

Interactive PTZ Camera Control System Using Wii Remote and Infrared Sensor Bar

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Abstract—This paper proposes an alternative control mechanism for an interactive Pan/Tilt/Zoom (PTZ) camera control system. Instead of using a mouse or a joystick, the proposed mechanism utilizes a Nintendo Wii remote and infrared (IR) sensor bar. The Wii remote has buttons that allows the user to control the movement of a PTZ camera through Bluetooth connectivity. In addition, the Wii remote has a built-in motion sensor that allows the user to give control signals to the PTZ camera through pitch and roll movement. A stationary IR sensor bar, placed at some distance away opposite the Wii remote, enables the detection of yaw movement. In addition, the Wii remote's built-in IR camera has the ability to detect its spatial position, and thus generates a control signal when the user moves the Wii remote. Some experiments are carried out and their performances are compared with an industry-standard PTZ joystick.

Keywords—Bluetooth, Infrared, Pan/Tilt/Zoom, PTZ Camera, Visual Surveillance, Wii Remote

I. INTRODUCTION

VISUAL surveillance systems are currently adopted by many public building or public area to counter security risks. The camera utilized in the system evolved from analogue camera to high resolution digital camera, from wide angle camera to Pan/Tilt/Zoom (PTZ) camera, which is able to enhance the image quality and increase the coverage area.

The PTZ camera allows the user to have arbitrary viewing angle in a surveillance scene [1]. In general, the movement of the PTZ camera is controlled by a mouse or a joystick. These two devices usually are connected to the computer via wires. This limits the user's workable region. Even with a PTZ joystick, the user is still restricted within the range of the Universal Serial Bus (USB) cable wire. To solve this problem, this paper proposes the use of the Wii remote as an alternative to a mouse or a joystick [2]. Fig. 1 illustrates an overview of the proposed system.

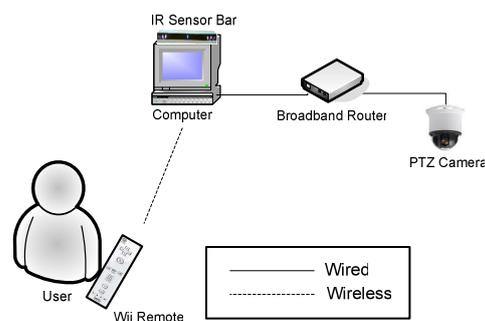


Fig. 1 Interactive PTZ camera control system using Wii remote and infrared sensor bar

This paper is split into six sections. Section II explains the component that is employed in the proposed system and Section III describes the proposed algorithms. There are a total of three proposed algorithms on how the Wii remote is used to control a PTZ camera; i) using buttons ii) using motion sensor and iii) using IR camera and infrared emitter. The system implementation is described in Section IV where the experimental results and comparison table are presented in Section V. The final section concludes the work done and suggests some future work.

II. SYSTEM COMPONENTS

The proposed interactive PTZ camera control system consists of a PTZ camera, a Nintendo Wii remote and an IR sensor bar [2], [3]. The Wii remote is connected to a computer via Bluetooth connection. When the user manipulates the Wii remote, either by pressing the buttons or by moving the Wii remote, the Wii remote sends corresponding signals to the processor. Then the processor calculates and generates corresponding signals and sends to PTZ camera [4], [5]. The PTZ camera pans, tilts and zooms accordingly and displays the image through a display device such as monitor or projector. The following explains each and every component utilized in this proposed system.

A. PTZ Camera

There are many different types of video surveillance network cameras which are available in different models to suit a wide variety of needs, such as fixed network cameras, fixed dome network cameras, PTZ network cameras, network dome cameras, and non-mechanical PTZ network cameras. The PTZ camera type used in this research is a network dome

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camera that is Internet Protocol (IP) enabled. The main advantages compare to other types is it has the ability to pan 360 degrees. It also provides mechanical robustness for continuous operation in a surveillance environment and is able to cover an area where 10 fixed cameras would be needed to do the same job [6]. The optical zoom for this camera is around 18x to 30x compared to other types of camera that have lower or none zoom rate zoom [6]. An example of a PTZ camera is illustrated in Fig. 2.



