Development of Functional Game Contents Using Wireless Acceleration Sensor

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Summary
Members of a silver generation have relatively lower ability of perception, learning and mobility due to physical decline. The need to develop and provide game contents to elderly people is emerging to help them maintain physical and mental health, to utilize leisure time and engage in healthy activities. In this research, functional game contents are proposed that involve overall physical exercise with focus on upper body muscles to promote health and leisure activity of elderly people. The proposed content is a 'rowing game' that helps to use upper body muscles, with application of interactive interface and wireless acceleration sensor for easy use. In the rowing game, two pairs of wireless acceleration sensors perceive acceleration value of a player's movement, and a parameter can be generated by identifying pattern of movement. Physical characteristics of elderly people need to be considered in designing game contents to facilitate game operation.

Key words:
Silver generation, Rowing Game, Acceleration sensor,

1. Introduction

Development of civilization and medical science brought about higher quality of living and longer life span, leading to emergence of an aging society. With advancement of electronic technology and wide distribution of computer, graphic design techniques have been greatly enhanced with significant impact on cultural contents business. In a digital contents market, leisure space for a silver generation has become an important issue. Instead of providing space for simple, traditional leisure activities, it is necessary to develop game contents that have beneficial effect in aspect of education, psychology, therapy and health condition. Functional game adds educational, training and therapeutical benefit to entertainment[1][2].
The primary purpose of a game is entertainment and play, and functional game adopts a social dimension that includes education, welfare, health management, skill training and medical benefit. Functional game can be divided into several types according to subjects, e.g. education/learning, public policy, political/social issues, health, business, military affairs, advertisement, project and medical science.
Encouraged by success of Nintendo, world-class IT corporations like Microsoft and Electronic Arts are now actively engaging in developing functional games[3][4]. Functional game is acclaimed as a new business item to inspire next-generation technology. In advanced countries such as U.S. Japan and Europe, functional games are widely in use in fields of politics, education, therapy and treatment, and related research is actively underway. Meanwhile, in Korea, systematic studies have not been carried out on the subject, and as a result, combining game with various social fields has not been very active. Especially, game contents for a silver generation are practically non-existent; even if there is, elderly people find it hard to access due to difficult interface[5]. Due to physical decline, elderly people have relatively lower ability of perception, learning, intellectual activity and physical movement. Thus, it is important to develop user interface that caters to silver contents. This research proposes a 'rowing game' with focus on exercise of upper body movement, by using interactive interface and wireless acceleration sensor to ensure easy access of a silver generation

2. Related Work

Recently, bolstered by success of Nintendo, global IT corporations including Microsoft and Electronic Arts are enthusiastically developing new game contents, accelerating 'functional evolution' of game. Currently, some of the well-known game contents for elderly people include Wii Fit(Nintendo), 'Braining Training', ‘Drum Master', 'Gate Touch' and 'Speed Touch' .

Fig. 1 'Wii Fit'

One year after introduction of Wii Sports, Nintendo released Wii Fit; called 'Healthpack,' the software even more focused on health and physical training than its predecessor Wii Sports. It uses a scale called 'balance

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board' as a controller. Wii Fit provides four activities: yoga, physical training, balance game and aerobics [3].

'Drum Master' was developed by researchers of Kyushu Medical School in Japan, to prevent Altzheimer's disease. A dance game requires prompt response as it challenges a player to push buttons that pop up according to music. In Sumo match, a player alternately pushes two buttons to push the other out of the match arena. In drum-making game, a player should put the materials falling on the screen into a box to build a big drum.

Nintendo's 'Brain Training for Adults' is not exactly an entertainment-oriented game. It contains medical and educational contents for adults, consisting of number, words and puzzle games. Some hospitals are equipped with Nintendo DS in ward or waiting room for elderly patients.

Nintendo's health-oriented games 'Yoga Anywhere' and 'Pilates Anywhere' combine elements of game and physical training. The console helps to measure physical condition of a player, and provides balance age.

