A Study on Intelligent Video Security Surveillance System with Active Tracking Technology in Multiple Objects Environment

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Abstract

We propose a new mechanism to resolve the object tracking problem on the video security surveillance system. Our method of location calculation is based on the Chirp Spread Spectrum (CSS) method which is considered the three-dimensional space to improve degree of accuracy of location information. The suggested new mechanism can make intelligent tracking and recording for interesting objects so that make the amount of valid video high and improve video's quality.

Keywords: *Intelligent Video Surveillance Systems, Active Tracking Technology, Multiple objects Environment*

1. Introduction

A video security surveillance technology has been developed from the existing passive technology which simply recoding facilities and passers to intelligent technology to recognize situations in real time and respond by itself. Currently, the intelligent video security surveillance systems are largely divided into system through image analysis and system based on location recognition applied to ubiquitous sensor network technology.

The location recognition technology has been so far studied and developed mainly with single interesting object for tracking human and things, mobile asset management, security and etc. Such location recognition technology provides accuracy in interior space within 2-3 meters without obstacles, but with obstacles, larger range of error is appeared, thus research for recognition of more accurate interior location has conducted. Not only that, interest in location recognition of multiple objects in environment is increased, not in environment with single object location recognition. The requirement to get valid images is very important at the video security surveillance system. This is because further video information cannot be recognized easily if the shooting range is strayed due to several fixed cameras to film with the most video security surveillance systems.

Therefore, in this paper, to improve the existing intelligent video security surveillance system, we will suggest useful intelligent tracking and video recording method with higher accuracy of location recognition for moving objects in interior spaces. With the suggested the new mechanism, an improvement of video quality and an increase of valid video information are expected in multiple objects environment.

2. Existing Technologies for location recognition and compensation

To calculate location information of moving objects in real time, the intelligent video security surveillance system based on video information predicts and estimates object movement with Digital Subtraction Angiography. However, in case that video

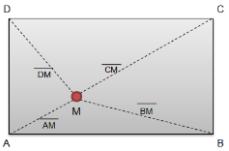
interference is appeared or we cannot obtain video information out of recording range, the accurate tracking and recording of object can be difficult or impossible[1]. Also, if we have more than two objects to be tracked, because of increasing video information analyzing data, the time for analyzing information and additional expense can be much longer and occurred, respectively.

The intelligent video security surveillance system based on ubiquitous sensor network technology is composed of combination of radio communications technology and algorithm of location calculation. The representative radio communications technologies are Wireless Fidelity (Wi-Fi), Radio Frequency Identification (RFID), ZigBee, Ultra Wide Band (UWB) and etc. Algorithms for location calculation are Angle of Arriva (AoA), Time of Arriva (ToA), Received Signal Strength Indication (RSSI), Chirp Spread Spectrum (CSS) and etc.

For intelligent video security surveillance system based on ubiquitous sensor network technology, CSS method is utilized which is recognized as the highest accuracy among location recognition method among radio communication technology. CSS, with ToA method, measures the distance between the moving and fixed node and calculates the location of moving node with Triangulation, using the measured distance value [2]. At this point, the distance between the moving and fixed nodes is used by Symmetric Double Sided-Two Way Ranging (SDS-TWR) which calculates wave delivering time for two times. However, because of irregular error range in interior environment, the accuracy of calculation of location information value is not reasonable.

$$t_p = \frac{1}{4}[(t_{roundA} - t_{replyB}) + (t_{roundB} - t_{replyA})] \tag{1}$$

To improve accuracy of location calculation, Algorithm for localization using the concept of Equivalent Distance Rate (AEDR) which was improved from the existing method of SDS-TWR is used [3].



$$AM^2 + CM^2 = BM^2 + DM^2 \tag{2}$$

Figure 1. AEDR Formula

However, by a character that the real distance measured value is more largely measured than distance between the fixed and moving nodes, the margin of error is generated. In case the range exceeds allowable limits of error (2-3m), $AM^2 > BM^2 + DM^2$ and $CM^2 > BM^2 + DM^2$ are established and a ranging value is revised as equation 3.