Fig. 2 PTZ Camera

B. The Nintendo Wii Remote

The Wii remote as illustrated in Fig. 3 is the primary controller for the Nintendo Wii video game console from Nintendo Company Ltd. It allows the user to interact with and to manipulate items on screen via pointing and movement. The Wii remote integrates an IR camera and accelerometer to sense its position in 3D space when pointed at the IR sensor bar. It also uses an accelerometer and a gyro meter to measure motion in roll and pitch [7]. This paper uses the Wii remote to emulate a keyboard, mouse or joystick by connecting the Wii remote to a personal computer via Bluetooth connection.

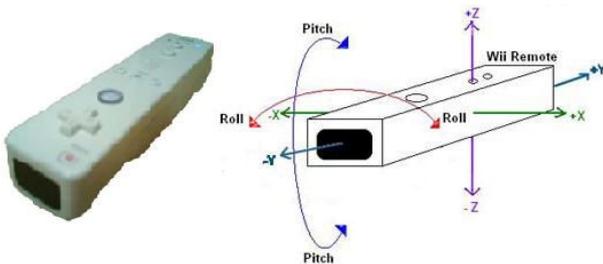


Fig. 3 Wii remote and 3D accelerometer measurements

C. IR Sensor Bar

The IR sensor bar as illustrated in Fig. 4 contains six infrared LEDs, arranged in threes side by side on either end. This sensor bar comes as part of the Nintendo Wii video game console and is used together with the Wii remote to obtain relative 3D coordinates. For best performance, the Wii remote should be used within five meters (approx. 16ft) of the sensor bar.



Fig. 4 IR Sensor Bar

III. ALGORITHM FOR INTERACTIVE CONTROL USING WII REMOTE

The algorithm developed in this research is to combine an interactive PTZ camera control system and a Wii remote. The general algorithm flow for interactive PTZ camera control system using Wii remote and infrared sensor bar algorithm is illustrated in Fig. 5.

The interactive PTZ camera control system connects to an IP PTZ camera and enables the Wii remote. Then it resets all the control signals. These signals include the panning angle ($-180^\circ \leq p^\circ \leq 180^\circ$), tilting angle ($-90 \leq t^\circ \leq 0^\circ$) and zooming factor ($1 \leq Z_f \leq 9999$). Once the Wii remote is enabled, the control system waits for an event from the Wii remote. If the event is not an exit command, the system will perform a series of tasks with respect to the triggered event.

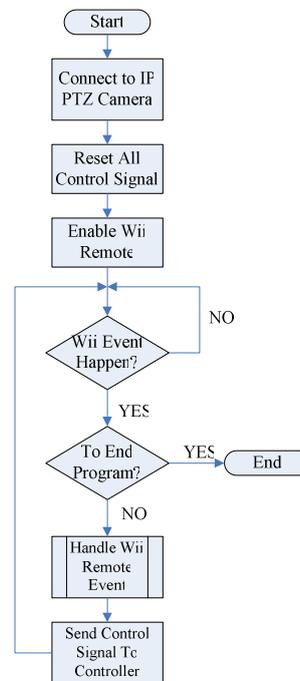


Fig. 5 General flow chart for interactive PTZ camera control system using Wii remote and infrared sensor bar algorithm

The following explains three different algorithms for interactive PTZ camera control system using Wii remote motion sensor, and infrared sensor. The three algorithms can only be used independently.

A. Algorithm for Interactive Control with Wii Remote Buttons

The algorithm for interactive control with the Wii remote buttons utilizes the direction buttons to control the pan, tilt and

zoom movement of a PTZ camera. The user can predefine the step size for each control signal. The Δp , Δt and Δz_F are the step size for the pan, tilt, and zoom respectively. Fig. 6 presents the algorithm flow in detail.