NGU Co., Ltd. developed interactive games 'Gate Touch' and 'Speed Touch' to revitalize mental and physical activities of elderly people. 'Gate Touch' is an interactive indoor gate ball game that has equal exercise effect as a real match. The online game overcomes restriction of space and weather condition. It provides online and offline game mode as well as training mode. One can play remotely to have tournament matches online. 'Speed Touch' lets a player to touch balls on the screen. It enhances immersion and interaction by engaging a player's both hands[1].

Fig. 2 interactive games 'Speed Touch'

In the "Gyeonggi Provincial Boat Show" that took place in Hwaseong City, 'Duck Game' was introduced, to enjoy rowing indoor, which is a water sports to compete speed of rowing boats. Two or more players are needed to enjoy the rowing game. The simulation program is easily operable with a computer and a monitor[6]. 'RowPro' developed by Digital Rowing Inc. is an advanced 3D water sports program that provides Internet-based online racing game on a computer. Each movement of an indoor rower is transferred to 3D screen real-time, and a player can enjoy fitness and weight-watching programs provided by experts [7].

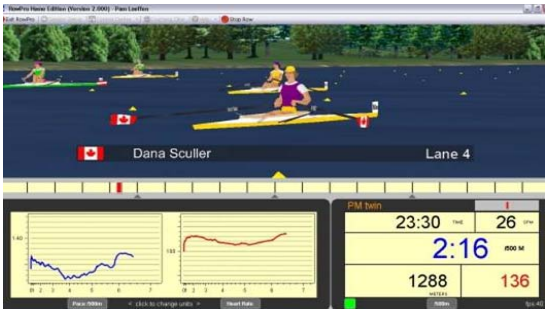

Fig. 3 'RowPro Game'

3. Functional Game Contents and Wireless Interface Technique

3.1 Functional game for a silver generation

Throughout the world, the proportion of elderly population is expanding rapidly since mid-20th century. In 2007, people over 65 years old in the South Korea was 4,810,000, 9.9% of the total population. In 2000, Korea entered into the aging society with 7.2% of aged population, and is expected to become the aged society in 2018 with 14.3% and the super-aged society in 2026 with 20.8%[8].

Social issues related to aging become keener and more significant. Many factors contribute to rapid increase of aging population, and some of the main contributors are extended life span due to medical advancement, increase in single family, increase in solitary elderly family due to early death of spouse and higher life expectancy of women. Due to physical decline, elderly people's bone structures change and the bodily dimensions decline with aging, accompanied by weakening of sensory organs.

A brain tends to lose power of learning, memory and perception with aging. Alzheimer's disease rises as a serious issue in an aging society. In preventing aging-related illnesses, functional game contents can play a crucial role by improving elderly people's ability for learning, perception, judgment and memory.

It can improve quality of living for a silver generation, while preventing illness. In developing game contents for the elderly, it is important to ensure easy visibility and interface, communication with others, role and contribution of elderly people as members of a society, by taking into account physical, psychological and mental condition of a silver generation.

Comprehensive consideration should be made in developing game contents for a silver generation to enhance their physical function, fulfill social needs, and diversify game platforms

3.2 Wireless interface

For a silver generation to have true-to-life experience of virtual environment or game, 'interaction' between virtual environment and a player is crucial. Wireless interface is more suitable for elderly people than line interface. Common interfaces of keyboard and mouse are contents-dependent and reduce degree of immersion. A touch screen or button type depends on a user input and thus passive in interaction. Also, it may not be suitable and inconvenient for a silver generation. Virtual environment in first-person perspective enables highest degree of immersion, but it requires special devices such as HMD (head mounted display), data glove or data suit. Therefore, for the purpose of the study, a functional game was developed using wireless interface environment that uses ZA sensor to perceive a player's movement and location for active interaction. ZA sensor consists of Zigbee sensor for wireless communication and 3-axis acceleration sensor. For a system and communication, IEEE 802.15.4 standards were used; Zigbee and acceleration sensor operated on TTL-level RS-232C communication.

