Development of A Monitoring System for Interior Spaces using Image Data and Environment Data

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Abstract. The objective of this study is to design a system that automatically monitors the state of interior spaces like offices where through image data and environment data, which includes temperature, humidity, and illuminance, and implement and test related application programs. The image data can be used as a more effective manner by establishing a system that recognizes situation in specific interior spaces based on the relationship between image and environment data. It is possible to perform unmanned on/off controls for various electronic equipments, such as air conditioners, lights through analyzing the data acquisited from environment sensors as dynamic states are not maintained for a specified period of time. For implementing these controls, this study analyzes environment data acquisited from temperature and humidity sensors and image data input from wireless cameras to recognize situation and that can be used to automatically control environment variables configured by users.

Keywords: monitoring system, environment data, automatic control, motion detection

1 Introduction

There exist several systems for monitoring situation in interior spaces, such as CCTVs, wireless cameras, and other devices, in lots of buildings according to the development of IT. However, these have been used as recognition purposes depended on a simple acquisition way of image data and its storage or analysis. The recent technologies used in the implementation of such monitoring systems are sensor networks in which wireless sensor nodes are allocated in various spaces, such as buildings, roads, mountains, and other locations, to monitor their environment data (temperature, humidity, illuminance, and carbon dioxide) as a wireless manner [1-3].

This study monitors dynamic states in an interior space, and design and implement an integrated system to perform automatic controls in the space effectively by combining the states with environment sensor data, such as temperature, illuminance, and other conditions, in order to maximize the applicability of image data acquisited from various wire and wireless cameras.

This study consists of five chapters as follows: Chapter 2 introduces related studies, Chapter 3 describes the proposed system implemented in this study, Chapter 4 demonstrates the proposed system through an experiment, and Chapter 5 represents the conclusion of this study and future projects.

2 Related studies

Studies on monitoring systems that use image and environment data input from wire and wireless cameras have been actively conducted. The monitoring systems that use image data have been largely used in object tracking systems as shown in [4-7].

In particular, [4] used adaptive background images to effectively detect the motion of objects. Also, [5] proposed a method that is able to track atypical objects, which are overlapped with other objects, using a comparison method that compares the present objects and templates.

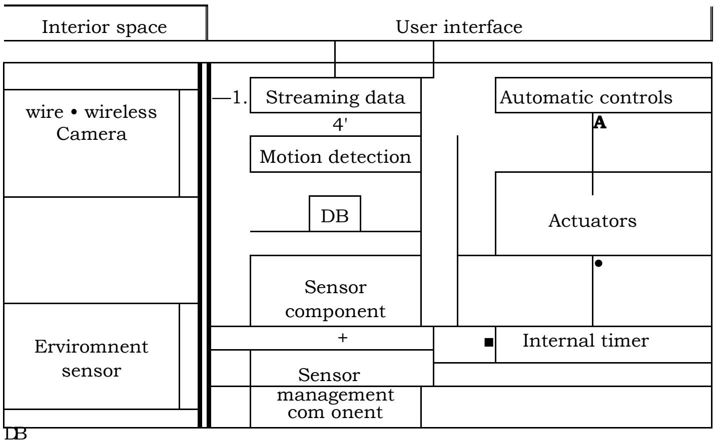
In addition, the monitoring systems using wireless network systems have been applied to various fields, such as environment monitoring, medical purpose, home networks, agriculture, and forest fire monitoring. In particular, [8] implemented a system that protects changes in quality of products through applying such wireless networks to transportation systems, such as reefer containers. Also, [9] implemented a structure safety system that monitors environment data, such as vibrations in roads and other structures, external shocks, and loads, by applying wireless sensor networks.

Although there are many studies on the methods for collecting and monitoring enviromnent data using object tracking methods and wireless networks used in monitoring systems, there are not much developments in the systems that monitor and control peripherals by combining these two methods.

3 Proposed monitoring system for interior spaces

3.1 System architecture

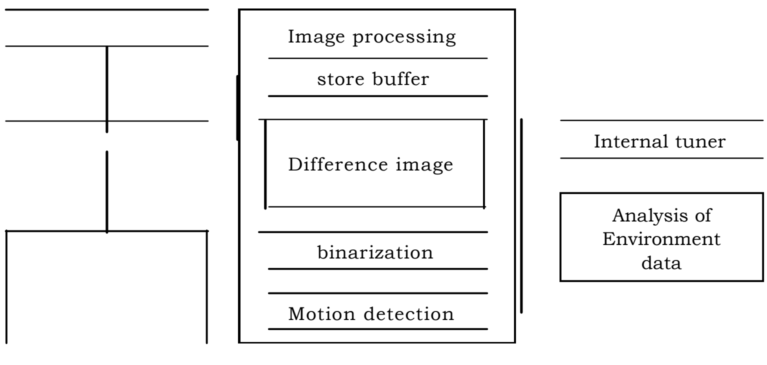
The system proposed in this study can be divided into three sections, such as a detection section that detects motions based on streaming data obtained from wire and wireless cameras as illustrated in Fig. 1, an acquisition section that obtains environment data, such as temperature, humidity, and illuminance, using sensor nodes, and a control section that controls required devices after comparing and analyzing the motion detection data and enviromnent sensor data through configuring an internal timer.



