WIRELESS REMOTE MONITORING SYSTEM WITH FLEXIBLY CONFIGURABLE MULTIVISION

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Abstract: Novel remote monitoring system for all day outdoor observation using wireless communication is proposed. It consists of three parts: a host station that is PC, remote station (camera and CPU) attached by solar cell and battery for power supply, and wireless sensor with ID (identification) signal. The remote station usually performs based on the event driven method by the sensor signal. It also can control the camera according to the sensor's ID. So the multivision monitoring system is flexibly configurable. This paper describes the details of the system and evaluates the maximum number of connectable remote stations. Since the systems are now really running at many places in Japan, we consider that the fact shows its effectiveness in a practical sense.

1 INTRODUCTION

Recently, the necessity of monitoring camera system has increased in a wide variety of fields. And the image processing research for such monitoring system has been done in many ways (K.Yamada, et al., 2000), (T.Sogo, et al., 2000), (H.Mori, et al., 2001), (H.Nagahara, et al., 2001). The purpose of this kind of vision system is not only for security against crime and disaster in the social and individual life, but also for investigation and control such as of vehicle traffic. In some of those monitoring camera systems, especially in outdoor system, the capability of all day and all weather monitoring with self-feeding of electric power is required. Moreover, the flexibility of configuration and installation of multiple cameras (multivision system) is also required, depending on the place to be observed.

In this paper, we present a compact wireless remote monitoring system that we have developed in order to meet the demands in outdoor monitoring system. The system is composed of three parts: host computer (PC) that we call *base station*, CPU built-in monitoring camera and the peripherals that we call *remote station*, and wireless sensors that are independent of the monitoring camera. The system has the following features.

The remote station is made as a self-feeding system, mainly using solar battery for power supply.

By the wireless communication of portable handy phone, etc., acquired images at the remote station are transmitted to the base station.

With all weather and darkness, the camera in the remote station can acquire images using the functions of auto focus, auto iris, lens zooming, and night vision. The camera automatically changes into an infrared one, depending on the lightness.

Usually based on the wireless sensor's signal, the remote station is driven to work. That is, as soon as one of the wireless sensors detects some object such as human body, it sends a radio signal to the remote station, then the station inputs image and transmits it to the base station.

Because each wireless sensor sends the discrimination radio signal (or radio ID signal) to the remote station, the station can control the viewpoint of camera according to the signal. Then, using those wireless sensors, it is expected that multi remote stations are easily composed as a multivision system with arbitrary configuration for various purposes such as cooperative tracking.

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2 SYSTEM

2.1 Outline

The monitoring system is composed of base station, remote station, and wireless sensors, as shown in Figure 1. The remote station usually takes rest state and it runs according to the wireless sensor's signal, that is, it drives and makes the camera acquire images, and then it transmits the compressed image data to the base station. After this series of operations, the remote station automatically takes a rest state again. The remote station also supplies the power to the infrared light when it runs at night. It is possible to force the remote station to run or to rest by a command signal from the base station.

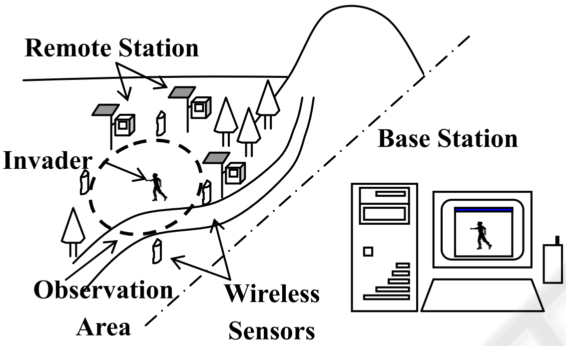

Figure 1: Conceptual image of the system.

The remote station can continuously keep running for 5 days using built-in battery, even if there is no power supply from the solar cell. The wireless sensor has also a built-in battery, and it keeps working for 2 years. One base station can control a maximum number of 256 remote stations. And one remote station can distinguish a maximum number of 16 wireless sensor signals. The wireless sensor's signal is effective within approximately 200 meters far from the remote station. Each wireless sensor can send the radio ID signal, so the remote station can operate depending on the ID signal. Then, the multiple remote stations can work cooperatively. For example, they can also acquire images of one object from many directions at the same time.

