Development of Force-Feedback Device for PC-Game using vibration

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ABSTRACT
Among recent technologies that are applied to game development, virtual reality part is getting much attention for its technological effectiveness in transmitting game processing circumstances in variety that are happening in game world very realistically. In this study we analyze interface for game that is based on a action realization technology and force-feedback technology among technologies for developing virtual reality, in other words, technical analogy on game controller and the positive and negative sides of game controller for each platform. Based on that, more ordinary and effective way to deliver the functions to users in PC game field where application of force-feedback technology is least satisfied. And, Force-Feedback device has been developed to satisfy the users' needs by using vibration.

Categories and Subject Descriptors
K.8.2 Hardware

General Terms
Performance

Keywords
Game Controller for PC game. Hardware design.

1. INTRODUCTION
When defining game in concept, it is composed of following three parts. They are player who actually enjoys the game, game world that is creation of game developer, and interface that works as the link that connects the other two compositions. Player and game world can communicate by pre-agreed acting method in condition that game developer intended or did not predict. And, this kind of acting method is called interaction. Game world shows a variety of feedback that stimulate sense of sight, hearing and touch, as the reaction to the actions of player. According to the level of delivery on players' reaction, it becomes crucial part that it will command the reality and action of game.

Virtual reality technology in game is an important factor to express the actions in game world and to compose the game with reality[1]. Recognition for possibility and necessity on application of virtual reality technology in these perspective is already well known. Thus, simulator technology that has been continuously studied in arcade game market is being an issue. But, study on game feedback system that is applied to console game or PC game except for arcade game is very limited.

This study analyzes how game feedback system that increase the action and reality of game by using the sense of touch, is realized, and kinds and characteristics of feedback device in platforms. Especially, kinds and functions of personal feedback system that is used in PC game field, are analyzed in this study. And, it also discusses the difficulty of realizing the feedback system compared to other platforms. As a result, new device that compromises the problems in personal feedback system that is applied to PC game of present, has been developed.

This device is mainly focused on compromising the negative side that presently developed and marketing other products are exclusively for the small number of mania, compared to the devices for other purposes. It was developed to be more general and a convenience to the player. Also, cost of device was maintained at low price to be competitive in the market. It is designed to operated as sub-device for PC, as well as game device at the same time. Presently, this device has been developed for testing and pending for patent..

2. ACTION REALIZATION TECHNOLOGY AND FORCE FEEDBACK TECHNOLOGY

Normally, when elements for sense of sighting and touch are both provided, it raises the perception of human more effectively[2]. Also, according to the human characteristics of sense, a person recognizes the change of surrounding environment faster with the reaction of touch, compared to with

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the reaction of sighting[3]. Therefore, it is very important to apply reaction of sense of touch to the game interface.

Sense of touch can be classified as a part in sense of skin among body sense in small meaning, but normally it is understood as one of 5 senses, which are sense of sighting, hearing, smell, taste and touch. In this case, it means the skin sense that feels through the skin in broad meaning[4][8]. Sense of touch is the most difficult part to have information, and is located in lower level, compared to other senses for its importance[5].

A person receives information from outside 20% by sense of hearing, 15% by sense of taste, 2% by the sense of smell. And rest of 60% of information is received by sense of sighting[6]. By analyzing these numbers, most important sense after sense of sighting and hearing that affects the information transferring system is sense of touch.

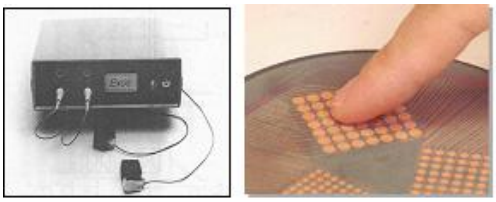

Figure 1. Touch Feedback Device & Sensor of Touch

Applying the sense of touch to the game field can be divided into 3 parts. There are Tactile technology[9] part that delivers sense of skin directly, force feedback technology part that recognizes transfer and reaction of power, and simulator technology part that realizes action[10].

Figure 2. Force Feedback Device. Phantom, Cybergrasp

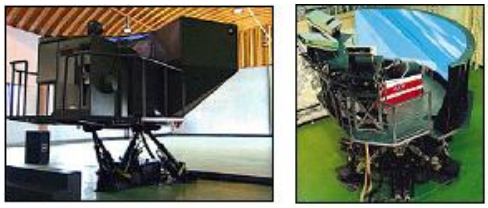

Figure 3. Simulator for Military affairs

3. GAME INTERFACE WITH WITH APPLICATION OF FORCE FEEDBACK TECHNOLOGY

3.1 Force Feedback technology in Arcade game field

Actually, game field that used application of force feedback technology aggressively is arcade game field. Because of characteristics of this technology, size of equipment is too big for an individual and price is too high. Therefore, it really fits well with arcade game field that provides players the large place to play compared to other game platforms. Therefore, arcade game field takes advantage of all the technologies mentioned above, and provides players maximum action and reality, and sense of touch and action, that is really close to real world.