To estimate real-time location of a moving object, minimum three points are required. In the study, four fixed nodes were used. Coordinates for each fixed node were set as, (x_1, y_1), (x_2, y_2), (x_3, y_3), and the present location of a mobile node was set as (x, y). According to Pythagorean Theorem, distance between mobile node and fixed nodes can be calculated as shown in (Formula 1).

$$\begin{aligned} d_1^2 &= (x-x_1)^2 + (y-y_1)^2 \\ d_2^2 &= (x-x_2)^2 + (y-y_2)^2 \\ d_3^2 &= (x-x_3)^2 + (y-y_3)^2 \end{aligned} \quad (1)$$

Here d_1, d_2, d_3 indicate value of RSSI (Received Signal strength indication). Since location of fixed nodes is given, an arm's location and movement can be tracked by estimating location of nodes with , , values.

3.3 Movement perception using acceleration sensor

Acceleration sensor utilizes acceleration data, and widely used in fields of automobile, aircraft, factory automation and robot control system. Recently, its application is expanding to mobile industries for mobile phone and games. Nintendo developed a Wii remote control with 3-axis acceleration sensor, which is acclaimed as a wireless joystick for the next generation.

Apple i-Phone and Samsung 'Anycall' also apply acceleration sensor to mobile phone and game operation. In this study, 3-axis acceleration sensor LIS3L02AL was used that was developed by STMicroelectorics. AD for sampling is 16bit ADC output, and its Vref (Reference Voltage) is 2.5V. AD value generated from movement of acceleration sensor can be converted to real acceleration value according to (Formula 2). Output value is 1.65V at 0, and shifts by ±660.

$$\begin{aligned} V &= AD/2^{16}*2.5 \\ A_x(g) &= (V_x - 1.65)/0.66 \\ A_y(g) &= (V_y - 1.65)/0.66 \\ A_z(g) &= (V_z - 1.65)/0.66 \end{aligned} \quad (2)$$

A_x indicates acceleration value on x axis; A_y on y axis; A_z on z axis. ‘g’ is unit gravitational value that the sensor tolerates. Acceleration values for each axis yield from the acceleration sensor AD value need to be converted to axis-specific rotational value to use as input data in virtual reality system.

Based on (Formula 3) the acceleration sensor yields axis-specific acceleration value for of gravitational value in perpendicular state of gravity. The acquired acceleration data can be converted to PITCH, ROLL and YAW through arcsin.

$$\begin{aligned} \text{PITCH} &= asin(A_x/g) \\ \text{ROLL} &= asin(A_y/g) \\ \text{YAW} &= asin(A_z/g) \end{aligned} \quad (3)$$

The acceleration data, PITCH, ROLL and YAW are used as interactive information in two modes. The first uses only PITCH value to perceive a player's movement; it determines arm's movement according to gradient of PITCH value, interacting with the virtual environment of the game. The second uses ZA sensor to activate a row in a rowing machine. All PITCH, ROLL, YAW values are used to control rowing game and direct a camera.

4. Functional Game Contents

Due to the aging phenomenon of the body, the silver generation is reduced in their dimensions of various parts of the body along with changes in the skeletal structure and show the phenomenon of decline or fall of sensory organs depending on their degree of aging phenomena. Therefore, for those functional games for the silver generation, interfaces that are easy to see and easy to operate, activation of communication with others and roles and contributions as members of society are important as results of considerations of physical, mental and psychological environments of the silver generation.

To develop games for the silver generation, the developer should understand elderly persons in diverse ways and the games should be configured to be more easily understandable and convenient compared to those games used by young people.

