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# Development of convenient remote controller for Internet Protocol TeleVision (IPTV) based on absolute coordinates

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The existing TV remote controls with relative coordinates have some difficulties in selecting various types of Internet Protocol TeleVision (IPTV) content. To move from the current position to the destination with relative coordinates, it needs to delay time. To solve this problem, this paper proposes an absolute coordinates based remote control to make the selection of IPTV channels more convenient for consumers. It uses a laser pointer to point at an IPTV, a camera mounted the remote control to locate the spot pointed, and control software to calculate the absolute coordinates of the spot pointed on the screen. We design and implement the proposed remote control, and perform comparative experiments in order to demonstrate the effectiveness of the proposed approach. It is easy to use, convenient, and more accurate in comparison with existing products.

***Keywords:*** Internet Protocol TeleVision, IPTV, remote control, absolute coordinates

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## INTRODUCTION

Internet Protocol TeleVision (IPTV) (Xiao 2007) is a system through which digital television service is delivered using internet protocol, while other TVs use traditional radio frequency broadcast or cable television formats. IPTV provides various services via two-way communications, such as Video On Demand (VOD), shopping, online video games, singing rooms and chatting as well as TV channels (Kerpez 2006, Lee 2009, Lee 2010, Montpetit 2009, Seo 2012, Yim 2013). It needs a set-top box for the IP-based services and an advanced remote control to utilize the services easily and efficiently (Ortiz 2006).

While the latest set-top box technologies have offered a number of interactive services, the remote controls have found some difficulties in keeping up with them. They just provide additional arrows buttons for moving a cursor, and it makes the interactive selection of contents difficult (Yang 2007, Enns 1990, Jana 2007). When pressing an arrow button, the cursor does not move directly to the point or contents on the screen which a user wants, but moves to the content next to the current one. It creates the need for a number of button presses, and inconvenience.

Relative coordinates used in existing remote controls is the root of the inconvenience, since it implies that we have to move starting from the current position to the target one by one. Sometimes we have to press the arrow buttons more than 20 times. It is the motivation of this paper to use absolute coordinates for moving the cursor on the screen. The absolute coordinate based remote control acts like a mouse for a Personal Computer (PC), so we can point at the content we want directly and promptly. This paper proposes a design and implementation of an IPTV remote control using absolute coordinates. It is equipped with a camera on the remote control itself. It marks the cursor on the point aimed at with the remote control like a laser pointer, and we can select contents, e.g. menu, options and programs, on the TV screen directly. We used the camera installed on the head of the remote control to calculate the absolute point of the cursor.

## RELATED WORKS

The first mouse control using a camera was the laser pointer system based on camera tracking, proposed by Kirstein (1998). In an ordinary presentation circumstance using a beam projector and a laser pointer, the main concept of the method was to photograph the image screen marked with the source of laser light, interpret the geometric location relation and convert it into the related location between the computer screen and the mouse pointer. Similar systems (Lapointe 2005, Olsen 2011, Sukthankar 2000, Cavens 2002, Ahlborn 2005) improved some of the difficulties found in the method.

Lapointe et al. (2005) proposed a method of installing a projector with a camera in the rear and perceiving and interpreting the laser pointer that a speaker in front aims at the screen. It needs to detect a strong source of laser light and convert the coordinates of the camera-screen along with the interaction technology proper for the laser pointer. Since the system uses the information from the images, there is a problem in detecting the laser light and converting it into accurate camera coordinates. The efficiency of the image processing has something directly to do with the efficiency of the system.

To reduce the time taken to detect the source of laser light, Olsen et al. (2011) covered the location of the laser light detected in the present frame with a regular-sized window and then detected the laser light in the next frame. Sukthankar et al. (2000) used the Active Region introduced to copy the button function of a mouse with a button less laser pointer. After designing buttons and so on at particular locations on the Graphic User Interface (GUI), if the laser light stays there for some fixed time, the domain of activation has the effect of generating 'Clicking'. The activation domain extracts particular functions and particular domains within the images, but expresses them into a fixed-form domain on the GUI.

Since the movement of a hand grasping the laser pointer is much faster than the image-processing time in the laser pointer system based on the camera tracking most of the time, it is natural that the source of laser light goes in advance and the cursor repeatedly follows it. Therefore, Cavens et al. (2002) and Ahlborn et al. (2005) used an invisible infrared-ray pointer, instead of a visible laser pointer so that the time spent to conduct a particular goal might be increased. However, the decline of satisfaction due to the latency brought about the same effect as that of the prior approach.