Figure 4. Game Interface in Arcade game field

Arcade game not only make the game interface of game material same as real world, but also applies force feedback technology to maximize the reality of the game. This is especially shown in the type of arcade games that is called sense game or experience game.

3.2 Force Feedback technology in Console game field

Force feedback technology is also applied already to the console game field. It does not take a big a part as it does in arcade game part in actual game, but it was developed in the direction to help the field distinguish with other game field. Especially, most of presently developed and sold console game box is already equipped with controller for game exclusively with force feedback function. Therefore, game users who enjoy the console game, can feel the excitement of game that can not be felt in PC game through these exclusive controllers.

Figure 5. Console Game Controller, Duel Shock

As seen Picture 5, two different sized vibration motors are attached to exclusive controllers for console game, and it is designed to deliver the effect of presentation created by console game through the vibration effectively. Of course, this device is attached to game box in standard specification. Therefore,

console game that supports the force feedback function, can deliver the reality of game. Especially in the excellent games that matches processing of game and Force Feedback function appropriately, excitement that players can get, can not be compared to the games that does not do a good job. And there are other custom made special controllers for the characteristics of games, other than standard controllers, in the market. Controller, that is equipped as standard, only operates force feedback function with 'vibration', but custom made specially designed controllers for specific games, can be equipped separately to enjoy the games.

Figure 6. Game Controller for Console Game

Picture 6 shows the a variety of controllers for console games in the market. These controllers are made to match the contents of the specific games, according to the materials of games. Therefore, they can maximize the action and reality of game, and players will have easier timer to control the game process.

But, they are expensive and can not be used generally, compared to standard controllers. Except for a couple of controllers that are used commonly, such as racing wheel or light gun, they can not be used generally. Therefore only mania users purchase them.

3.3 Force Feedback technology in PC game field

Compared to application of Force Feedback technology in other platform, PC game field is not very active. PC game is created, based upon personal computer. Therefore, ability to express the game is not as good as those of console game box or arcade games. Same thing can be said to the function part of Force Feedback. MS-Direct-X, which is tool to make PC game, supports Force Feedback function to be realized, but there are not sufficient equipments to deliver it to players. Therefore only small number of action games supports force feedback function. Development of exclusive controller is also behind. There are not many controllers, except for game controllers for racing games and flight simulation games for mania, that supports Force Feedback function. Therefore players, who favors console games over PC games, point out the fact that action and reality are not as good in PC games as in console games. Picture 7 is the kind of exclusive game controller that supports Force Feedback, used in PC game. Joystick for flight simulation and Game-Wheel for racing games are the only exclusive game controllers that support force feedback function.

Figure 7. Game Controller for PC Game

4. COMPARISON AND ANALYSIS ON FUNCTION OF FORCE FEEDBACK FOR DIFFERENT PLATFORMS

Force Feedback technology applied in game field was developed distinctively in three different fields. First, it can be divided into arcade game part, console game part and PC game part. Arcade game field applied most for force feedback technology for its characteristics. Console game field applied force feedback technology into standard game controller. In the PC game field, it was developed focused on the controllers for the mania. Table 1 shows the supporting type and positive and negative sides of Force Feedback technology applied to each platforms.

Comparing PC games and console games, the biggest difference is whether game interface is exclusive controller or sub-controller. Console game basically has force feedback function in basic game interface used to proceed game. Therefore game developers can realize appropriate reality for game situation and it can be applied to every games. Players do not need to purchase device that supports force feedback function, except for special games.

But, in PC game, basic game interface is keyboard and mouse. Therefore, force feedback function is not included. Therefore, in order to experience the force feedback function, specific game interface device must be purchased separately.

Table 1. The comparative analysis against the Force Feedback technique which is applied with Game platform

	Strength	Weakness
Arcade Game	- Action realization is good - Action & Reality is good - VR Tech is applicable	- Very expensive - Space restriction is big - Use scope is narrow
Console Game	- Use scope is wide - Feedback function is included in basic controller - Not expensive - The addition of equipment does ease - There is not space restriction	- Action realization is not good
PC Game	- Not expensive - The addition of equipment does ease	- It is limited in specific game - Action realization is not good - Function is not included in basic controller

Because of this limitation, only specific games like military action game, racing game, flight simulation game, etc. has applied force feedback function in PC game. Example of applying simple force feedback function in mouse with small motor is in the market already like shown in Picture 8. But, as mentioned before, it disturbs the precise control during game play. Therefore it was turned away by users[7]. If there are devices that can use force feedback function better for PC game, it help express better and broader game world, and increase the reality and action that players will enjoy.

