importance. Researchers strive to find new ways for improving efficiency of interaction between the human and the smart device. This calls for viable techniques for both presenting the information and entering the data.

Currently, two input techniques for mobile devices are investigated the most: the keyboard and the touchscreen. However, there are also other less popular input techniques such as tilt-based input, facial/eye tracking-based input (Newman *et al*. 2013), and voice-based data input (Alapetite *et al*. 2009). Thus far, tilt-based input is most frequently used for choosing orientation of the screen, as well as for playing games (Marzo *et al*. 2014), or for remote control of home appliances.

There are attempts to employ tilt-based interaction as input technique on mobile devices (MacKenzie & Teather 2012). Until now, studies were performed using the following independent variables: mobility and keyboard size. While performing research on usability of tilt-based interaction for text entry, it is also aimed to find out the factors that may influence the sensitivity of control. For instance, Rahman *et al*. (2009) conducted a study on human wrist, and they found that a person can conveniently set up to 16 positions in each of the three axes of accelerometer. The age of users is an important factor in the human-computer interaction studies, since users of various age adapt to the new text entry technique differently.

Others attempted to compare several text entry techniques (Ljubic *et al*. 2013). They claim that so far only tilt-based input is not convenient for text input, so they combined tilt-based text entry with a touchscreen input (Ljubic *et al*. 2014). Cuaresma, MacKenzie (2014) performed a study to compare tilt-based text entry with an input modality that uses facial tracking and position of the eyes.

In this study, we investigate the effect of riding in a car and road conditions on text entry using tilt-based interaction. This kind of research is scarce. Some reported investigations on the road parameters and ways to automatically determine them as well as the quality of the entire road (Prażnowski, Mamala 2016). Others investigated the relationship between quality of the road and fuel expenditure, as well as finding ways to adjust the chassis of the vehicle to the road parameters for improved safety (Dabrowski, Slaski 2016). There are also studies on the effect of road conditions on human health (Granlund 2008). There are many parameters to describe the road quality (Prażnowski, Mamala 2016). In the current study, we categorize the roads into three groups based on the accelerometer data from the mobile device: having small unevenness, moderate unevenness and large unevenness.

Method

Two independent parameters were manipulated in the study: mobility (while seated behind the desk and while riding the vehicle) and quality of the road (having small unevenness, moderate unevenness, and large unevenness). This resulted in four different experimental conditions. All the trials were completed on the same 4×10 keyboard.

14 randomly selected participants took part in the study. They all were volunteers without any financial reward for their participation in the experiment. All participants considered their experience in using smart devices as moderate. The age of the participants ranged 25 to 50.

The study employed a modified version of the freeware hosted by I. Scott MacKenzie at York University, Toronto, Canada (MacKenzie & Teather 2012). The software was adapted to Android Lollipop version 5.1.1 and DELL Venue 7" smart device.

The software uses position-control mapping with the tilt of the device being mapped directly onto the position of the cursor. Holding the device parallel to ground in both the pitch and roll planes moves the cursor to its central location on the screen.

The pitch and roll axes are linked directly to the accelerometer of the smart device. To prevent unintended start of the task, the ball is initially located at one of the screen corners. During each task, participants were requested to select 10 letters from a 10×4 array in a predetermined sequence. Each letter square was 3×2.5 cm in size (Fig. 1). The sequence of letters to be selected is generated at random. The square with the letter that needs to be selected next is shown shaded with a different colour. To complete a selection, the cursor is to be kept within the boundaries of the target square for at least 500 ms.

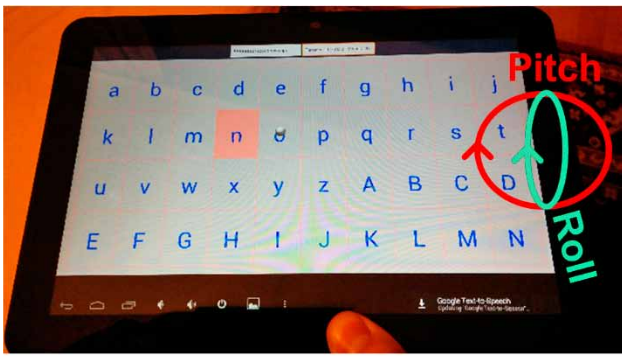

Fig. 1. Tilt-based text input using axelerometer data

When the cursor enters the target square, the boundary of the square gets highlighted. Upon a successful attempt, the selected letter is displayed at the top of the screen, and the participant proceeds with selecting another letter. The data of every task being completed are saved in a local file for further processing.