All the existing methods are about the interaction between a beam projector and a laser pointer, and a camera which should be set by using a tripod next to the projector. IPTV as consumer electronics on the wall with a camera set up next to the couch is not an appropriate living room item. This paper instead proposes a small-sized mobile camera mounted on the remote control while using four infrared-ray Light Emitting Diode (LED) on the corners of the IPTV to calculate the coordinates.

## DESIGN OF REMOTE CONTROL

The camera-typed remote control consists of a Charge Coupled Device (CCD) camera, an Analog/Digital (A/D) convertor, Field Programmable Gate Array (FPGA). Micro Controller Unit (MCU) and a wireless transmitter, as shown in Figure 1.The image signals produced are generally analog signals, but in the case of a small-sized camera built into a cell phone, they are digital image signals. When choosing a digital camera outputting digital image signals, it is not necessary to design an additional A/D transformation circuit. On the other hand, a CCD camera is usually analog, so it needs an A/D converter. In the case that a camera with a 1280 × 1024 resolution outputs images at 15 times per second, it is required to choose a FPGA able to process 8 bit data at over 30 MHz speed.

The FPGA plays a role in receiving the camera image signal data and extracting the core data. The MCU calculates the point coordinate aimed at and transmits the coordinate and button signals calculated to the set-top box through the wireless transmitting circuit. The remote control proposed can be completed by designing and assembling hardware and firmware, such as a camera, a lens, FPGA, MCU, and a wireless transmitting circuit in a proper case.

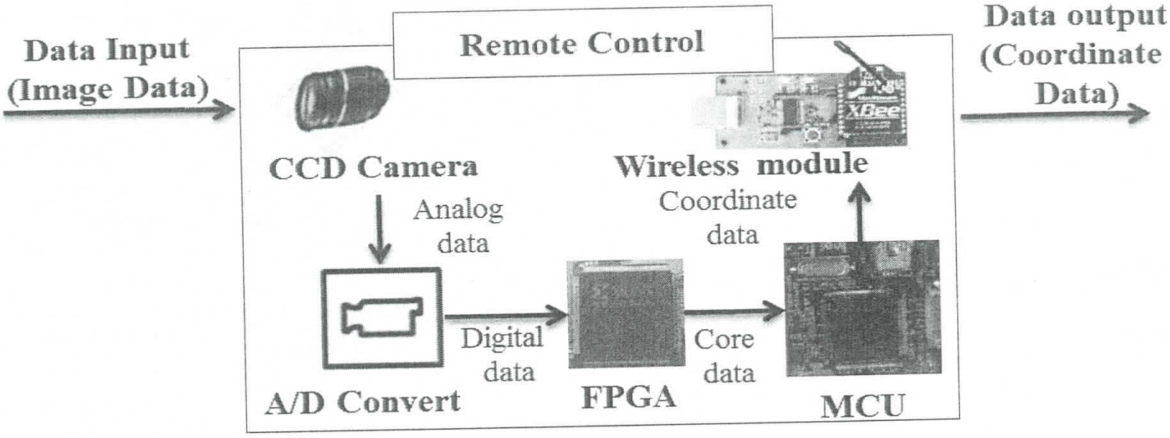



Figure 1. H/W architecture for a remote control based on a camera.

When analyzing ordinary images it is quite difficult to find a spot aimed at by the camera (Singh 2011). Therefore, this paper tried to reduce the object domain by installing particular marks at the four corner spots outside the TV screen as well as in the directions of 3-, 6-, 9- and 12-o'clocks. The particular marks can be reference points to find the points aimed at and the basic information to calculate coordinates. The particular marks are infrared-ray LEDs to be recognized distinctively from the interior or exterior images of the TV screen. The TV screen is luminescent with infrared-ray LEDs installed around the TV screen, and when the remote control faces the TV screen with the IR filter installed on the camera, the image data are input into the camera as shown in Figure 2, while the four circles correspond to the particular mark domain.