(Fig. 1 System architecture)

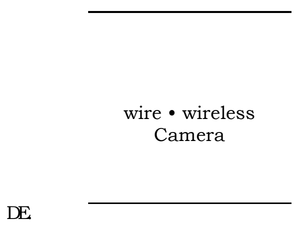
3.2 Image acquisition and motion detection

The proposed system generates streaming data input from wire and wireless cameras using OpenCV (Open Source Computer Vision Library) and VFW (Video for Window) and detects motions. Differences in two neighbor frames can be used to detect motion in image data. Fig. 2 shows the flowchart of image acquisition and



motion detection processes.

User interface
Streaming data



(Fig. 2 The flowchart of image acquisition and motion detection processes)

As shown in Fig. 2, motions can be detected by storing streaming data input from wire and wireless cameras to different buffers with a specific delay in time and inspecting whether the value of the difference in data stored in different buffers exceeds its threshold value. Detected frames are stored as binary images and can be issued to certain user interfaces according to the requirement of users. Also, appropriate devices can be automatically controlled by analyzing environment sensor data as motions are detected. For instance, as motions are detected from image data, the illtuninance sensing data performs on/off controls for lights to adjust the illuminance data for the configured range when the configured range is not satisfied due to the presence of people in an interior space.

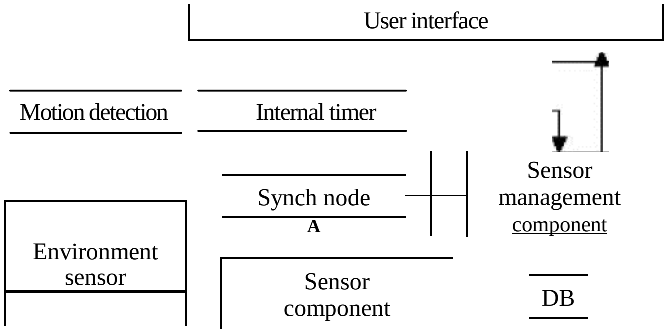
3.3 Collection of environment data using sensor nodes

This section describes the collection of environment data using sensor nodes. Although there are several types of sensor nodes according to types of platforms and micro controllers, the sensor node used in this study is Kmote-S1, which uses TelosB as a platform. This sensor is installed at several sections as a distributed manner in an interior space and measures surrounding temperature, humidity, and illuminance, and it transfers the measured data to synch nodes through a transmission section. Fig. 3 illustrates the sensor and synch nodes used in this study.

Kmote-S1 Kmote-Basic

(Fig. 3 Sensor node and synch-node)

Fig. 4 shows the flowchart of the collection of environment data using sensor nodes. As shown in the flowchart, the environment data, such as temperature, humidity, and illuminance, collected from sensor nodes, which are installed in an interior space, is transferred to the synch nodes connected to a PC as Tos messages through an RS232 communication method. Then, the data is received as hexa data and that is changed as decimal values again in order to output it user interfaces and store it into a specific database.

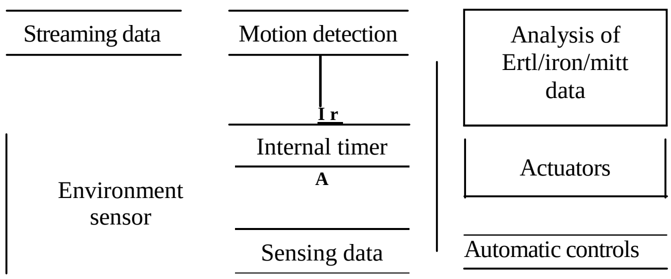


(Fig. 4 The flowchart of the collection of environment data using sensor nodes)

While the data is sensed at an interval of 1 minute, it will be analyzed to identify the information sensed at the time between the detection time through an internal timer and the closest moment at the detection when motions are detected.

3.4 Automatic control

This section describes a control section that automatically controls peripherals by analyzing sensed data through actuators. Fig. 5 represents the flowchart of the control section.