Figure 8. A Mouse using Vibration, Logitech Co.

5. DEVELOPMENT OF NEW FORCE FEEDBACK DEVICE, USING VIBRATION FOR PC

Looking carefully through analysis from the Table 1, it is found that each game platforms has their positive and negative sides. Especially, only for considering realization of reality, arcade game box is most excellent, and only for general use, console game box, which has built in Force Feedback realization function in standard controller is most sufficient. But, game for PC is far behind in functional and general matters, compared to other game platforms. It is due to the fact that presently, force feedback function for PC games is limited to the specific games, such as racing games or flight simulation games. And, also it does not have price advantage for customers to purchase easily.

Therefore, this study develops new force feedback device for PC game that will use the characteristics of PC, which sub-devices can be easily added, realize the maximum force feedback effect, and competitive in the market. Since the part for realizing action requires expensive equipments due to its technical characteristics, it is left out in the study. Realization of vibration at low cost is applied.

Especially, in order to compromise the negative side of existing PC game controller, that they can not be used for other purposes, basic functions of controllers are added carefully, just like in console games. PC uses generally mouse and keyboard for input device. Mouse with vibration function in picture 8 was turned way by the players, because of control problem, and keyboard could not be used properly for the same reason.

Wrist protector is developed for counterproposal. It is based on the fact that most PC users use the gel type wrist protector for keyboard or mouse. If vibration device of wrist protector type can be developed, it can generally be used as wrist protector, and can operate the function of force feedback device, using vibration while enjoying games to solve the negative side. Delivering the vibration may take a little longer than grip type console game exclusive controller, but it can be compromised with low price.

5.1 Hardware Technology Part

Core technology of developing hardware is to develop Device Driver that transfer vibration data, received through USB to two vibration motors that is built in inside wrist protector, and to deliver the vibration generated from vibration motors most effectively to the users.

< Main Technology >

- Using USB Controller built-in MCU (8bit or 16bit) : There are many types of MCU with built in USB Controller, but ADC16S310 from ADChips or TUSB3210from TI are used.
- Control of different kinds of appropriate vibration motor for the situation
- Supports Plug & Play
- Realizes Firmware Up Grade ?USB1.1 spec. : Because there are MCUs with built-in USB Controller that do not support the USB2.0, and this product does not require fast data transfer, USB 1.1spec that has good compatibility is used for development.

< Development Environment >

- EISC studio (GCC compiler)
- Keil 7.03a
- ORCAD 9.2.3

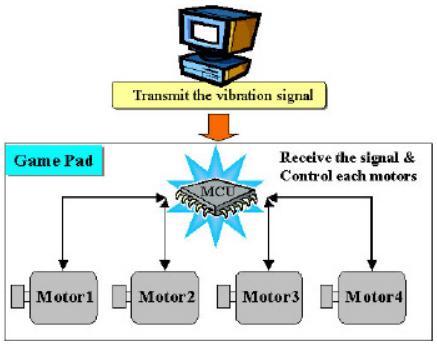

Figure 9. A diagram of general system structure

Picture 9 is general structural diagram. First, computer sends out the active signal, and it operates according to the signal. Active signals sent by computer can happen in various kinds of situation, and operations for each situation are not the same. Therefore, there must be many motors to realize the different feels of vibrations. And, the locations of motors are distributed well to deliver different kinds of feeling. For active signals from computer, data is sent by using USB port. Then, MCU inside vibration pad analyzes data received through USB and operates according to the data.

Picture 10 is a block diagram of Vibration pad's hardware part. In this diagram, USB and CPU is composed as one. And, it uses ROM and RAM to activate hardware, and there is separate booting location of Boot ROM for downloading

program of ROM to upgrade the product. I/O is controlled by using I/O port of MCU. Separate current drive circuit is created to increase the stability on current, because motor is the kind of device that uses much current.

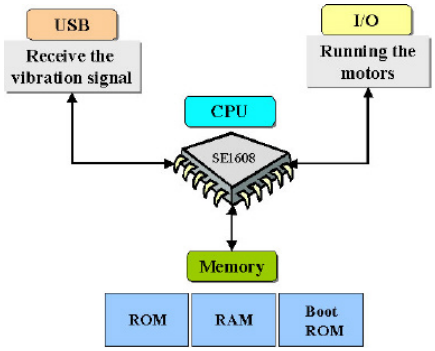

Figure 10. A Block diagram of Hardware

5.2 Software Technology Part

This device makes vibration pad operates according to the specific situations during the game process. For that, vibration information should be included inside game or vibration information must be included for the games that will be developed in the future. When these vibration information are inserted to the game, using Direct-X technology of Microsoft, it creates signal in hardware with these information, and in the end, vibration pad operates according to the situations of game process.