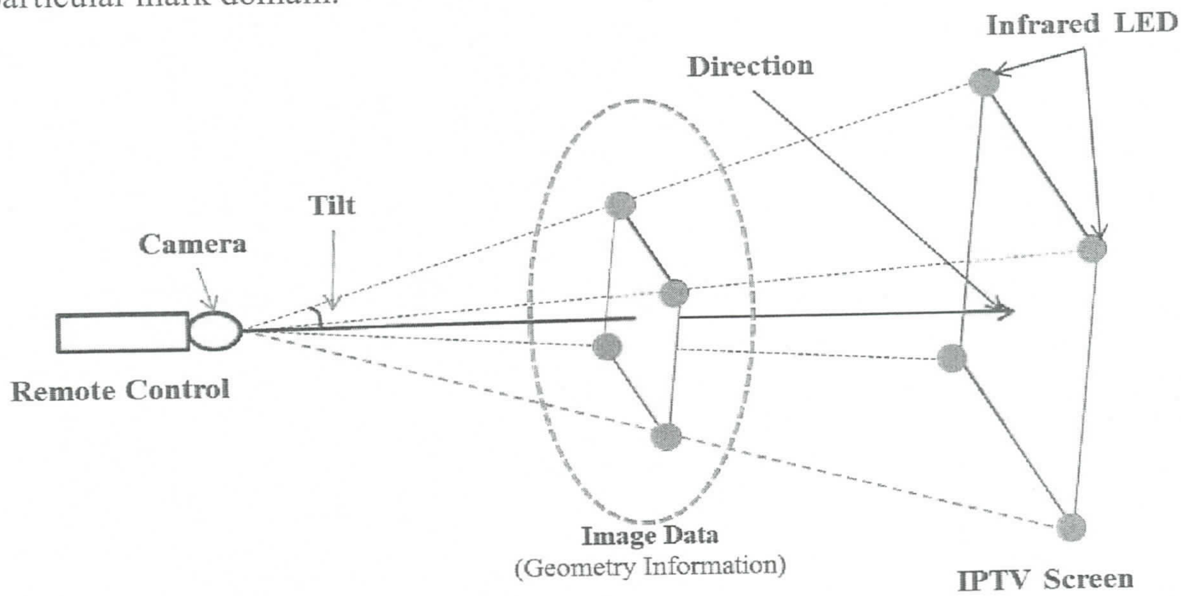



Figure 2. Optical composition of the camera to perceive particular marks.

Since the particular marks discharge infrared rays, the domain of the particular marks will look bright like they are white. The inside and outside of the TV screen discharge visible rays, looking dark. Even if the data of the particular mark domain can be compiled, it is possible to perceive the locations of the TV screen, such as the width, length and central location.

## IMPLEMENTATION

In order to convert the image data input from the camera into coordinates, the process shown in Figure 3 should be followed. The original images input through the camera include too much information. The core data need to be extracted through data filtering. The geometric information is then extracted from the core data, through which coordinates are calculated.

The image data input comes with all the unnecessary data. Therefore, the input information of the infrared-ray LEDs need to be separated from the unnecessary rest of the data. As for a way of separation, core domains are extracted after removing values below certain fixed values by using the boundary value (Lee 2009).

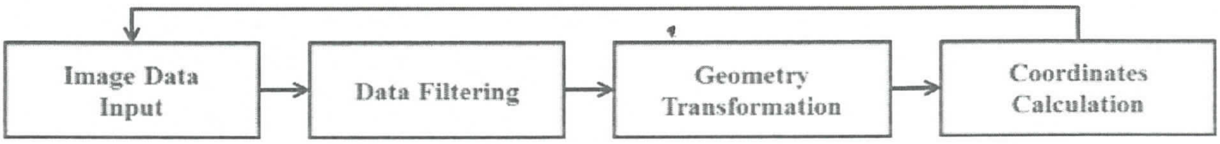



Figure 3. Process for calculating the coordinates.

As a result of carrying out several experiments to find out the boundary value, it was found that the brightness of the luminescence domain of the infrared-ray LEDs was above 200 and below 255. In contrast, the inside and outside of the TV screen were both below 50. In the case of establishing the boundary value of 100, the data with brightnesses of less than 100 need to be ignored, and only include X and Y coordinates filtered about the luminescence domain of the infrared-ray LEDs having a brightness of more than 100. At this point, the number of data points should be less than 1,000 in either X or Y coordinates.

Out of these, four locations of the LED domain should be obtained. In the case that the first luminescence X coordinate is x1 and the final luminescence X coordinate is x2 on the same vertical line (i.e., the same Y coordinate, e.g. y1), if the average value of x1 and x2 is x3, only the X and Y coordinates (x3 and y1) should be extracted as the core data. The core data can be classified into four circle domains, showing the central value in the location of the four particular marks.

By using the core data extracted through data-filtering, the location coordinates aimed at by the remote control can be calculated as follows. First of all, by using the extracted core data, the location of a particular mark, that is, the luminescence location of an infrared-ray LED, should be calculated. Then, the geometric information of the TV screen is calculated from the particular mark location (Aldair 2010). The location coordinate aimed at by the remote control can be calculated by using the geometric information of the TV screen.

