A Study of Kinect-Based Smart TV Control Mode

He Li, Jing Qiu, and Long Gao

School of Mechatronics Engineering,
University of Electronic Science and Technology of China
2010082020004@std.uestc.edu.cn, qiujing_2000@hotmail.com,
764819527@qq.com

Abstract. TV plays a more and more important role in daily life. And it will be a protagonist in our home. However, the progress of smart TV control mode did not catch up with the development of smart TV's software and hardware. In this paper, a survey was conducted to confirm the way of future smart TV control mode. According to the results of the survey, an experiment was executed in order to investigate design parameters of the new smart TV control mode. Therefore, the precautions on design the smart TV control mode was proposed.

Keywords: Kinect; Gesture Control; Smart TV Control Mode.

1 Introduction

As a common household device in daily life, TV is becoming more and more important. It is an obbligato entertainment terminal for home as well. However, the traditional TV can only receive real-time and specific programs provided by Medias. Though this kind of TV can be simple and convenient, it cannot satisfy the people's requirements of diversity and intelligent (Liu, 2011; Dahl, 2008). Accompanied with the requirements, smart TV is appeared as a part of smart home (Bjorkskog, 2007). Compared with traditional TV, smart TV also contains the functions such as web search, game etc. A study was conducted to investigate the relationships between smart TV advertisement and consumer's behavior in USA. The results indicated that smart TV is necessary as an important element to enrich the current media plan (YuMe Company, 2013).

Recently, a few types of the smart TV have been commercially marketed, e.g. Google smart TV, Samsung smart TV, Haier smart TV. Since 2006, the number of applying for patents in the field of smart TV is about 1200[Wang, 2012].However, the studies on smart TV control mode do not catch up with the development of hardware and software. Fu Yong and his fellows applied the technique of Gyroscope and Acceleration Sensor, proposed and realized a new concept of smart TV controller (Fu et al., 2012). However, this method is still based on the concept of traditional TV control mode. The disadvantages of the traditional TV control mode (Chang et al., 2012):

Along with the increasing of household electronic devices, there are more and more controllers in our homes. The operators can be confused because of the controllers;

P.L.P. Rau (Ed.): CCD/HCII 2014, LNCS 8528, pp. 174–183, 2014.

- The way, that controls traditional TV by pressing the buttons, cannot meet the operator's requirements of natural and intelligent for human-computer interaction;
- Along with the increasing of controlling functions, the traditional TV controller turns to be clumsy;
- Traditional TV controllers cannot meet the requirements on functions and applications of smart TV.

Hence，the society urgently needs a new TV control mode. The new control mode will be human-centered and can make the interaction between human and machine more fluent what's more it can enrich the user's experience (Sun et al.,2012). Cox. D et al. also proposed a concept that transfers the method of game control to TV [Cox et al., 2012].

In 2010, Microsoft published the Kinect that as a new game device. As a revolutionary human-computer interaction device, the Kinect can cause a revolution in human computer interaction (Sun, 2012; Chen, 2013). A Kinect sensor has three cameras. Two of cameras generate the deep images; the remaining generates the color image. Meanwhile, a Kinect sensor has a microphone array composed with 4 microphones. Hence, it can realize the functions, e.g. motion capture, speech input, image recognition, speech recognition (Chen, 2013).This visual sensing unit can real-time track and record the space position of 20 joints of the body in the rate of 30 frames per second using a space Cartesian (Zhang, 2012).

In recent years, studies on the application of human-interaction based on Kinect gradually increased. Chen has been studied the gesture recognition, proposed the technology path of application, and used it to teaching practice (Chen,2013). Wang et al. proposed an application of Kinect and created a three-dimensional animated character based on the bone points (Wang et al., 2012). Chang and his fellows proposed the technical framework for a new Kinect-based control mode, and proved the feasibility of Kinect-based smart TV control mode (Chang et al., 2012).

In the current study, the aim is to figure out the smart TV control mode's development tendency. Meanwhile, the key issue is to propose a better control mode for smart TV in terms of technical parameters.

2 Methods

2.1 Experiment Design

Intending to confirm the new smart TV control mode, a survey about TV control mode was conducted by means of questionnaire. The questionnaire consisted of two parts:

- Background information, e.g. name, gender, age, home address, live time.
- TV control mode information: 42 questionnaires of present and future TV control modes were proposed.