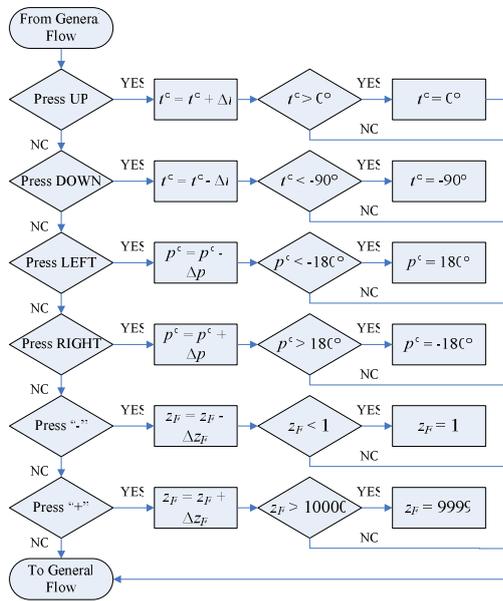


Fig. 6 Flow chart for Interactive Control with Wii Remote Buttons algorithm

B. Algorithm for Interactive Control with Wii Remote Motion Sensor

This algorithm uses the Wii remote motion sensing capability to control the PTZ camera. To employ this method, user is required to hold the Wii remote horizontally with the interactive surface facing upward and the direction buttons are on the user's left hand side as illustrated in Fig. 7.



Fig. 7 User hold the Wii remote horizontally

The motion sensor requires the user to first enable and disable it. This is to ensure that the Wii remote will not receive signal simultaneously from different interaction method and thus unable to determine which signals are expected to be sent to the PTZ camera.

The pitch value returned from the Wii remote is doubled and used as the panning angle whereas the roll angle returned from the Wii remote is assigned to the tilt angle as expressed below:

$$t^{\circ} = \text{roll value}$$

$$p^{\circ} = \text{pitch value} * 2$$

The limit of pitch value is 90 and thus it is doubled before it is assigned to the panning angle where the limit is 180. The algorithm flow of the Wii remote using motion sensing to control the PTZ is illustrated in Fig. 8.

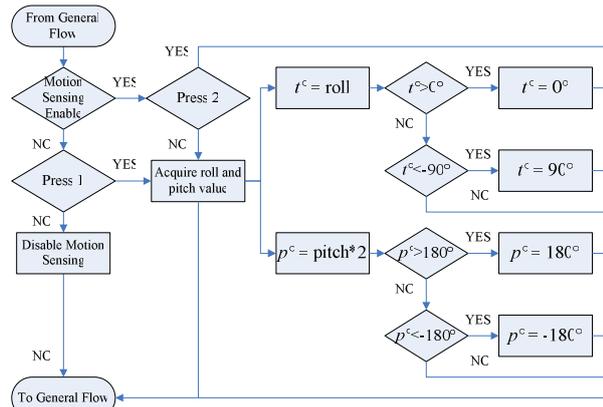


Fig. 8 Flow chart for Interactive Control with Wii Remote Motion Sensor algorithm

C. Algorithm for Interactive Control with Infrared Sensor

This algorithm uses the Wii remote and IR sensor bar to control the PTZ camera. The algorithm flow for interactive control with infrared sensor is illustrated in Fig. 9. When button 'B' of the Wii remote is pressed, the IR sensor is enabled. When the IR sensor is enabled, the IR sensor bar will be detected and x , y and z position data is calculated.

The pan, tilt and zoom are controlled using the movement of the Wii remote, according to the value changes in the x , y and z data. The x_C is the current x data and the x_P is the previous data, and same goes to y and z data. User can predefine the sensitivity of the zoom by defining the z_S for faster zoom increment. Therefore x_I , y_I , and z_I are tolerance values to cope with the sensitivity of the x , y , and z data to minimize hand shake movement. When button 'B' is released, the IR sensor is disabled.