< Applied Technology >

- USB Device Driver : USB Device Driver lets computer recognize hardware
- Direct X : Uses DirectInput. It is controlling part that approaches hardware activated by USB Device Driver and activates actual vibration.
- Setting and Management Program : It sets up functions, such as the vibration level of vibration pad or vibration period

< Development Tool >

- Direct-X 8.1 SDK
- Visual C++ 6.0
- WDM DDK(Windows 2000 or NT)

In order to activate this device, USB Device Driver that controls hardware in PC must be generated.

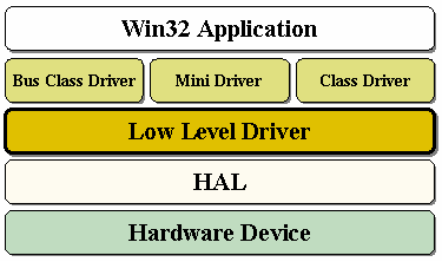

Figure 11. A Class Layer of hardware driver structure

In Picture 11, most important part in developing the device is the low level driver. Since this device operates with USB, attachment and detachment can be made during the operations, and at that moment, corresponding device must operate immediately. Device driver, like shown in Picture 12, needs to be developed and filter type driver needs to be developed for realizing wanted operation. In other words, when player detaches vibration pad during using computer, it operates same as other existing USB devices. Therefore, WDM DDK is used for low level driver development for developing vibration pad, and this device is controlled by using USB. Thus, in the end, vibration pad operates by developing driver, using filter type driver

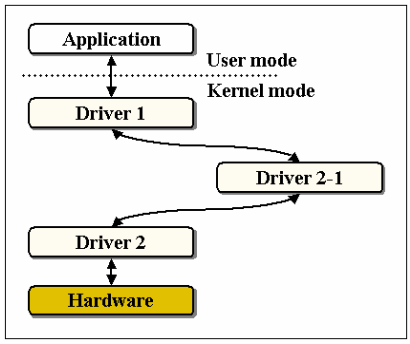

Figure 12. A Device driver structure of filter method

6. CONCLUSION & FUTURE DIRECTION OF DEVELOPMENT

This device has been developed for testing presently, and Picture 13 is the product design model of this device. Since wrist protector are in two types for mouse and keyboard, this device is also designed in two types. Effectiveness of this developed device is not yet inspected. But, it is very meaningful that general and low price device for PC game which is poorly developed so far, compared to realization of force feedback technology in other platforms, is developed. Also, it compromised the negative side that it is sub-device that can only be used for game by adding 'vibration' function for existing PC. And it also considered the convenience of users. This device is pending for a patent under the support from the Ministry of Information and Communication, and will be able compete in the market in short time.

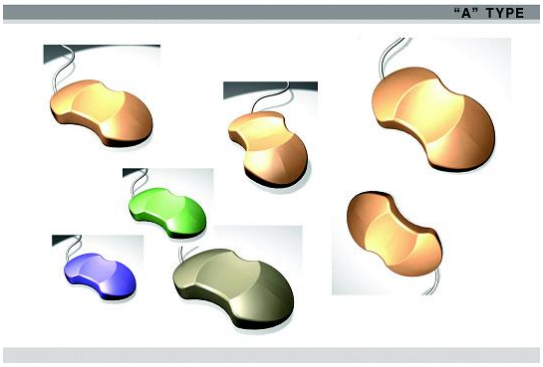

Figure 13. Product design of type A

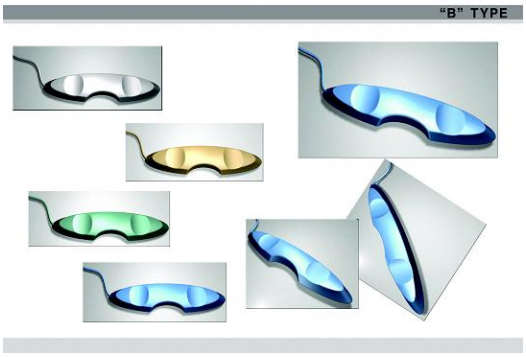

Figure 14. Product design of type B

For the direction of future development, it will be focused on the study of delivering the vibration that occurs in two small motors that are used in most effective way to player.

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