REACH: Enabling Single-Handed Operation on Large Screen Mobile Devices

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ABSTRACT

Categories and Subject Descriptors

H.5.2 [**Information interfaces and presentation**]: User Interfaces—graphical user interfaces

General Terms

Design, Experimentation, Human Factors

Keywords

Data analytics

1. INTRODUCTION

2. RELATED WORK

Many researchers have suggested that the devices should be intelligent enough to detect user's situation for better support as in [9] and [13]. For instance, *ability based design* aims to find the best match between the ability of the users and the interfaces [19]. There are also researches to recognize the activity of users on devices (also known as *activity recognition*). Choudhuri *et al.* [2] built a wearable device with sensors to detect the activity of the users. In [16], Laerhoven used an accelerometer in a phone to recognize different motions of walking, climbing stairs, *etc.* Schmidt *et al.* [13] also used accelerometer but to detect both the user movement and the place of the device itself whether it is in the hand or on a table or in a suitcase. GripSense [4] used gyroscope and vibration motor to classify the user's touches based on the pressure on the screen. There is also many studies in the context of detecting hand postures. Harrison *et al.* [6] and Kim *et al.* [12] used touch sensors to detect the pattern of user's grips on mobiles. Furthermore, Taylor and Bove [15] used accelerometers to improve the detection of the changes in the grip dynamically.

Many researchers also studied hand posture on devices to make them more intelligent and interactive to the situations caused by posture. For instance, Wobbrock *et al.* [20] studied different hand postures and measured the finger performance with mobile devices. Holz *et al.* [8] have evaluated systematic error in selecting the target with finger touch. Researchers [7, 17, 11] also found that mobile interfaces are designed for double-handed operation although users may prefer to use one single hand. Karlson *et al.* [10] studied those interfaces and evaluated the performance of thumb mobility on those interfaces. Azenkot and Zhai [1] showed that different hand postures lead to different touch patterns, thus, effect the performance of typing on mobile devices. AppLens and LaunchTiles [11] designed interfaces based on different thumb gestures for one handed interactions.

Fitzmaurice *et al.* [3] introduced the idea of "graspable user interfaces" where you can control the interface by interacting with a physical object. SqueezeBlock [5] is an implementation of this idea in which it provides haptic feedback according to the level of "squashiness" on a physical object. Wimmer *et al.* [18] deployed optical fibers into a surface of device to detect grasping pressure. Harrison *et al.* [6] used FSRs for squeezing pressure detection. Strachan and Murray-Smith [14], used muscle tremor as a form of input to detect pressure on devices by leveraging accelerometer logs.

3. DESIGN OF REACH

3.1 Hardware design of REACH

3.2 Building the Grip Classifier

In addition to the hardware implementation by selecting appropriate force sensors and locating them in the appropriate places around the mobile device, we also build the classifier for the hand grip. In this section, we discuss how we collect force sensor values from mobile device for training and how we implement the classifier for grip pattern detection. We then used the model to predict the pattern in realtime manner.

We selected three grip pattern classes in our prototype: Hold, Squeeze, and Reach. In Hold, the subject holds the device without any activity on device. In Squeeze, the subject is applying the squeeze-force on the device and in Reach, the subject is moving his thumb finger to reach the top of the device while he is holding the device. After we identified the grip pattern classes, we collected the training data from 3 subjects. Each subject was asked to perform Hold, Squeeze, and Reach for 3 times. The 12 force sensors around the device continuously generated data at ***Hz and we calculated three metrics; mean, variance, and delta variance as features to train a classifier model. Therefore, the training data from each grip consists from **** numerical values and the final data consists from **** numerical values for each grip pattern.

For training the model, we used the Weka (Witten & Frank 2005) machine learning library for Android API. We used Bayesian network, Naive Bayes and Support vector machine for training the model on the collected data. We performed off-line training on a laptop and extracted the parameters of the best model to implement the realtime version of REACH.