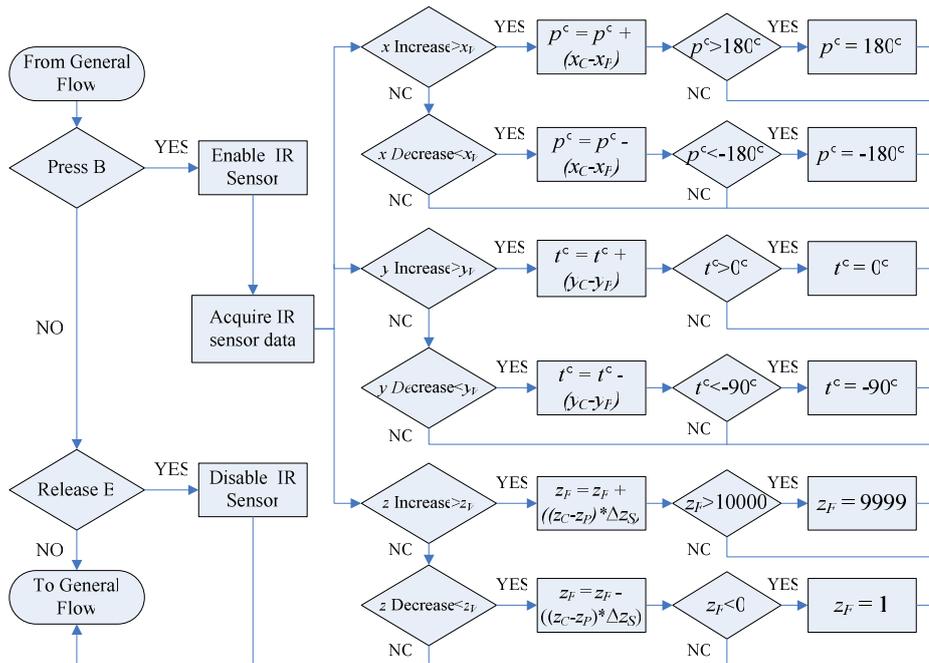


Fig. 9 Flow chart for Interactive Control with Infrared Sensor

IV. IMPLEMENTATION

The AXIS Camera Control Software Development Kit (SDK) (version 1.1) is part of the PTZ camera control system. This SDK is written in C++ with Microsoft Foundation Class (MFC) and ActiveX. The SDK is able to capture live video streams and process them into motion-jpeg (MJPG) images. The PTZ camera control system used in this research is a program that calls the AXIS Camera Control SDK. This program is a C++ based program using MFC and ActiveX. The SDK version for this PTZ camera control program used in this research is version 1.1.

This camera control SDK is able to view a place scene that installed with PTZ camera and able to interactive with Pan, Tilt, and Zoom (PTZ) control of device using directly in Microsoft development Tools (Software used: Microsoft Visual Studio 2005) and Microsoft Internet Explorer. In the PTZ camera control, it supports features such as playing live MJPG streams from networked devices, interactive Pan, Tilt, and Zoom (PTZ) control of devices, playing live audio streams from networked devices, and playing recorded videos for networked player devices. When the AXIS Camera Control SDK starts, it will request a user name and Password in-order to gain access to the stated IP addresses in the program.

To start the interactive PTZ camera control system using Wii remote and infrared sensor bar, the Wii remote library

which is called "wiiuse" is used in this research. The "wiiuse" contains functions for the Wii remote coded in C language to control it. The current version of "wiiuse" library used in this research is version 0.12. This Wii remote library can be downloaded from the internet [8].

The program is displayed using a 17 inches computer screen. In order to maximize performance and accuracy, larger inches computer screen is recommended. Increasing the display size does not affect the performance of the program.