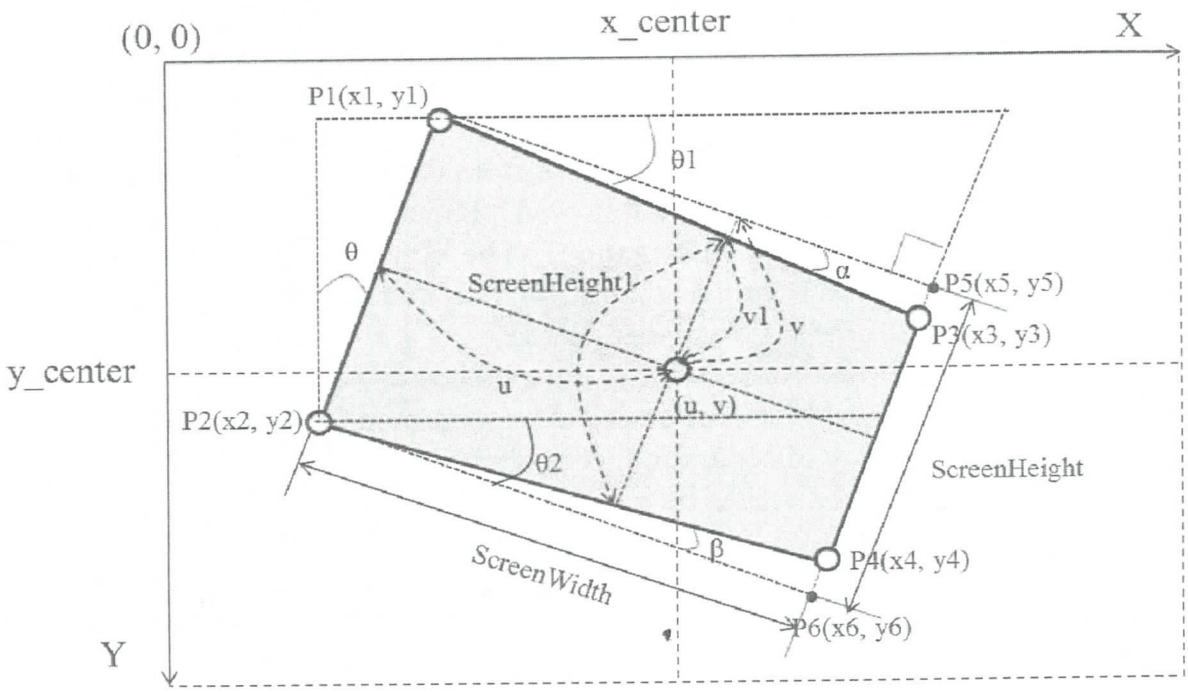



Figure 4. Calculation of coordinates using geometric information.

By using the geometric information calculated during the process above, such as the width, length and tilt of the TV screen, the coordinate of a location aimed at by the remote control can be calculated. If it is assumed that the TV screen is rectangular, ScreenWidth, ScreenHeight, sin(α), cos(α), sin(β) and cos (β) of a location aimed at by the remote control are calculated by referring to Figure 4.

Before calculating the coordinate, the values of u and v need to be calculated by using equations (1) and (2).

$$u = (x\_center - x_1) \times \cos\theta + (y_2 - y\_center) \times \sin\theta \quad (1)$$
$$v = (y\_center - y_1) \times \cos\theta - (x\_center - x_1) \times \sin\theta \quad (2)$$

Since the actual form of the TV screen is trapezoid, the height of the TV screen changes while the V coordinate of the aimed point changes as well due to the change of the U coordinate of a point aimed at by the remote control. In an actual circumstance of the trapezoid-form TV screen, v of the V coordinates of a point aimed by the remote control changes to v1. Therefore, it is required to calculate the value of v1 changed by using equation (3).