4. EVALUATION

4.1 Off-line Evaluation

4.2 Realtime Evaluation

5. CONCLUSIONS AND FUTURE WORKS

6. REFERENCES

[1] S. Azenkot and S. Zhai. Touch behavior with different postures on soft smartphone keyboards. In *Proceedings of the 14th International Conference on Human-computer Interaction with Mobile Devices and Services*, MobileHCI '12, pages 251–260, 2012.

[2] T. Choudhury, S. Consolvo, B. Harrison, J. Hightower, A. LaMarca, L. LeGrand, A. Rahimi, A. Rea, G. Bordello, B. Hemingway, et al. The mobile sensing platform: An embedded activity recognition system. *Pervasive Computing, IEEE*, 7(2):32–41, 2008.

[3] G. W. Fitzmaurice, H. Ishii, and W. A. S. Buxton. Bricks: Laying the foundations for graspable user interfaces. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '95, pages 442–449, 1995.

[4] M. Goel, J. Wobbrock, and S. Patel. Gripsense: using built-in sensors to detect hand posture and pressure on commodity mobile phones. In *Proceedings of the 25th annual ACM symposium on User interface software and technology*, pages 545–554. ACM, 2012.

[5] S. Gupta, T. Campbell, J. R. Hightower, and S. N. Patel. Squeezeblock: Using virtual springs in mobile devices for eyes-free interaction. In *Proceedings of the 23Nd Annual ACM Symposium on User Interface Software and Technology*, UIST '10, pages 101–104, 2010.

[6] B. L. Harrison, K. P. Fishkin, A. Gujar, C. Mochon, and R. Want. Squeeze me, hold me, tilt me! an exploration of manipulative user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 17–24, 1998.

[7] K. Hinckley and H. Song. Sensor synaesthesia: Touch in motion, and motion in touch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '11, pages 801–810, 2011.

[8] C. Holz and P. Baudisch. Understanding touch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '11, pages 2501–2510, 2011.

[9] P. Johnson. Usability and mobility; interactions on the move. In *First Workshop on Human Computer Interaction with Mobile Devices*, 1998.

[10] A. K. Karlson and B. B. Bederson. Understanding single-handed mobile device interaction. Technical report, 2006.

[11] A. K. Karlson, B. B. Bederson, and J. SanGiovanni. Applens and launchtile: Two designs for one-handed thumb use on small devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '05, pages 201–210, 2005.

[12] K.-E. Kim, W. Chang, S.-J. Cho, J. Shim, H. Lee, J. Park, Y. Lee, and S. Kim. Hand grip pattern recognition for mobile user interfaces. In *Proceedings of the National Conference on Artificial Intelligence*, volume 21, page 1789, 2006.

[13] A. Schmidt, K. A. Aidoo, A. Takaluoma, U. Tuomela, K. V. Laerhoven, and W. V. d. Velde. Advanced interaction in context. In *Proceedings of the 1st International Symposium on Handheld and Ubiquitous Computing*, HUC '99, pages 89–101, 1999.

[14] S. Strachan and R. Murray-Smith. Muscle tremor as an input mechanism. 2004.

[15] B. T. Taylor and V. M. Bove Jr. Graspables: grasp-recognition as a user interface. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 917–926. ACM, 2009.

[16] K. Van Laerhoven and O. Cakmakci. What shall we teach our pants? In *Wearable Computers, The Fourth International Symposium on*, pages 77–83. IEEE, 2000.

[17] L. Weberg, T. Brange, and A. W. Hansson. A piece of butter on the pda display. In *CHI '01 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '01, pages 435–436, 2001.

[18] R. Wimmer. Flyeye: Grasp-sensitive surfaces using optical fiber. In *Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction*, TEI '10, pages 245–248, 2010.

[19] J. O. Wobbrock, S. K. Kane, K. Z. Gajos, S. Harada, and J. Froehlich. Ability-based design: Concept, principles and examples. *ACM Transactions on Accessible Computing (TACCESS)*, 3(3):9, 2011.

[20] J. O. Wobbrock, B. A. Myers, and H. H. Aung. The performance of hand postures in front- and back-of-device interaction for mobile computing. *Int. J. Hum.-Comput. Stud.*, 66(12):857–875, 2008.