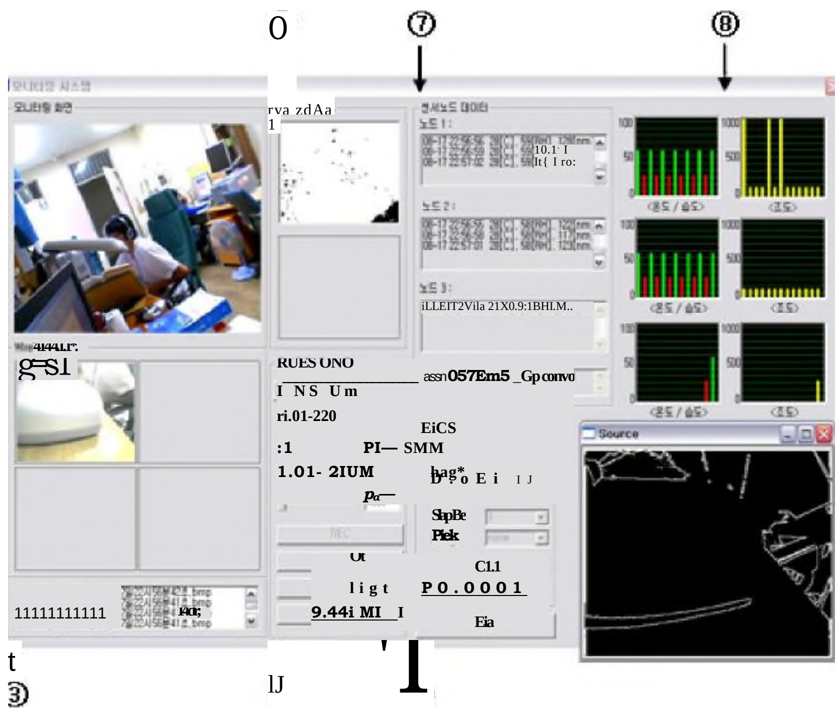
(Fig. 5 The flowchart of the control section)

As mentioned in the previous section, if motions are detected, internal timers will operate in which the sensed data is to be automatically analyzed within the range of detection time. Here, the motion detection from image data and the range of detection time can be arbitrarily configured for analyzing such sensed data. If the sensed data, such as temperature, humidity, and illuminance, exceeds usual states and values, the control section issues proper automatic control signals to appropriate devices.

4 Implementation and experiment results

This section represents the implementation environment of the monitoring system proposed in this study. The operating system used in sensor nodes was TinyOS 2.0, and the program was written and compiled by using NesC language and Cygwin, respectively. Also, the user interface and integration software system were implemented using the Microsoft Visual C++ 6.0 under the operation system of the Windows XP Professional. The hardware devices used in this study were the Kmote-S1 sensor node developed by I.N.tech Co., Ltd that shows a TelosB platform environment, Kmote-basic that plays a role in a gateway, and wire and wireless cameras for detecting the motion of objects.

Fig. 6 shows the user interface. As shown in Fig. 6, a¯) and (2) output streaming data acquisited from wire or wireless cameras. In particular, (2) operate four wireless cameras maximum and that are able to monitor possible motions in several points and control peripherals. Also, CT is an interface that saves the image generated by detecting motions as bmp files and outputs images. (4) is an interface that precisely applies the motion included in image data under given environments and configures the sensitivity and recording condition of image data. (5) represents difference images as binary formats when motions are detected and identifies which objects represent motions precisely. 6 is an interface that configures serials and receives data by connecting it to sensor nodes. C7L,'' is an interface that issues data generated from sensor nodes, and the data can be issued at an interval of 1 minute with the order of temperature, humidity, and illumination

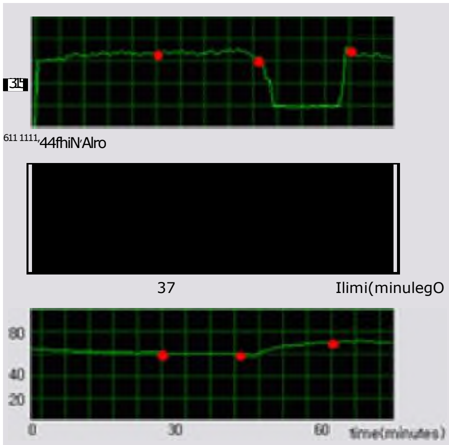


(Fig. 6 User interface)

In addition, (5': is a graph that presents the output data of temperature, humidity, and illuminance as a visual way. While motions are detected in the monitoring system, the system analyzes the data obtained from sensor nodes, such as temperature, humidity, and illuminance, and compares this data with the predetermined data. Then, the system controls lights or an air conditioner as 'on' based on these results from the analysis and comparison. Also, it controls peripherals as 'off by comparing sensed data with the average data automatically if there are no motions for a specific period of time.