$$v_1 = v - v \times \tan\alpha \quad (3)$$

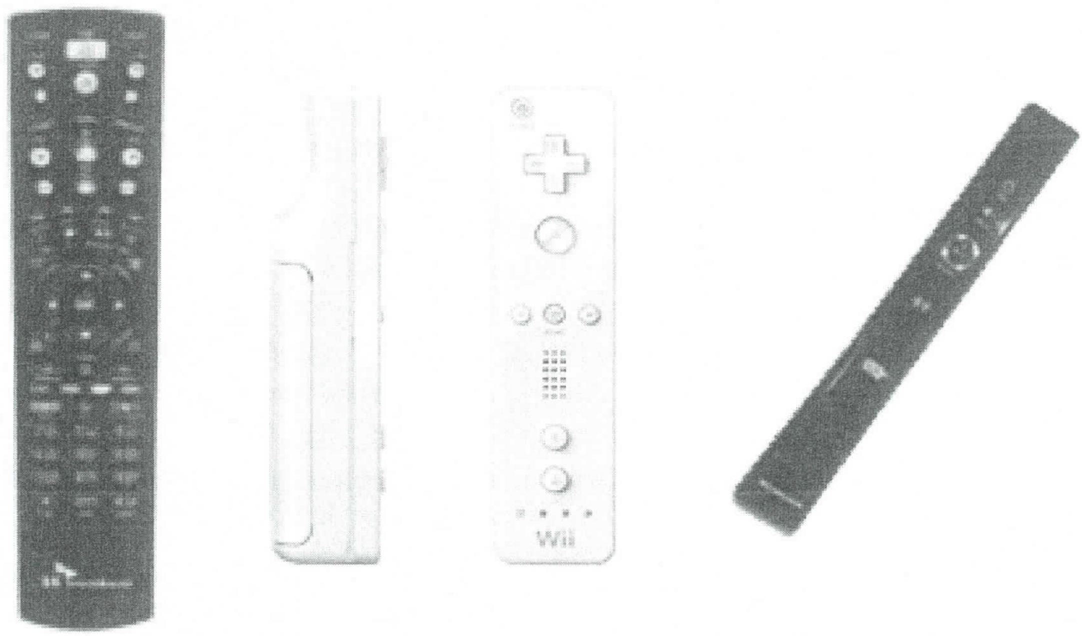
Overall, by using u, v1, ScreenWidth and ScreenHeight1, it is possible to calculate the ratio of the coordinate aimed at by the camera. When applying this ratio to the actual size of the TV screen, it is possible to calculate the coordinates on the TV screen by using equations (4) and (5).

$$x = (u \div ScreenWidth) \times Real\_TV\_Width \quad (4)$$
$$y = (v_1 \div ScreenHeight_1) \times Real\_TV\_Height \quad (5)$$

For instance, it is assumed that the ScreenWidth of a rectangular-form TV screen is 600, the ScreenHeight is 500 and the aimed spot coordinate, U and U, are extracted to 400 and 200, respectively. In an actual circumstance of a trapezoid-form TV screen, when the ScreenHeight1 of the TV screen is 450 and v1 of the V coordinate of a point aimed at by the remote control is calculated to be 170, the location of the x-axle is 0.67 and the location of the y-axle is 0.38 for a spot aimed at by the remote control.

## EXPERIMENTAL RESULTS AND ANALYSIS

The coordinate tracking method using an existing camera was all about the interaction between a beam projector and a laser pointer. Since that method was for a beam projector, it has the same movement principle, but it cannot be applied to IPTV. This research has used a hana TV remote control[1], a Wii remote[2], and an Xcanvas Magic motion remote control[3] for the comparative experiment. The reasons that these three products, shown in Figure 5, were selected for comparison



(a) (b) (c)

Figure 5. Relative coordinate remote controls: (a) the hana TV remote control; (b) the Wii Remote, and (c) the Xcanvas Magic motion remote control.

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[1]hana TV, http://www.hanatv.co.kr

[2]Wii remote, http://www.nintendo.com/

[3]Magic motion remote control, http://www.xcanvas.co.kr/

are as follows. The Wii remote and Magic remote control, popular commercial products in the market, use relative coordinates rather than absolute coordinates. The Wii remote and Magic remote control are the newest remote controls in family gaming and IPTV.

Regarding the experimental method, 12 subjects in the age range of 10 to 70, executed the movement patterns shown in Figure 6. To evaluate the performance efficiency, such criteria as accuracy, latency and movement were established.

