Imagining In-Air Interaction for Hemiplegia Sufferer

Zhihan Lv
FIVAN, Valencia, Spain
Email: lvzhihan@gmail.com

Haibo Li
Royal Institute of Technology (KTH)
Stockholm, Sweden
Email: haibli@kth.se

Abstract—In this paper, we described the imagination scenarios of a touch-less interaction technology for hemiplegia, which can support either hand or foot interaction with the smartphone or head mounted device (HMD). The computer vision interaction technology is implemented in our previous work, which provides a core support for gesture interaction by accurately detecting and tracking the hand or foot gesture. The patients interact with the application using hand/foot gesture motion in the camera view.

I. INTRODUCTION

Nowadays, the society appeals all the people to devote sympathy and concern to paralysis sufferers, in which hemiplegia sufferers have the most amount and suffer paralysis of one side of the body. The research about experiencing of being a hemiplegia sufferer is this kind of social contribution [21]. Besides, there have been quite a lot of software and hardware research about virtual rehabilitation tool design and development for hemiplegia currently [4] [2] [8] [5], which are also this kind of contributions for hemiplegia. The purpose of our research is not a rehabilitation assistive tool, however, provides a new low-cost hand and foot interaction approach for hemiplegia. Currently, the related research have been conducted [10] [17] [3] mostly on the specific expensive devices, which cannot be consumed by hemiplegia patients in poor economic condition. The specific game designed for cerebral palsy sufferer are already proved [6] [7], the input device is however designed for common player. A leapmotion based interactive game is designed for stroke sufferer [9].

Recent research in mobile phone computing has led to a number of input techniques that allow for spatial input by hands beyond a touchscreen, all provide a level of spatial input in a mobile setting. Some hemiplegia patients prefer feet since their hands have lost touch of sense. Considering handheld computing various foot gesture detection and tracking system have been proposed such as multitoe, foot tapping. We designed hand and foot gesture interaction on handheld devices or vision based wearable device such as google glasses. The ‘anywhere’ [18] and ‘connectivity’ [1] are two marked features of current mobile device which met our practical demand, beside of low-cost.

In this paper, we imagine to utilize our touch-less interaction approach for hemiplegia, where patient wearable vision based head-mounted-device (HMD) and performs 'in air' interaction gestures using fingers or feet. The amount of hemiplegia sufferers is much high. In our clinical sample database, there are sixty hemiplegia sufferers, but no any monoplegia sufferers.

II. TOUCH-LESS INTERACTION

Four wearable applications to illustrate and explore different use cases (as shown in Figure 2), have presented [11]. The applications are respectively 'Social media site launch' and 'Bouncing ball game' for hand (finger) gesture, as well as 'Football game' and 'Foot-Play Piano' for foot gesture. Accordingly, we report on a user study comparing usability and emotions at VR2015 [13]. We expect the patients to perceive the touch-less approach as being stretched from his/her hand/foot for manipulating content on the virtual scene of the applications and augmented graphic feedback is brought to the vision. In order to complete this interaction loop, our system maps and updates the physical hand/foot onto the glasses projector. The system has been demonstrated [14].

III. IMAGINATION OF SCENARIOS

The practical scenarios have been presented before. In this paper we imagine that the player is a hemiplegia sufferer who is using the applications, and we will see to what extent the touch-less interaction technology could be used by hemiplegia sufferers.

In the Wearable Circle Menu app, a round-shape menu can lunch several popular social media sites. Patients can rotate the suspended circle menu and select the icon using finger gesture in air. To access the required icon, one can make the circle menu rotating and select any icon. The expected icon can be selected and unselected by the same gesture. The Bouncing ball game is a handball court with a camera view overlay. An augmented reality glove image is rendered following the finger gesture. The handball always bounces back and forth on the court area until it’s into the goal or the sufferer intercept and hold it. When the sufferer holds the ball, he can dribble the ball to the desired position by slowly swing finger or throw the ball by swing finger fast. 'Football game' and 'Bouncing ball game' have the nearly same game rulers beside active controlling body are respectively foot and hand. In the Football
game, the sufferers use real foot to kick the ball. In the Foot-
Play Piano application scenario, a circle progress plate is on
the right-top corner of the screen, which is used to show how
long the sufferer press the piano key; eg. semi-circle is a half
mora. When the volume up button is pressed , the application
starts to look for the movement of the foot through camera.
When a collision is detected with any of the augmented piano-
key, the code related to that key is generated by the program,
and the circle progress plate whirls until the sufferer release
the piano key.

IV. CONCLUSIONS

The touch-less interaction solution provides a low-cost
solution which is also potentially applicable to wear on other
body parts for example tongue. The therapist suggests that
the full hand motion is easier for hemiplegia sufferers than
finger motion. We believe that it’s entirely possible to be
equipped on hemiplegia sufferers for their daily interaction.
The touch-less interaction technology is also suitable for future
rehabilitation application. Touch-less interaction technology
has been planed to widely apply in many fields range from
everyday entertainment [12] [22] to traditional research fields
such as geography [19] [15] [16] and biology [20].

ACKNOWLEDGMENT

The authors would like to thank Pablo Gagliardo and
Sonja Blasco for fruitful discussion and clinical suggestions,
and thank Dr. Alaa Halawani and Dr. Shafiq Ur Rehman for
previous work. The authors thank to LanPercept, a Marie
Curie Initial Training Network funded through the 7th EU
Framework Programme (316748).