$$AM^2 = (BM^2 + DM^2) - CM^2 \quad \text{or} \quad CM^2 = (BM^2 + DM^2) - AM^2 \tag{3}$$

In case the margin of error is within the allowable limits of error with less than 1m, $AM^2 < (BM^2 + DM^2) - CM^2$ and $CM^2 < (BM^2 + DM^2) - AM^2$ are established and equation 4 is revised. Accordingly, condition of equation 5 is established and the equal distance ratio is satisfied.

$$(AM - n)^2 + (CM - n)^2 \approx BM^2 + DM^2 \tag{4}$$

$$AM^2 + CM^2 \approx BM^2 + DM^2 \tag{5}$$

So far, to obtain video information in video security surveillance system, mostly the several fixed cameras which provide zoom-functions have been used and the video information of objects has been saved. However, the fixed camera should be improved in video quality and valid video information amount because it is used in limited space due to limit of viewing angle.

3. A New Mechanism for Intelligent Tracking and Video Recording

To overcome technical limit in the existing intelligent video security surveillance system, an intelligent object tracking and recording method is necessary on object routing and solutions to improve calculation accuracy on moving object's location. Thus, the following new mechanism is suggested.

3.1. Improved Location Calculation considering Three-Dimensional Space

To increase calculation accuracy of location information, Line of sight (LOS) environment should be provided, considering the three-dimensional space (length, width, and height), not a plane space of two-dimension (length and width). Considering real measured distance (d_x) and distinction of height (d_y), the value is revised into necessary distance (d_{xy}) in calculation. Through this, the information accuracy of object location in real time can be improved.

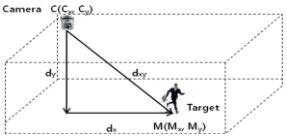


Figure 2. Three-Dimensional Space

$$\begin{aligned} d_x &= |M_x - C_x| \\ d_y &= |M_y - C_y| \\ d_{xy} &= \sqrt{d_x^{\,2} + d_y^{\,2}} \end{aligned} \tag{6}$$

3.2. Method for Video Quality Improvement

In this research, to improve video quality and obtain tracking information in real time for moving objects, PTZ (Pan-Tilt-Zoom) camera was applied and we improved valid video information ratio, supporting horizontal and vertical movements of camera and efficient zoom-functions so that video quality can be improved.

First, based on Euler's formula to control horizontal movement of camera, with a transformed equation between polar coordinates and Cartesian coordinates, calculate θ_P which is a horizontal turning angle of the PTZ camera.

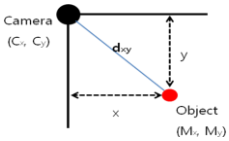


Figure 3. Horizontal rotation range

$$\theta_p = \begin{cases} \tan^{-1}\left(\frac{Y}{X}\right) & X>0,\ Y\geq 0 \\ \tan^{-1}\left(\frac{Y}{X}\right)+360^\circ & X>0,\ Y<0 \\ \tan^{-1}\left(\frac{Y}{X}\right)+180^\circ & X<0 \\ 180^\circ & X=0,\ Y>0 \\ 270^\circ & X=0,\ Y<0 \end{cases} \quad (where, 0^\circ < \theta_t < 90^\circ) \tag{7}$$

To control camera's vertical movement, with h_c, the height from the floor to the camera and h_m, the height from camera to moving material, calculate θ_t which is a vertical turning angle.

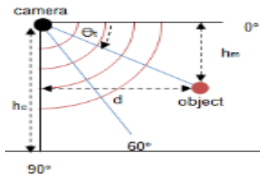


Figure 4. Vertical Rotation Range

$$\theta_t = \cos^{-1}\left(\frac{h}{\sqrt{d_{xy}^2 + h^2}}\right) \quad (where, h = |h_c - h_m|, 0^\circ < \theta_t < 90^\circ) \tag{8}$$

Also, considering camera's nonlinear recording character of camera, a movement controlling is included depending on zoom parameter of the PTZ camera on distance between interest objects.