In order to achieve our purpose mentioned above, some results will be presented as follows:

- For the question "Your vision for the future TV control mode", the result shows that almost a half of interviewees preferred body control to be new smart TV control mode.
- For the question "In the circumstance of no TV remote controller, which body action do you want to use to control the TV?",50% of interviewees supported hand control to be new smart TV control mode.
- For the question "In the circumstance of no TV remote controller, which hand action do you want to control the TV", 88.2% of interviewees preferred to use wave for controlling a new smart TV.

Based on the results of the survey, an experiment was executed to define technical parameters for a hand-wave control mode. The detailed purposes are as follows:

- to define an envelope space that all participants' motions confined in it;
- to define an average instantaneous velocity of wave that was used to control the smart TV;
- to evaluate usability of the proposed smart TV control mode.

In this experiment, a background questionnaire was developed to collect participants' habits and perspectives on watching TV, e.g. TV condition, participants' attitude to tradition TV control mode, and TV remote controller. The method of Wizard of Oz was used in the experiment (Mäkelä et al., 2001) (S. Carbiniet al. 2006), so that the participants could wave naturally their hands. During the experiment, a tester controlled actually TV as participants waved their hands to 'control'. The ways for TV controlling were as follows: wave right for next channel; wave left for front channel; wave up for sound increase; wave down for sound decrease; drawing the corresponding arabic numerals for specific channel; and drawing a circle for return (Fig. 1).

During the experiment, two situations for TV controlling were considered: sitting posture and standing posture. For each posture, 28 times for hand wave were designed: 5 wave left, 5 wave right, 5 wave up, 5 wave down, 4 arabic numerals, and 4 circles.

A questionnaire was developed to collect participants' perspectives of the new smart TV control mode. Five questions were included in this questionnaire:

- 'Your satisfaction towards this TV control mode',
- 'Do you think it is difficult to control this TV by this way for you', for this two questions five options were set, as for very satisfied, satisfied, ordinary, no, never. 'Do you think this TV control mode effective'
- 'Do you think the TV control mode is easy to learn'
- 'The control actions reasonable?'

Fig. 1. The ways for TV controlling

2.2 Participants

During the experiment, 21 volunteers (11 males, 10 females) were recruited from our university. Their ages ranged from 19 to 24, with an average age of 22±1.33. 21 volunteers come from 10 provinces of China, and 90.48% of volunteers lived in their hometown more than 10 years.

2.3 Experiment Material and Equipment

During the experiment，a 32-inch Changhong TV was placed in front of a test room. A Kinect was placed on TV. A computer was connected the Kinect to record participants' 'controlling' hand movements. Furthermore, a chair for participants was putting front of the TV. The distance between them is 3m. A remote TV controller was used to control TV (Fig. 2).

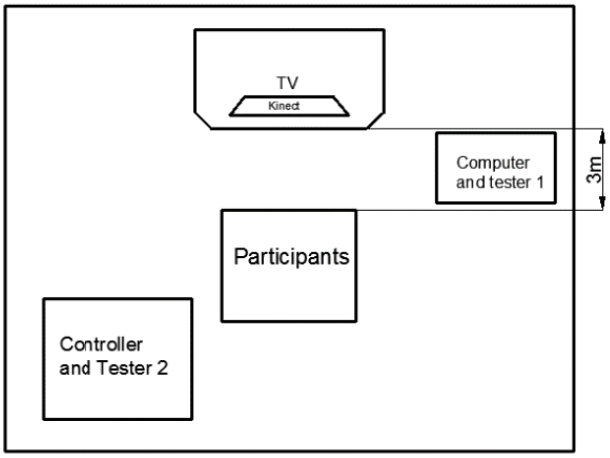

Fig. 2. The Experiment Room

2.4 Procedure

At the beginning of the experiment, the participants were asked to fill a background questionnaire. Participants were explained exactly how to control the smart TV front of them by waving hand. All wave actions for each posture were tested randomly one by one. Then the participants sit ahead the TV. A tester issued instructions for control commands, e.g. next channel, sound decrease, return. According to the instructions, Participants wave their hands to 'control' the TV. Meanwhile, the other tester controlled the TV by remote controller beyond participants' views. After that, the participants were required to control the TV by stand posture. At the end of the experiment, a questionnaire was delivered to participants to collect their attitude toward the new proposed smart TV control mode. The whole process takes about twenty minutes.