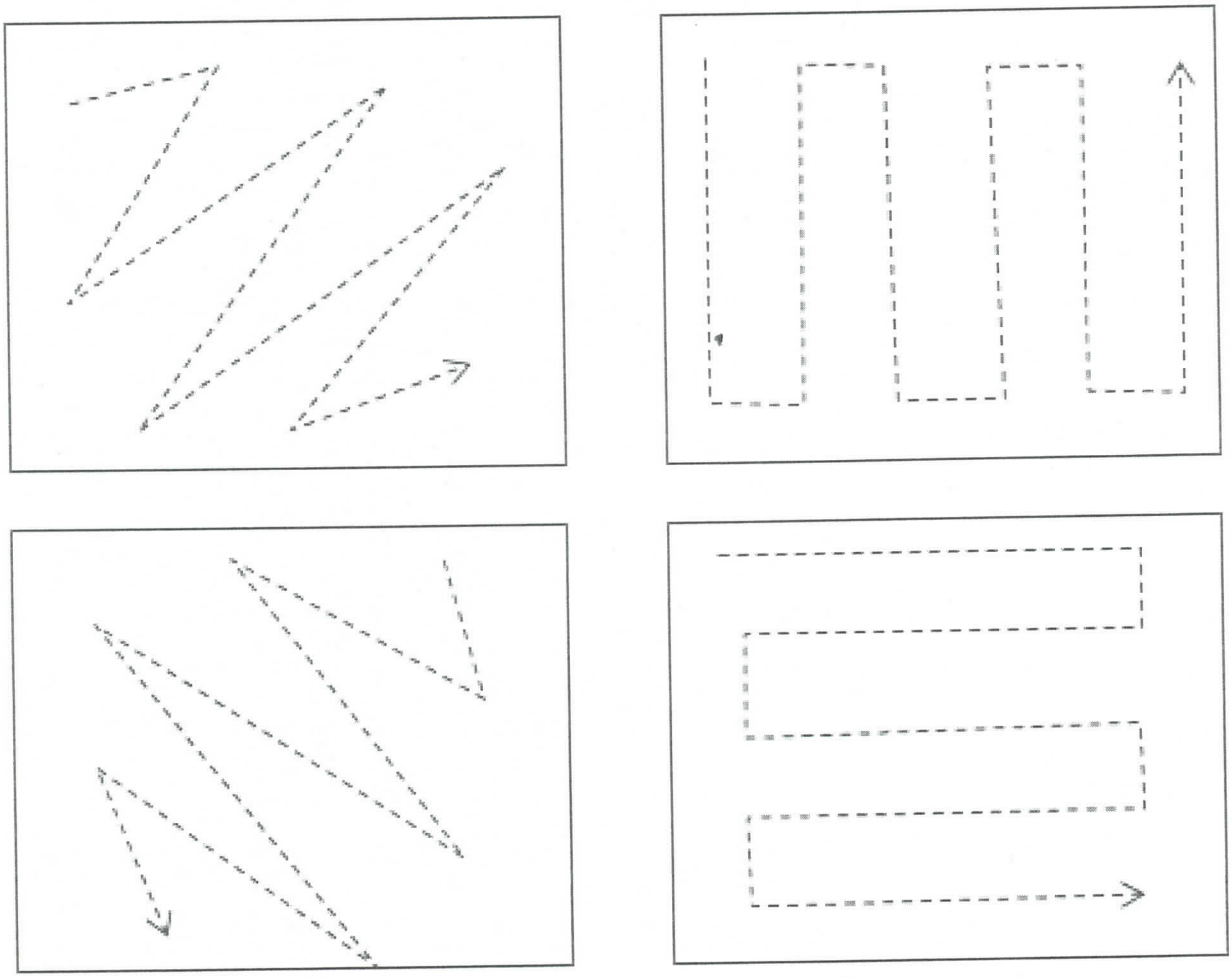


Figure 6. Four patterns for the experiment.

***Accuracy.*** As for the accuracy, a laser pointer was installed on the remote control, which was the experimental object, to compare and estimate the direction aimed at by the laser pointer and the movement course of the mouse. Figure 7 represents the error rate in pixel units versus time.

The hana TV remote control, due to its buttons, showed quite unstable target and mouse cursor locations and recorded an increasing number of errors as it easily made the user tired. The Wii Remote and Xcanvas Magic motion remote control, each using a relative coordinate system, functioned comparatively accurately at the beginning, however they accumulated errors and the error pixel range increased as time passed. The proposed remote control was able to maintain a certain limit in errors with time, even though it started with a larger error pixel range than the relative coordinate system remote controls. This proposed method can control the target location within a certain error range regardless of time shift.