Procedure

First, the participants were explained the aim of the investigation. After the participants submitted information about their age and experience using mobile devices, they were given a demonstration showing how to complete the task. Then, the participants had some training performing the task while seated on a stationary chair.

The data collected during the training sessions was not saved. Upon completion of five training tasks in a row, the participants proceeded to the experiment. During the experiment, every task representing a different condition was repeated five times, with 10 letters to be selected in each condition. To obtain consistent data, the tasks were performed in a random sequence. This allowed reducing the bias due to the anticipation that the participants might gain through repetition. Every participant performed the task 15 times in total – riding a vehicle on a road with small, moderate, and large unevenness.

Roads are characterized by a variety of parameters: texture, longitudinal, transversal and vertical unevenness, horizontal curvature and so on (Prażnowski, Mamala 2016). In the current study, we did not attempt to evaluate each type of road unevenness. Instead, we measured road unevenness as a general indicator using the accelerometer data of the mobile device. Hence, we obtained deviations from the ideal version of the road in x, y, and z axes. Then, these deviations were added to evaluate the general quality of the road. This allowed us building three different categories: the roads with small unevenness, moderate unevenness, and large unevenness (Fig. 2).

For the current investigation, we chose roads in the vicinity of Vilnius featuring small unevenness (Fig. 2, a), regular moderate unevenness (Fig. 2, b), and large irregular unevenness (Fig. 2, c).

During the experiment, the vehicle moved at a constant speed of 50 km/h with an error of ±5 km/h. The accelerometer data corresponding to the three different road types are shown in Fig. 2, d, e, and f.

Results

All participants were able to complete the task on their own. Results from each session were recorded into a file.

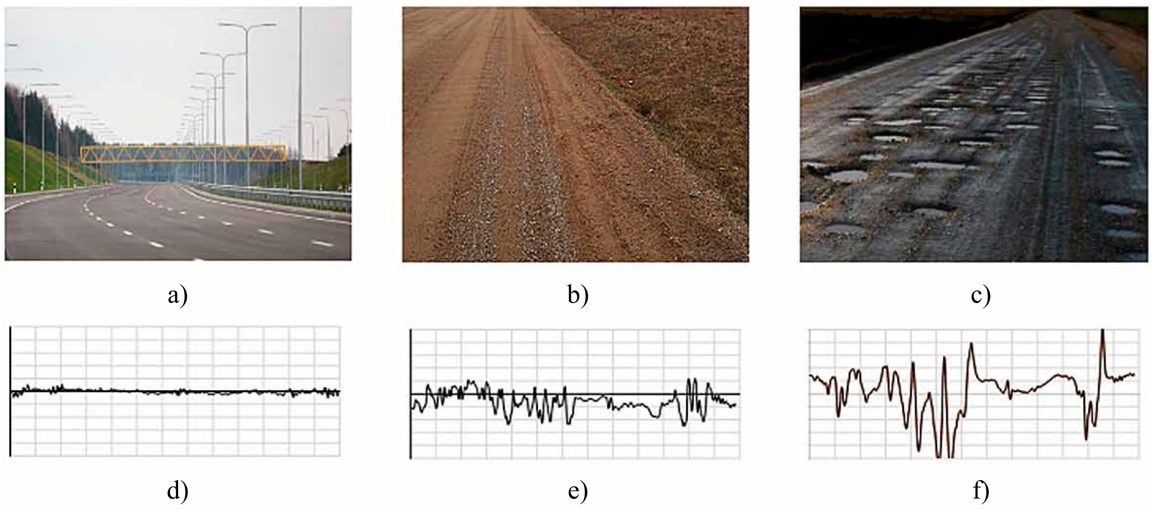

Fig. 2. The road with a) small unevenness, b) moderate unevenness, and c) large unevenness and summed data of three axis of accelerometer of road with d) small unevenness, e) moderate unevenness, and f) large unevenness

Each record consisted of task completion time (Fig. 3), error rate (Fig. 4), and movement efficiency (Fig. 5). Error rate is defined as the ration between erroneous selections and correct selections. For instance, three erroneous selections will yields the error rate of 3/10 = 30 %, since each task involves ten correct selections. Meanwhile, movement efficiency is the ratio of the length of the ideal path (i.e., straight line) connecting targets and the length of the actual path covered by the ball.