2.5 Data Collection and Analysis

Kinect can generate a space Cartesian refers itself, X-axis in the horizontal direction, Y-axis in a vertical direction, Z-axis in a front and rear direction, the original point is in the center of Kinect (Fig. 3). Hence, Kinect was used to collect the experiment data, including the real-time position of 20 joints all over the body and the moving speed of the wrist.

Wrist was tracked for determine envelope space. In order to analyze the wrist movement data generated by Kinect, valid control motions were defined. For example, the starting point of control motion for wave up was defined to be the start of the valid control motion, and the highest point defined to be the end of the valid control motion. Then, the frames corresponding with the valid control motion were selected from the video produced by Kinect during the experiment. Hence, the value of

X-Coordinates, Y-Coordinates, Z-Coordinates of wrist was selected. The maximum and the minimum values could be determined. Therefore, an envelope space could be determined, in which all valid control motions were confined.

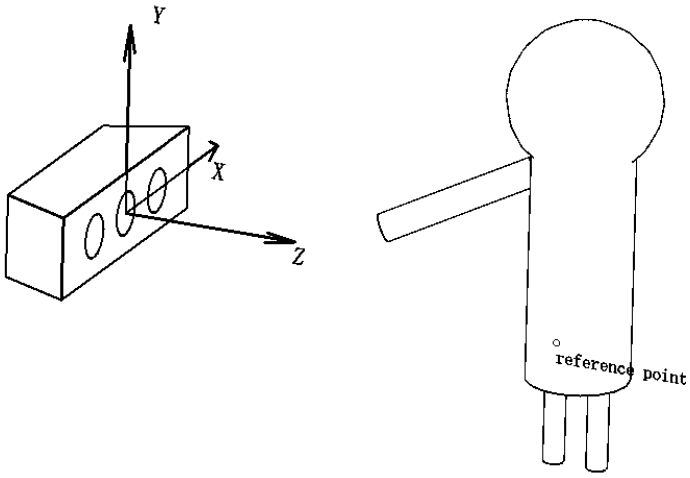

Fig. 3. Cartesian of Kinect

Furthermore, hip center was selected as reference point in standing posture; shoulder center was selected as reference point in sitting posture. Thus, not only the envelope space but the distance between envelope space and human body can be calculated (Fig. 4).

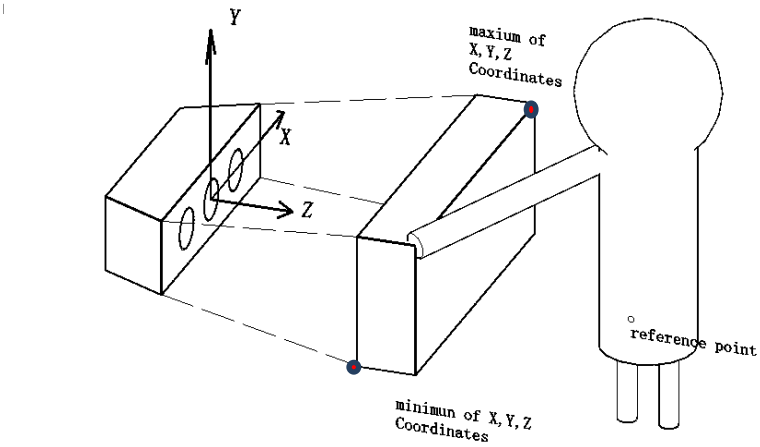

Fig. 4. Envelope Space in Standing Posture

The distance between two frames was calculated using Function (1).

$$d=\sqrt{(x_1 - x_0)^2+(y_1 - y_0)^2+(z_1 - z_0)^2} \quad (1)$$

Kinect can track and record the space position of 20 joints of the body in the rate of 30 frames per second, so the time between two frames can be calculated by Function (2).

$$t=\frac{1s}{30}=0.033s \quad (2)$$

Hence the speed between two frames can be calculated by Function (3).

$$v=\frac{d}{0.033s} \quad (3)$$

According to calculating the average speed of several frames which composing a valid control motion, a valid control motion's average speed was found.