V. EXPERIMENT RESULTS

In this research, the results obtained for this work is good and it provides an intuitive interface for the user to control the PTZ using a Wii remote controller. The following paragraphs will explain the results, in terms of comparisons between different control mechanisms. The comparisons of different interactive controls are illustrated in Table I.

The result of this comparison shows that using Wii remote buttons and motion sensing opens up a very large range of control for the PTZ which is very user friendly. Adding the IR sensor bar however, limits the range to within five meters of the sensor bar.

TABLE I
COMPARISON OF INTERACTIVE CONTROL WITH PTZ JOYSTICK

	PTZ Joystick	Wii Remote Buttons	Wii Remote Motion Sensing	Infrared Sensor Bar
Connectivity	• USB (wired)	• Bluetooth (wireless)	• Bluetooth (wireless)	• Bluetooth (wireless)
Range	• Within USB wire meter	• Up to 25 meter range	• Up to 25 meter range	• Up to 5 meter range • Within the infrared field of view
Pan and Tilt Control	• Through Joystick	• Through buttons	• Through Motion Sensing	• Through movement
Pan and Tilt Simultaneously	• Yes	• No	• Yes	• Yes
Pan Tilt Zoom Speed	• Instant	• Delay approximately 1 second	• Instant Pan and Tilt • Delay approximately 1 second for Zoom	• Instant
Zoom Control	• Through Joystick buttons	• Through buttons	• Through buttons	• Through movement
Zoom Capability	• Continuous	• Set value of Δz_F	• Set value of Δz_F	• Continuous

A. Interactive Control with Wii Remote Buttons

The experiment for Wii remote buttons to control the PTZ camera functions works well and this experiment makes the Wii remote becomes similar to a wireless button remote control for the PTZ camera. This sort of interactive control is stable and very ease to use. The extended range of up to 25 meters is also an advantage for usage. The result is that it is able to pan, tilt and zoom the PTZ camera according to the button presses on the Wii remote. There is a minor the delay of approximately 1 second but it is anticipated that this does not pose a serious problem and can be improved upon in future work.

B. Interactive Control with Wii Remote Motion Sensing

In this experiment, the Wii remote motion sensing is able to interact well with the PTZ camera and able to change the view of pan and tilt according to the degree changes on roll and pitch. The main advantage for this method is it can pan and tilt simultaneously with no delay and wireless range of up to 25 meters. The zoom control is implemented via the Wii remote's buttons and the flexibility and ease of use that this combination provides more different methods and functions to control the PTZ camera.

C. Interactive Control with Infrared Sensor Bar

The main advantage for this experiment result is that this method is able to control the PTZ camera pan, tilt, and zoom according to the movement of the Wii remote with the sensor bar simultaneously. By holding the Wii remote, the user is able to have direct control of the PTZ camera without the need to press buttons. It is envisioned that users can strap a remote with similar capabilities as the Wii remote and control the camera, which frees up the hands and finger for other tasks. However, the limitation for this method is that the IR sensor bar has to be within the distance of 5 meters.

VI. CONCLUSION AND FUTURE WORK

The experimental result indicates that the Wii remote is able to utilize all controls functions in a PTZ camera using the capabilities of the Wii remote. The interactive control with motion sensing and sensor bar is a newly implemented function to control PTZ camera in this research to improve upon the previous interactivity methods. The interactive control with Wii remote motion sensing is capable of controlling the directions of pan and tilt simultaneously within a larger range because this method used Bluetooth connection as its wireless protocol. Meanwhile interactive control with sensor bar is able to control pan, tilt, and zoom according to movement of the Wii remote which is the main advantage for this method. However, the use of the IR sensor bar has limited range of freedom for the user to move around.

In the future, this research will be extended to build a control room system with a few Wii remote connected to a few IP PTZ cameras spread across different location. The increase in flexibility, intuitive control, and ease of use will hopefully be able to improve upon the current user experience of controlling a PTZ camera for surveillance or other tasks.

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