4. Experimental Result

Based on ubiquitous sensor network technology, the suggested mechanism obtains the object position in real time and supports PTZ camera control of the center of interesting object. In this paper, intelligent video security surveillance system applied the suggested mechanism is realized and experiment environment which accept multiple objects and multiple cameras was created and tested with internal rectangle structure(18.3m x 8.8m), as shown in Figure 5.

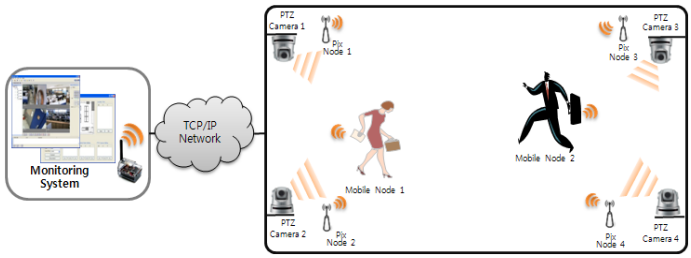


Figure 5. Experiment Environment Diagram for Proposed Mechanism

For the intelligent video surveillance system which was applied to intelligent multiple cameras in the suggested mechanism and video security system based on the existing fixed camera, performance evaluation was conducted based on the following criteria and the result is shown on Table 1.

(1) Recording by movement recognition of objects: If an object is moved, recognize the movement and evaluate whether the movement can be taken by a surveillance camera.
(2) Time for record responding: If the movement of object is recognized, evaluate the time required until starting recording of interest objects by the surveillance camera.
(3) Amount of valid video information: In case the object movement is recognized, evaluate whether video information can be earned in various angles with more than two cameras.
(4) Video quality: Evaluate whether taken video information by surveillance camera is possible to distinguish with the naked eye with materials and people.

Table 1. Recording Result of Tracking Objects

Item	Existing Mechanism	Proposed Mechanism
Recording by movement detection of objects	9/10 Times	6/10 Times
Time for record responding	510 ms	690 ms
Amount of valid video information	4,320/8,400 frame (51.43%)	5,160/8,400 frame (61.42%)
Video quality	3,700/8,400 frame (39.29%)	4,740/8,400 frame (56.42%)

When we applied the suggested mechanism, compared to IEEE 802.15.4a standard suggested algorithm to recognize position applied to the existing intelligent video security surveillance system, we could obtain more accurate position information from even average error deviation and decreased maximum error average. Also, with interesting object position information depending on detected various interesting object movement, through selected PTZ camera control for each interesting object, interesting object tracking is possible to be taken so compared to the existing system, we verified that valid video information was increased about 17% and the amount of video information was increased about 10%. However, in table 1, it is shown that the responding time and the number of recording by movement detection of interesting object are shown lower than the existing system. It is caused by the fact that we excluded unnecessary movement tracking and recording for objects

in the suggested mechanism in this paper. This is because we recognized valid range movement as the same one in object movement.

The Figure 6 is one of experimental results that the existing system and the intelligent video security surveillance system applied the proposed mechanism comparison result in multiple object environments. In the existing system, objects No.1 and 2 moved into inside and camera No.2 and No.4 took them. The mechanism applied system under the same condition, all other cameras tracked and recorded objects No.1 and 2.

(a) Existing Mechanism (b) Proposed Mechanism

Figure 6. Recording Result of Intelligent Tracking Objects with 4 Cameras

5. Conclusion

In this paper, to improve video security surveillance system's problems, the new mechanism which can intelligently tracks and records interesting objects in multiple objects environment was proposed.

To calculate location information of interesting objects more precisely, the Chirp Spread Spectrum method which was considered the three-dimensional space was applied. Also, the active tracking and recording was possible through PTZ camera control with location recognition technology of moving objects based on ubiquitous sensor network, and we verified that valid video information is increased.

In further, margin of recognition technology error should be more improved and in diverse interior environment, tracking and recording of interesting objects and selecting of recording range should be further studied.

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