2.6 Results

This experiment, 21 volunteers' 588 motions was collected and analyzed. Table 1 shows the space envelope of standing for both sexes. Male's range of actions is larger than female's. The space envelope of sitting posture for both sexes was presented in Table 2. The similar results as standing posture can be observed from Table 2. Male's range of actions is larger than female's in sitting posture.

Table 1. Standing space envelope for Male and Female

	Max.(m)	**Min.(m)**	**Range(m)**	**Reference point(m)**
			(Male/Female)	
X (m)	1.9285/0.2673	1.2165/-0.5980	0.7120/0.8654	-0.0431/-0.1675
Y(m)	3.0707/0.8273	2.1838/0.0119	0.8869/0.8155	0.0149/0.1815
Z(m)	2.5992/2.1917	2.5092/1.7164	0.0899/0.4752	2.3004/2.1021

Hence, Male's range of actions is larger than female's for both sitting and standing postures. This reason may owe the difference in gender or males are more powerful than female. Meanwhile, standing posture's range of actions is larger than sitting posture, for the reason that participants be more active when they stood.

Furthermore, the average speed of all motions is 1.2957m/s. And the maximum speed of all motions is 4.4998m/s. It was found that males' speed is faster than females'. The reason may be difference in gender. And males were more active than female.

Table 2. Sitting space envelope for Male and Female

	Max.(m)	Min.(m)	Range(m)	Reference point(m)
Axis		**(Male/Female)**		
X	0.8666/0.2675	0.4496/-0.4941	0.4170/0.7616	0.0043/-0.1762
Y	2.4767/0.3629	2.2014/-0.3813	0.2753/0.7443	0.3024/0.1318
Z	1.8601/2.1836	1.4653/1.8280	0.3948/0.3557	2.0890/2.2181

For the five questions of acceptability for our proposed mode, Fig.5 illustrates the results of perspectives of the participants. According to Fig.3, 81% of them show their satisfactions toward the new control mode. 76% of them hold that it is easy to operate. All of them reported it was easy to learn. 95% of them reported the actions to control TV was reasonable.

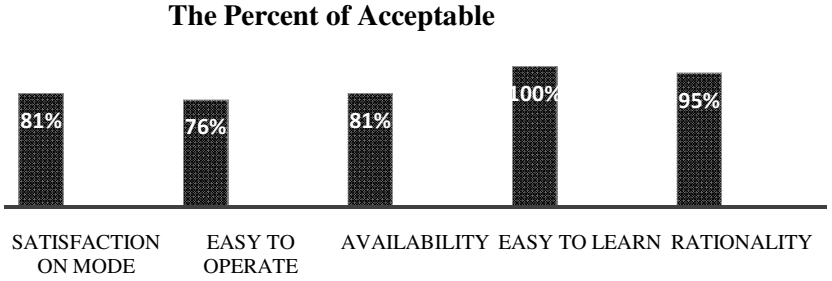

Fig. 5. Acceptability for proposed mode

3 Discussion

According the experiment, we put forward the new smart TV control mode design ideas:

- For instructions: during the stage of creating the smart TV instructions, it should pay more attention to the forms of instructions based on our results. Such as, the range of instructions should within the space. A large space or long distance may cause discomfort for the users, and make them be tired easily. A small space or short distance may result in a situation of uncertain;
- For instruction's speed: it should be noticed of definition of the speed of instructions. A fast speed would increase the burden on the users. Meanwhile, a low speed may cause some uncertain situations;
- For guidance to control: A guide should be designed for operators to control TV. For example, an instruction should be displayed in a special place of the scream during controlling TV. To release operators' burden in remember control motions;

- For feedback: The mechanism of feedback allows the operators to confirm their operations which he/she is going to give out, hence TV can executive orders more exactly.

4 Conclusion

By means of questionnaire, a new gesture-based smart TV control mode was proposed. Furthermore an experiment was conducted to draw design ideas and design parameters of Kinect-based Smart TV control mode. According to the results of availability evaluation, the new control mode is available and satisfied. Kinect as an advanced and full-featured mutual device, owing to the functions like motion capture and joint tracking, provides a platform for this new smart TV control mode. This study has significance toward the appearance of new smart TV control mode.

In the future, we emphasize more functions for smart TV. Meanwhile, we should emphasize the way that human-computer interaction, which more intelligent and convenient.