In this research, wireless acceleration sensor is used to program a rowing game for upper body exercise as functional game contents. The game has interactive qualities, as it lets a player exercise abdomen and thigh parts as well as overall upper body. Based on 3D game engine, the rowing game applies wireless acceleration sensor, control technology for real-time interaction with ZA sensor, in order to enhance immersion and interactive quality of the game. To display realistic graphic, special effects and sounds are employed in the game background. To display realistic view of water, physical properties of water are truthfully visualized including wavelength, wave, friction, buoyancy and gravity, helping players to better concentrate on the game. The rowing game operates in a practice or competition mode. It perceives five movements including driving, and three levels of practice—basic, intermediate, advanced. In the competition mode, a player is challenged to move forward to the goal, acquiring various items on the way (available exercise time: 10 min, 20min, 30min). Figure 4 illustrates overall system configuration of the rowing game.

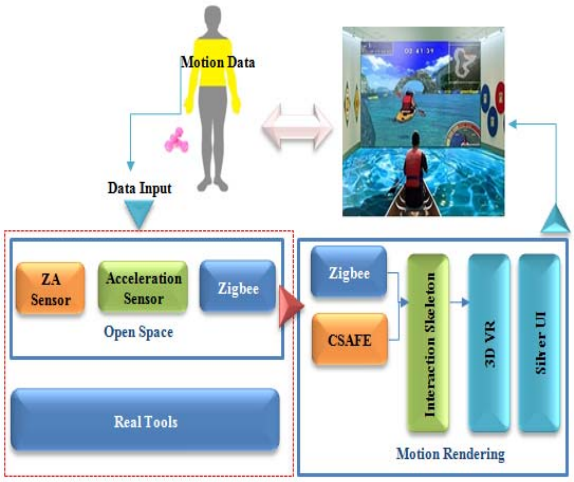

Fig. 4 overall system configuration

To utilize wireless acceleration sensor in the rowing game, a central technology is to transfer a player's movement to the system. In this research, the goal is to activate a sensor without interruption from equipment restriction.

According to a player's characteristics, values that are entered into each sensor node are recognized as pattern and transferred to the hardware. By using 3-axis acceleration sensor, a player's movement is analyzed for changing motion pattern. Real-time motion data are generated and analyzed to applied to the game contents. The hardware and contents adopted Zigbee wireless communication protocol.

Figure 5 presents a monitoring program to check on communication between the sensor and the system; the graph illustrates movement of a player's seat when the left row is in action and the right row is still.

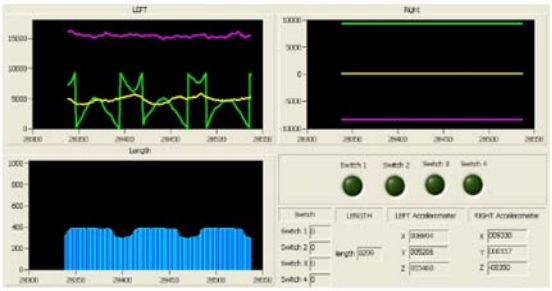

Fig. 5 Check Movement of a player's seat, left/right row

Figure 6 shows a monitoring program for changing volume of acceleration data that uses two acceleration sensors to acquire motion data, measure vertical and horizontal advancement, height from a default location and pace of changing height.

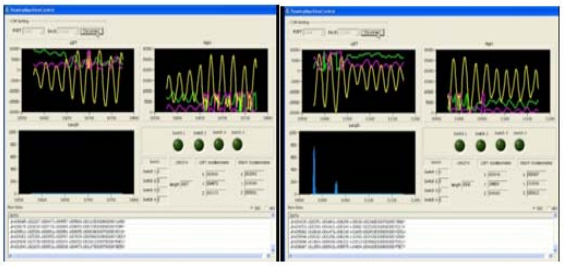

Fig. 6 Monitoring program

Figure 7 displays the acceleration sensor and fixed node Zigbee, interactive interfaces used for the experiments.