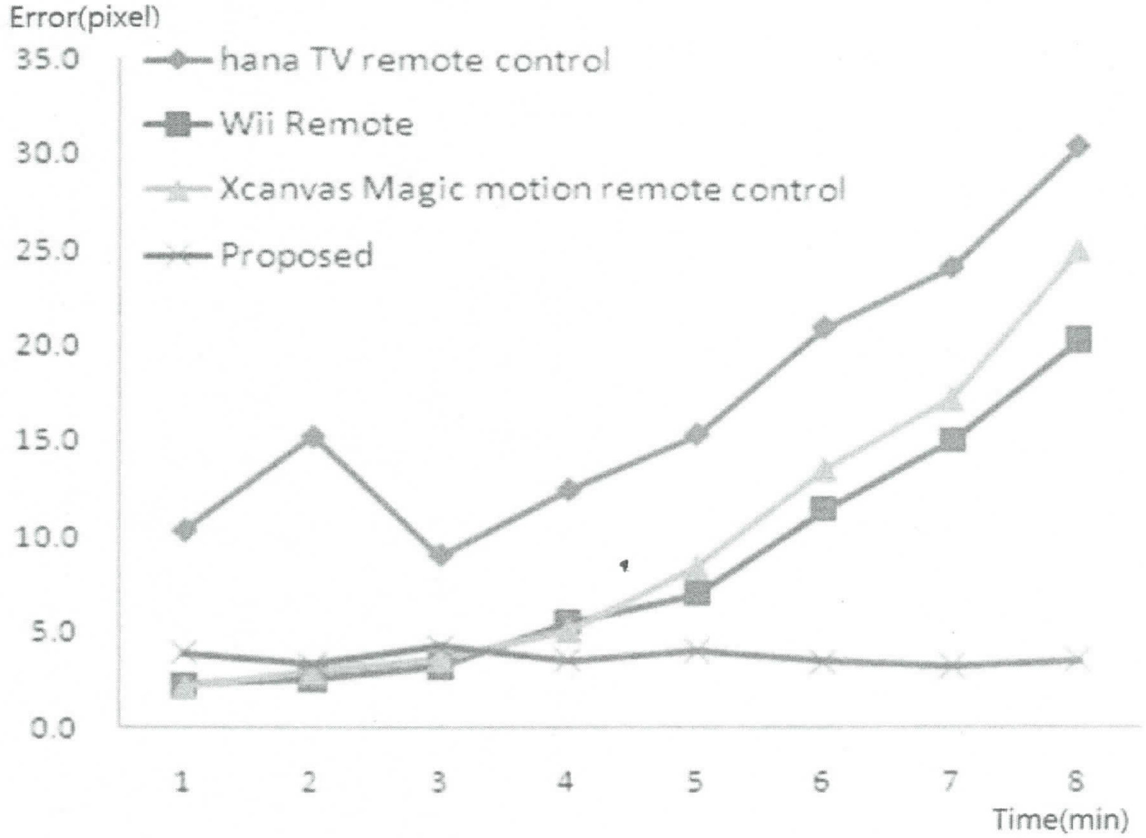



Figure 7. Accuracy comparison chart.

***Latency.*** Latency is the time needed for a remote to react. As the hana TV remote control, Wii Remote, and Xcanvas Magic motion remote controls are already on the market, measuring latency is only possible through a test. The method proposed utilized a camera which called for a low-resolution (width 640 and length 480) camera, an image-processing board, a PC, an IR filter, infrared-ray LEDs and so on to perform the test. The wavelength of the infrared-ray LEDs used for the experiment were 850 nm and that of the IR filter was 800 nm.

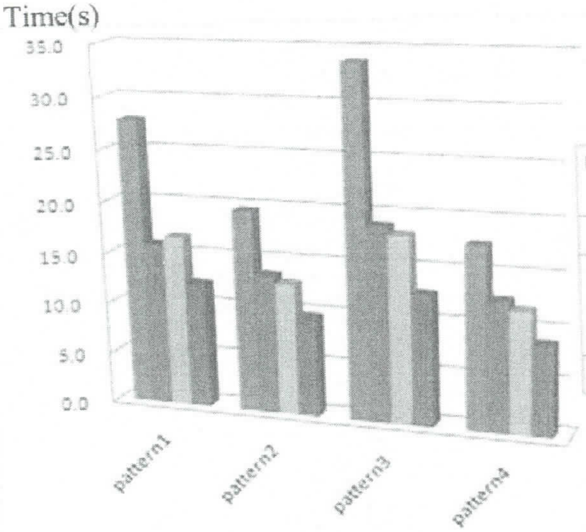
Table 1. Measured values of the latency of the Remote Control (RC).

| Section | hana TV RC, ms | Wii Remote, ms | Xcanvas Magic motion RC, ms | This work, ms |
|---|---|---|---|---|
| Min | 50 | 22 | 24 | 33 |
| Mean (average) | 55 | 25 | 27 | 38 |
| Max | 60 | 30 | 32 | 40 |

The testing method is recording the time between a subject's action on the remote and the reaction of the mouse cursor. Table 1 shows the measured values of the proposed remote control against the existing remote controls.

The results of the experiment showed that the hana TV remote control has the longest latency measurement and is more difficult to operate. The Wii Remote and Xcanvas Magic motion remote control have similar results since they both use acceleration sensors and similar mechanisms. The proposed remote control's camera output image data 30 times per second and calculated the location coordinate 25 to 30 times per second. The existing remote controls reacted faster than the proposed one, as they did not carry the load of needing to calculate the location coordinate. However, the proposed method's reaction speed did not cause any difficulty in using the remote control.