The results reveal that task completion time was the shortest when riding the vehicle on the smooth road. In this condition, it took on average almost 25 seconds for the participants to complete the task. Meanwhile, in the road with moderate unevenness condition, mean task completion time increased to more than 35 seconds. When riding the vehicle on the road with large unevenness, task completion time extended to approximately 47 seconds.

To help reveal the impact of different road conditions on tilt-based text entry, one should investigate two additional parameters, the error rate and movement efficiency. Error rate is expressed in percentage, and it is equal to zero in the ideal case. In the road with small unevenness condition, the error rate does not exceed 33%; moderate unevenness condition – 50% and large unevenness condition –52%. We expected a larger difference between the error rates corresponding to the moderate and large unevenness conditions. This might be attributed to the fact that hitting the required square was much more challenging

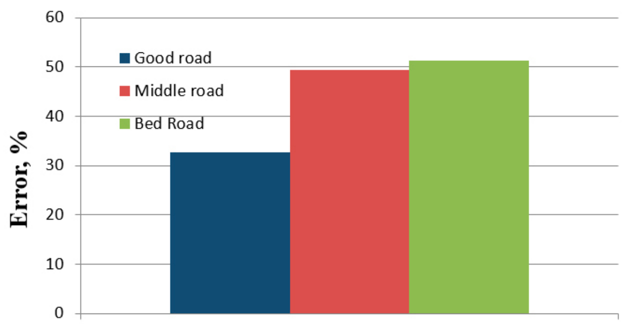

Fig. 4. Mean error rates for all conditions

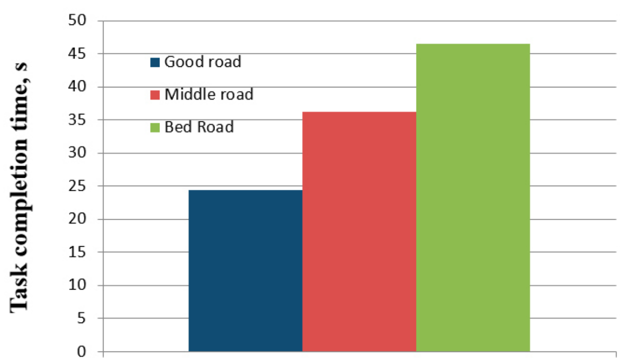

Fig. 3. Mean task completion times

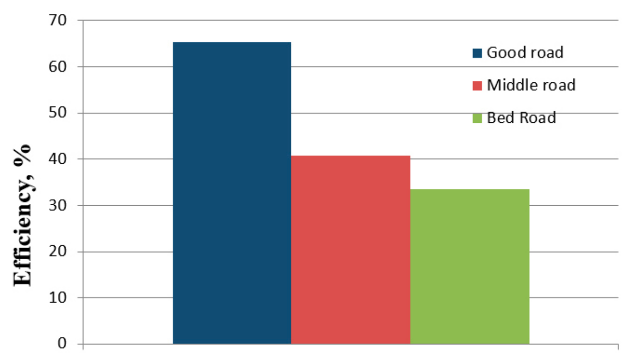

Fig. 5. Mean movement efficiency for all conditions

while riding on the road with large unevenness. In turn, this reduced the chance for erroneous selection making the observed difference less evident.

The best movement efficiency (≥65%) was observed in the road with small unevenness condition (Fig. 5). In the moderate unevenness condition, this parameter reduced to below 41%. Finally, movement efficiency was below 34% in the large unevenness condition.

Conclusions

1. The results of this study show that tilt-based interaction can be used as a text entry technique while riding in a vehicle as a passenger.
2. The impact of road unevenness on the quality of text entry is significant. Mean task completion time was found to be: 24.5 seconds in the small unevenness condition, 36.5 seconds in the moderate unevenness condition, and 46.5 seconds in the large unevenness condition. The error rate was found to be 32.6% in the small unevenness condition and even 51.3% in the large unevenness condition.
3. Movement efficiency was the highest (65.3%) in the road with small unevenness condition and only 33.5% in the large unevenness condition. This trend could probably be explained by the higher degree of focus demonstrated by the participants when required to perform the task under more challenging conditions.