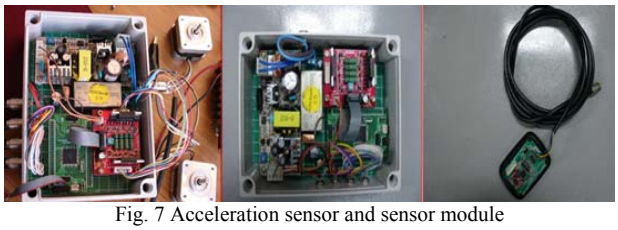

Fig. 7 Acceleration sensor and sensor module

Figure 8 shows a rowing game screen using both wireless and line communication.

Fig. 8 Rowing game screen(wireless and line communication)

Figure 9 shows the characters appeared in this paper and Figure 10 displays a rowing game screen using the left, right row.

Fig. 9 Game characters

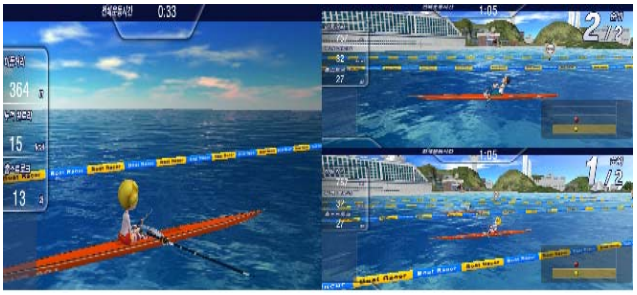

Fig. 10 A rowing game screen

The functional game contents in research focus on training of upper body and parts of lower body to promote physical exercise. For this purpose, interactive interface is designed to enable free movement and enhance exercise effect. Figure 8 captures a screen from the rowing game.

5. Conclusion

Currently, the volume of aging population is steadily on the rise throughout the world. Aging society is emerging as the most critical social issue of our time. Members of a silver generation have relatively poor ability of perception, learning and intellectual activity, as well as physical activity and mobility. Thus, it is essential to develop user interface that is suitable for silver contents.

Considering this, the research suggested a proposal for functional game contents with physical training effect to help leisure activity and health condition of elderly people. A rowing game was developed, using easy interactive interface and wireless acceleration sensor to be accessible to a silver generation. In the game, two pairs of wireless acceleration sensors acquire acceleration data from a player's movement and define pattern of movements. Based on the data, parameter for the game is generated, to be applied to game programming in consideration of physical characteristics of elderly people.

The proposed game contents are based on virtual reality 3D modeling and adopted colors and layout that feel comfortable and friendly to elderly people. The interactive interface promotes exercise effect, and the game is expected to encourage elderly people to enjoy leisure activities and engage in physical exercise. A game console will be designed to promote software development and distribution of game contents so that elderly people can enjoy various kinds of games with interactive interface.

Acknowledgments

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References

[1] JeollaNamdo, "JunNam U-Silver Culture Contents Policy Forum", 2008.
[2] Hyun-Cheol Lee, Eun-Seok Kim, Im-Chul, Kang and Gi-Taek Hur, "A Study on the Functional Silver Game Contents and Interface Technology", IJCSNS, VOL.9 No.6, June 2009.
[3] http://www.nintendo.co.kr/
[4] http://www.exergamekorea.co.kr
[5] J.A. Kim, K.K. Kang, X. Li, S. Ming, "A Study on the Development a Sensory Gate-Ball Game for the Aged People", Journal of Korea Game Society, 7(4), 13-21, 2007.
[6] http://www.koreaboatshow.org
[7] http://www.concept2.co.kr/home/i-row.htm
[8] Eun-Seok Kim, Hyun-Cheol Lee, Beom-Seok Kim, Gi-Taek Hur, "A Method of Functional Game Design for the Silver Generation", Journal of Korea Multimedia Society Vol.13, No.1, January 2010.

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