2.2 Remote Station

Since the multiple remote stations can take images in many different ways such as synchronous or asynchronous acquisition, according to the configurations in the area to be monitored, we can flexibly construct various multivision monitoring system. The block diagram of the remote station is shown in Figure 2.

The remote station is excellent in portability and is easily installed. After the remote station is put at some place, the base station can tune up the precise viewpoint of camera and lens zooming, etc., because the base station can easily control the remote station by wireless communication.

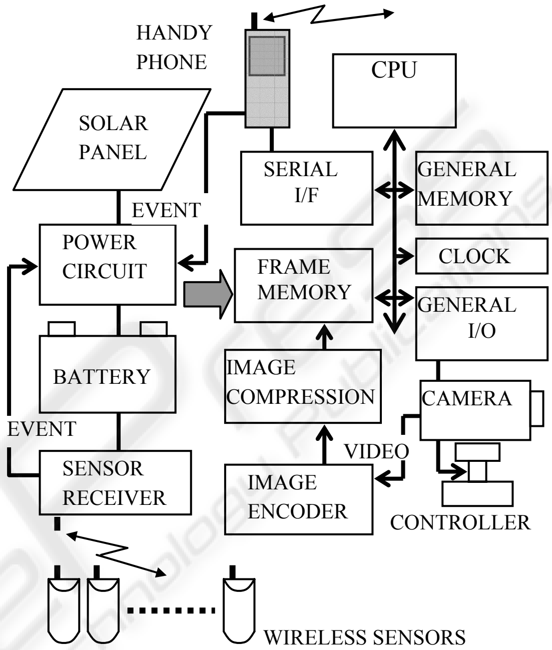

Figure 2: Block diagram of the remote station.

2.3 Performance of Remote Station

As aforementioned, the Built-in microprocessor (CPU) in the remote station recognizes the wireless sensor's ID signal, and take a series of actions: image acquisition, image data compression, image transmission, etc. The storage battery in the station stores electric power by solar energy and supplies it when necessary.

The specification of the remote station is as follows.

・Battery:
12V, 15Ah.
・Solar cell:
16.3V, 1.65A/24W.
・Continuous working period without sunlight:
5 days guaranteed.
・Unit box:
Dust and water proof.
Size [mm]: W270×H310×D200×2.
Weight [kg]: Approximately 13kg×2.

As for the image data, the specification is as follows.

・Image to be transmitted:
Still image, JPEG formatted.
・Size of one original image data (RGB color image):
640x480 [pixels] x 3[Byte/pixel] = 921.6 kByte.
・Compressed image file size:
Attached header etc.: 2kByte.
Compressed image: 40 kByte (Average).
・Frame memory (RGB color image):
640x480 [pixels] x 3[Byte/pixel] x 10.
・Image transmission rate [sec/frame] :
Cellular phone: 60.
Handy Phone: 30 (Approximately).

As for the transmission time of compressed image file, the average value is as follows.

・Dialling time: Approximately 10 seconds.
・Transmission time including the above dialling time:
Cellular phone line: Approximately 55 seconds.
Handy phone line: Approximately 30 seconds.

Figure 3 shows the appearance of the remote station that is divided into two units for the weight balance. The installation example is shown in Figure 4.

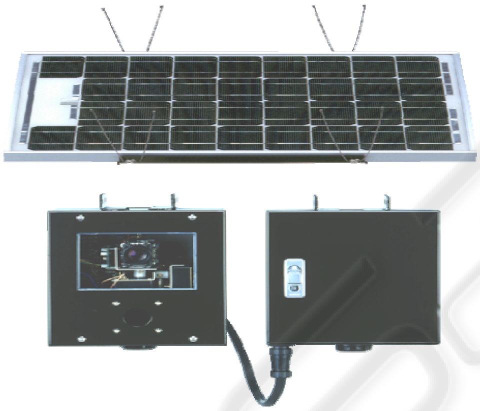

Figure 3: Outlook of the remote station.