Experiments were performed in a laboratory that represents not much changes in the motions of background except for objects existed in this laboratory and surrounding information. In addition, the data sensed from the laboratory, such as temperature, humidity, and illuminance, was stored before detecting actual motions. Then, changes in such enviromnent data were analyzed as motions were detected and determined the control of on/off based on this analysis. In addition, this study analyzed the success rate in automatic controls according to the variance in motions and distances for each hour throughout the day.

Fig. 7 illustrates the results of the analysis of enviromnent data, such as temperature, humidity, and illuminance. The three sections presented as origin points in the graph demonstrate certain changes in the interior environment. The environment data presented by temperature, humidity, and illuminance in the initial stage was determined as 24 t, 59%, and 726mn, respectively. The section between the second and third points presented in the graph represented a state of 'off for lights and an air conditioner because there were no motions even though the monitoring was applied for about 20 minutes. Here, the illuminance decreased from 726mm to 92mm, and the data of temperature and humidity increased gradually after passing some time. Finally, the section after the third point was a state of 'on' for lights and an air conditioner due to the detection of motion in the space in which the data of illuminance increased as 713mm again, and the data of humidity decreased gradually instead of sudden changes even though the air conditioner was controlled as 'on'.



1 temperature data graph

41 humidity data graph

41 illuminaace data graph

(Fig. 7 Results of environment data analysis)

Fig. 8 shows the state of controls for peripherals as a unit of frame after detecting motions and that represents the section after the third point. Scenes presented in the first row shows a state that represents a person who just enter the space without motions in the space. The second row shows that the system detects motions and analyzes the state of the received data, such as temperature, humidity, and illuminance, and then controls the lights as 'on' automatically based on the state of illuminance, which shows a low level. The third and fourth rows represent the binary data of the difference images between frames in order to verify the motion.

(Fig. 8 Results of Motion Detection and Automatic controls)

Table 1 shows the results of the monitoring for each hour throughout the day. Experiments were applied by 10 times, and the data obtained in the experiments was analyzed as a manner of the success rate in automatic controls according to the reliability of sensed data, detection success rate in motions, and detection distances.

Table 1. Results of the experiment for each hour

The number of experiment : 10 times				
Time	Reliability of the sensed data	Motion (1m) detection success rate(%)	Distance (2m) Automatic Control success rate (%)	Distance Automatic Control success rate (%)
08:00 12:00	0	100%	100%	100%
12:00 16:00	0	100%	90%	100%
16:00 —20:00	0	100%	100%	100%
20:00 —24:00	0	100%	100%	100%

0: excellent A :good X:bad

The reliability of the sensed data was obtained by comparing the error in temperature, humidity, and illuminance for each sensor node through installing three sensor node in the laboratory in which a small value in errors represents 'excellent' results. The success rate in automatic controls means the success rate in the controls of on/off. In particular, the control of lights was applied for the distance between the sensor nodes and the lights determined by 2m and 1m because the lights can be significantly influenced by the data of illuminance. As a result, the motion detection was successfully performed regardless of detection hours. It was considered that an interior space like this laboratory shows not much changes in background images. However, the success rate in automatic controls showed a success rate of 90% during 12:00-16:00 for the detection range of 2m. The results were related to the influence of external illuminance that represents the highest level of illuminance during 14:00-15:00 due to the strong sunlight and that showed some errors in the determination of automatic controls due to the small difference in the data of illuminance between the external illumination and the internal illuminance by lights in the laboratory. However, the success rate in automatic controls showed 100% for the detection distance closed from 2m to lm regardless of detection hours.
In the results of these experiments, there were no difficulties in the determination of the state of on/off for peripherals using the image data (motion detection) and environment data, such as temperature, humidity, and illuminance Also, it was considered that the monitoring system proposed in this study was successfully implemented.

5 Conclusion

The monitoring system proposed and implemented in this study is a new system that monitors motions by combining a motion detection method used in monitoring systems and a monitoring method of environment data using sensor nodes and automatically controls peripherals. In the actual implementation in a laboratory, the system controlled devices as on/off states effectively by analyzing acquisited sensor data when motions were detected or not detected for a specific period of time. Regarding future studies, this study will focus on the increase in the effectiveness of monitoring, reliability, and security for possible invaders by combining object tracking and object recognition including the detection of motions simultaneously.

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