Acknowledgement. This study was supported by the Natural Science Foundation of China(71201017)and the National Higher-education Institution General Research and Develop-ment Funding (ZYGX2012J101).

References

1. Liu, G.H.: Research and implementation for television program search system of interactive TV., Dissertation. Fudan University, Shanghai (2011)
2. Dahl, Y.: Modeling human-computer interaction in smart spaces: existing and emerging techniques. In: Asai, K. (ed.), Human Computer Interaction: New Developments (2008), http://www.intechopen.com/books/human_computer_interaction_new_developments/modeling_human-computer_interaction_in_smart_spaces__existing_and_emerging_techniques
3. Björkskog, C.: Human computer interaction in smart homes. Seminar on Human-Computer Issues in Ubiquitous Computing , Department of computer Science, University of Helsinki (2007), https://www.hiit.fi/u/oulasvir/58307110/smarthomes.pdf
4. YuMe Company: Understanding the smart TV user (January 20, 2013) http://www.yume.com (retrieved)
5. Wang, X.: The interactive technology on Smart TV patents. IC Application 10, 14–15 (2012)
6. Fu, Y., Ping, T.T., Zhou, M.Y.: Design and implementation of new human-computer interaction space of flat panel TV's remote controller. TV Technology 36, 27–29 (2012)
7. Chang, Z.W., Huang, J.F., Han, C.X.: Somatosensory control technology on TV. Radio and TV Information 03, 89–90 (2012)

8. Sun, M.H.: Research and Implementation of 3D recognition technology on television system based on human-computer interaction. Dissertation. Qing Dao: Ocean University of China (2012)
9. Cox, D., Wolford, J., Beardsley, D.: An evolution of game controllers and tablets as controllers for interactive TV applications. In: Proceedings of 14th ACM International Conference on Multimodal Interaction (ICMI 2012), pp. 181–188. ACM, New York (2012)
10. Chen, J.: Kinect-based gesture recognition technology and its application in teaching, Dissertation, pp. 1–6. Shanghai Jiaotong University, Shang Hai (2013)
11. Wang, X.: Ma Qiang, Wang Wanliang. KINECT driven 3D character animation using semantic framework. In: Proceedings of IEEE CCIS2012, Hangzhou, China (2012)
12. Zhang, D.: Discussion on Kinect applications. Logistics Engineering and Management, Sixth 34, 39–41 (2012)
13. Mäkelä, K.: Esa-Pekka Salonen, Markku Turunen, Jaakko Hakulinen, Roope Raisamo.: Conducting a Wizard of Oz Experiment on a Ubiquitous Computer System Doorman. In: Proceedings of the International Workshop on Information Presentation and Natural Multimodal Dialogue (2001)
14. http://www.doc88.com/p-3611626504250.html
15. Carbini, S., Delphin-Poulat, L., Perron, L., Viallet, J.E.: From a wizard of oz experiment to a real time speech and gesture multimodal interface. In: Signal Process (2006), http://zbmath.org/?q=an:05623216
16. Shin, D.-H., Hwang, Y., Choo, H.: Smart TV: are they really smart in interacting with people? Understanding the interactivity of Korean Smart TV. Behaviour& Information Technology, pp.156–172 (2013)
17. Lee, S.-H., Sohn, M.-K., Kim, D.-J., Kim, B., Kim, H.: Smart TV interaction system using face and hand gesture recognition. In: IEEE International Conference on Consumer Electronics (ICCE), Shenzhen (2013)
18. Lee, W.-P., CheKaoli, Huang, J.-Y.: A smart TV system with body-gesture control, tag-based rating and context-aware recommendation. Knowledge-Based Systems 56, 167–178 (2013)
19. Junyi, X., Alfredo, S.R.: A real-time respiratory motion monitoring system using KINECT: proof of concept. Medical Physics 36, 2682 (2012)
20. Choppin, S., Wheat, J.: The potential of the Microsoft Kinect in sports analysis and biomechanics. Sports Technology 6, 78–85 (2013)
21. Kozono, K., Aoki, M., Ono, M., Kamikawa, Y., Arimura, H., Toyofuku, F.: SU-E-I-92: Accuracy Evaluation of Depth Data in Microsoft Kinect. Medical Physics 39, 3646 (2012)