Acknowledgement

We thank I. Scott MacKenzie from York University, Toronto, Canada, for valuable guidance in this field of research and sharing the original experimental software.

References

Alapetite, A.; Boje, A. H.; Morten, H. 2009. Acceptance of speech recognition by physicians: a survey of expectations, experiences, and social influence, *International Journal of Human-Computer Studies* 67(1): 36–49. https://doi.org/10.1016/j.ijhcs.2008.08.004

Cuaresma, J.; MacKenzie, I. S. 2014. A comparison between tilt-input and facial tracking as input methods for mobile games, in *Proceedings of Conference 2014 IEEE Media Entertainment*, 22–24 October 2014, Toronto, Canada, 70–76. https://doi.org/10.1109/GEM.2014.7048080

Dabrowski, K.; Slaski, G. 2016. Method and algorithm of automatic estimation of road surface type for variable damping control, *Materials Science and Engineering* 148(1): 1–10.

Marzo, A.; Bossavit, B.; Hachet, M. 2014. Evaluating controls for a point and shoot mobile game: augmented reality, tilt and touch, in *2014 IEEE International Symposium on Mixed and Augmented Reality – Media, Art, Social Science, Humanities and Design (ISMAR-MASH'D),* 10–12 September 2014, Munich, Germany, 1–4.

Granlund, J. 2008. *Health issues raised by poorly maintained road networks* [online], [cited 03 April 2017]. Swedish Road Administration. 146 p. Available from Internet: http://www.roadex.org/wp-content/uploads/2014/01/Health-Issues-RIII.pdf

Ljubic, S.; Glavinic, V.; Kukec, M. 2014. Predicting upper-bound text entry speeds for discrete-tilt-based input on smartphones, *Journal of Interaction Science* 2(3): 1–15. https://doi.org/10.1186/s40166–014–0003–6

Ljubic, S.; Kukec, M.; Glavinic, V. 2013. Tilt-based support for multimodal text entry on touchscreen smartphones: using pitch and roll, in *Proceedings of 7th international conference on Universal Access in Human-Computer Interaction: applications and services for quality of life*, 21–26 July, Las Vegas, USA, 651–660.

Newman, K. E.; Hobbs, E.; Blei, M. 2013. A tablet based hands free interface to nurse communication in the standard hospital room for limited mobility patients, *Information Engineering Letters* 3(3): 50–56.

Prażnowski, K.; Mamala, J. 2016. Classification of the road surface condition on the basis of vibrations of the sprung mass in a passenger car, *Materials Science and Engineering* 148(1): 1–10. https://doi.org/10.1088/1757–899x/148/1/012022

Rahman, M.; Gustafson, S.; Irani, P.; Subramanian, S. 2009. Tilt techniques: investigating the dexterity of wrist-based input, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2009)*, 4–9 April, Boston, USA: 1943–1952.

MacKenzie, I. S.; Teather, R. J. 2012. FittsTilt: the application of fitts' law to tilt-based interaction, in *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design (NordiCHI 2012)*, 14–17 October, Copenhagen, Denmark, 568–577.

KELIO NETOLYGUMŲ ĮTAKOS AKSELEROMETRU GRĮSTAI MOBILIOJO ĮRENGINIO TEKSTO ĮVESČIAI TYRIMAS

D. Miniotas, A. Katkevičius, D. Plonis

Santrauka

Greitai besivystant mobiliųjų įrenginių technologijoms vienas iš perspektyvių teksto įvesties būdų yra teksto įvestis naudojant mobiliojo įrenginio akselerometrą. Buvo atliktas kelio kokybės įtakos įvesčiai taikant ekselerometrą tyrimas. Kelio kokybė buvo nustatoma naudojant to paties akselerometro duomenis. Tyrimai parodė, kad važiuojant geros kokybės keliu užduotis atliekama per 24,5 sekundės. Blogėjant kelio kokybei užduoties atlikimo laikas ilgėja. Kartu blogėja ir vidutinės klaidos bei vidutinio judesio efektyvumo rezultatai.

Reikšminiai žodžiai: mobilioji teksto įvestis, pokrypio įvestis, klaviatūros dydis, kelio nelygumai.