REFERENCES

[1] O. Amft and P. Lukowicz. From backpacks to smartphones: Past,
present, and future of wearable computers. IEEE Pervasive
Computing, 8(3):8–13, 2009.
[2] S. Bhat. Touchtone: An electronic musical instrument for children with
hemiplegic cerebral palsy. In Proceedings of the Fourth International
Conference on Tangible, Embedded, and Embodied Interaction,
TEI ’10, pages 305–306, New York, NY, USA, 2010. ACM.
[3] M. Bouri, C. Baur, R. Clavel, C. J. Newman, and M. Zeddka. handrea:
A new hand and wrist haptic device for hemiplegic children. In ACHI
2013, The Sixth International Conference on Advances in Computer-
Human Interactions, pages 286–292, 2013.
[4] S. Cho, K. Han, H. Lee, J. Park, I. Y. Kim, S. I. Kim, J. Ku, and
Y. J. Kang. Effect of proprioception training of patient with hemiplegia
by manipulating visual feedback using virtual reality; The preliminary
results. In Proceedings of the 2009 IEEE Virtual Reality Conference,
VR ’09, pages 283–284, Washington, DC, USA, 2009.
[5] H. J. Choi, Y. S. Kim, D. S. Park, and H. J. Kang. Effects of wheelchair-
based rehabilitation on the physical functions and health perception of
stroke patients. Personal Ubiquitous Comput., 17(7):1365–1372, Oct.
2013.
[6] H. A. Hernandez, T. Graham, D. Fehlings, L. Switzer, Z. Ye, Q. Bellay,
M. A. Hamza, C. Savery, and T. Stach. Design of an exergaming
station for children with cerebral palsy. In Proceedings of the SIGCHI
Conference on Human Factors in Computing Systems, pages 2619–
2628. ACM, 2012.
[7] H. A. Hernandez, Z. Ye, T. Graham, D. Fehlings, and L. Switzer.
Designing action-based exergames for children with cerebral palsy.
In Proceedings of the SIGCHI Conference on Human Factors in
Computing Systems, pages 1261–1270. ACM, 2013.
[8] S. H. Johnson, G. Sprehn, and A. J. Saykin. Intact motor imagery
in chronic upper limb hemiplegics: Evidence for activity-independent
action representations. J. Cognitive Neuroscience, 14(6):841–852, Aug.
2002.
[9] M. Khademi, H. Mousavi Honordi, A. McKenzie, L. Dodukian, C. V.
Lopes, and S. C. Cramer. Free-hand interaction with leap motion
controller for stroke rehabilitation. In CHI’14 Extended Abstracts on
Human Factors in Computing Systems, pages 1663–1668. ACM, 2014.
[10] J. Kim, S. Hwang, R. Sohn, Y. Lee, and Y. Kim. Development of an
active ankle foot orthosis to prevent foot drop and toe drag in hemiplegic
patients: A preliminary study. Appl. Bionics Biomechanics, 8(3,4):377–
384, July 2011.
[11] Z. Lv. Wearable smartphone: Wearable hybrid framework for hand and
foot gesture interaction on smartphone. In 2013 IEEE International
Conference on Computer Vision Workshops, pages 436–443. IEEE,
2013.
[12] Z. Lv, G. Chen, C. Zhong, Y. Han, and Y. Y. Qi. A framework for
multi-dimensional weigbs based interactive online virtual community.
Advanced Science Letters, 7(1):215–219, 2012.
[13] Z. Lv, L. Feng, S. Feng, and H. Li. Extending touch-less interaction
on vision based wearable device. In Virtual Reality (VR), 2015 iEEE.
IEEE, 2015.
[14] Z. Lv, L. Feng, H. Li, and S. Feng. Hand-free motion interaction on
google glass. In SIGGRAPH Asia 2014 Mobile Graphics and Interactive
Applications. ACM, 2014.
[15] Z. Lv and T. Su. 3d seabed modeling and visualization on ubiquitous
context. In SIGGRAPH Asia 2014 Posters, page 33. ACM, 2014.
[16] Z. Lv, T. Su, X. Li, and S. Feng. 3d visual analysis of seabed on
smartphone. In Visualization Symposium (PacificVis), 2015 IEEE
Pacific. IEEE, 2015.
[17] S. Maeshima, A. Osawa, D. Nishio, H. Hiran0, K. Takeda, H. Kigawa,
y and Y. Sankai. Efficacy of a hybrid assistive limb in post-stroke
hemiplegic patients: a preliminary report. BMC neurology, 11(1):116,
2011.
[18] P. Mistry, P. Maes, and L. Chang. Waw - wear ur world: a wearable
gestural interface. In CHI ’09 Extended Abstracts on Human Factors in
Computing Systems, CHI EA ’09, pages 4111–4116, New York, NY,
USA, 2009. ACM.
[19] T. Su, Z. Lv, S. Gao, X. Li, and H. Lv. 3d seabed: 3d modeling and
visualization platform for the seabed. In Multimedia and Expo
Workshops (ICMEW), 2014 IEEE International Conference on, pages
1–6. IEEE, 2014.
[20] A. Tek, B. Laurent, M. Pizzi, Z. Lu, M. Chavent, M. Baaden, O. Dela-
lande, C. Martin, L. Piccinali, B. Katz, et al. Advances in human-protein
interaction-interactive and immersive molecular simulations. Biochem-
istry, Genetics and Molecular Biology “Protein-Protein Interactions-
Computational and Experimental Tools”, pages 27–65, 2012.
[21] S. Wesugi. Design approach of simulation exercise with use of device
and its significance: Design of novel device for realistic experience of
being a hemiplegia patient. HCI International’13, pages 315–324,
Berlin, Heidelberg, 2013. Springer-Verlag.
[22] M. Zhang, Z. Lv, X. Zhang, G. Chen, and K. Zhang. Research and
application of the 3d virtual community based on webvr and ria.
Computer and Information Science, 2(1):P84, 2009.