***Movement.*** In the experiment for comparing the movements of the remote controls, each subject's execution speed for the four action patterns in Figure 6 was measured. Figure 8 represents the mean time taken for each user in completing the movement.




| | pattern1 | pattern2 | pattern3 | pattern4 |
|---|---|---|---|---|
| hana TV remote control | 27.8 | 19.6 | 33.8 | 17.7 |
| Wii Remote | 15.9 | 13.5 | 18.9 | 12.6 |
| Xcanvas Magic motion remote control | 16.7 | 12.8 | 18.2 | 11.8 |
| Proposed | 12.2 | 9.7 | 12.7 | 8.8 |

Figure 8. Remote control speed comparison.

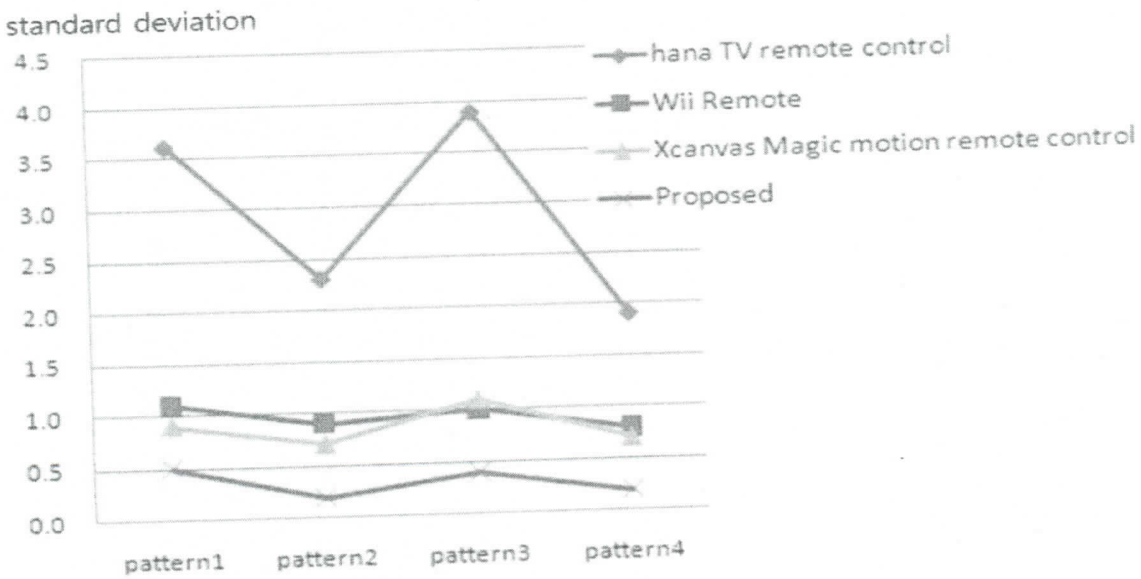



Figure 9. Remote controls' standard deviation.

The hana TV remote control with its button action limiting the distance per action produced the slowest results. The Wii Remote's and Xcanvas Magic motion remote control's results were close and the proposed remote control was the fastest. The reason for this is that the proposed remote control utilizes a camera enabling direct location skips, while the Wii remote and Xcanvas Magic motion remote control used acceleration sensors, resulting in a large coverage per action.

Also, the tested remote controls' standard deviation in Figure 9 extracted the distribution of the remote controls' movements. The hana TV remote control was dependent on the button data, which varied greatly according to the user's operational ability. In contrast, the Wii Remote, Xcanvas Magic motion remote control and the proposed remote control were able to output constant data even by different users.

The proposed remote control compared to the existing remote controls is a little more latent yet very accurate in processing the user's aiming point, and anyone could move the cursor with speed and ease.

## CONCLUSION

IPTV (Internet Protocol Television) provides a variety of two-way services, such as a VOD service, a TV home shopping service, on-line games, a singing-room service and an internet chatting service, in addition to the existing TV channels. With existing remote controls it is difficult to easily select among the hundreds of types of content available through IPTV.

To solve this problem of the existing remote control technology, this research designed and implemented a new remote control for IPTV based on absolute coordinates. The remote control methodology is to install four infrared-ray LEDs on the TV set and to calculate coordinates through a real-time analysis of the images taken by the camera. For this process, an algorithm was developed to create coordinates with the input images from the camera by using trigonometric functions and an equation to calculate the distance.

Regarding the experiment, when the new remote control was compared with the existing common remote controls, its latency was rather slow, but users could direct the aiming point quite accurately and move the cursor rapidly.

Future work is being planned for a method to optimize an algorithm for the remote control and to increase the accuracy for the movement of coordinates. Moreover, we are planning to apply the suggested remote control not only to IPTV but also to lamps, electronic boards, beam projectors and LED advertisement boards.

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