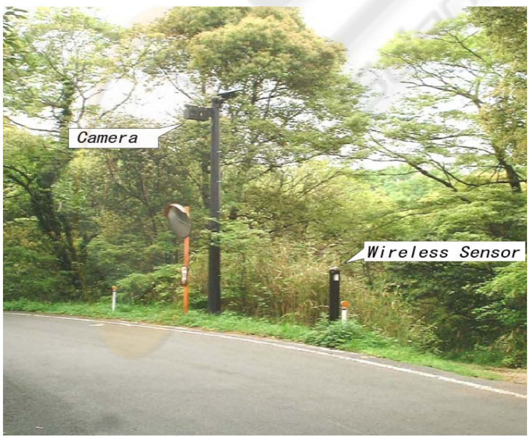

Figure 4: Example of the installation.

2.4 Base Station

The station is composed of an IBM compatible PC (personal computer) and the interface for wireless communication (Figure 5).

The base station can control the remote station freely. When it receives an image from the remote, it tells the fact to an operator (or supervisor) by a voice message. If the operator is absent, the base station automatically transfers the voice message to a designated telephone. The station can also store the transmitted image for at maximum 1,000 days.

Figure 5: Outlook of the base station.

3 THE NUMBER OF REMOTE STATIONS

3.1 Bit Error Rate and Transmission Time

In usual case, it is not difficult for the base station to do image processing faster than the speed of video signal transmission, if it uses some hardware image processor. Then, the performance of the monitoring system considerably depends on the communication system.

We roughly estimate the transmission time, assuming that the bit error stochastically occurs in Poisson process and that only error detection function is effective in the communication between the remote station and the base one.

Let T_0 and T be the original necessary transmission time without any error occurrence and the average transmission time under the environment where bit error occurs with the probability P_b (BER: Bit Error Rate), respectively. And, let S be the packet length, we have

$$T = T_0 \times (1 + P_b \times S) \quad (1)$$

Based on (1), the relation between P_b and T is illustrated in Figure 6.

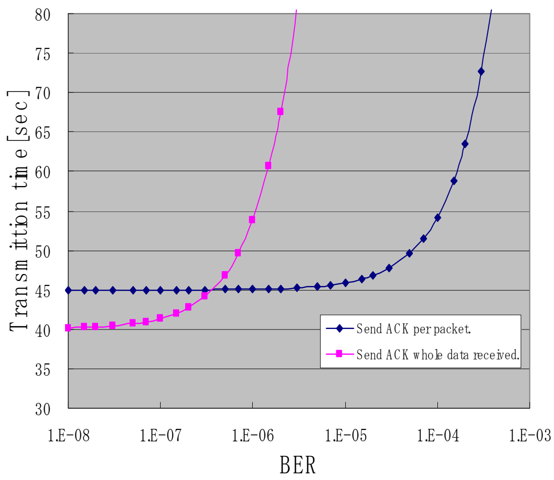

Figure 6: The relation between BER and transmission time

3.2 Estimation of Connectable Units

Now we suppose that all remote stations have to send one image data to the base station. Let Rn and Tc be the number of remote stations and the average transmission time per image data including dialling time, etc., respectively. There happens many collisions in connection to the channel (or line), however with or without any collision, we can roughly estimate that the total time for all image data to be sent is approximately Tc×Rn.

Let C be a miscellaneous time such as dialling time. And let Nave and Lt be the average number of image data to be sent and the effective (or active) time for communication between the base station and remote stations, respectively. Then, among those parameters and the aforementioned time T_0 and Tc, the following relational expressions hold.

$$Tc = T_0 \times (1+P_b \times S)+C \quad (2)$$

$$Tc \times Nave \times Rn \leqq Lt \quad (3)$$

From (3), the number of connectable remote stations Rn can be calculated. Now we assume that the bit error rate P_b is 1.0×10^{-7} and that the transmission rate is 9600bps as aforementioned. In this case, for the simplicity, we set each parameter as follows.

T_0 =45 [sec/image], S=256 [Byte] =2048 [bit], P_b =1.0 × 10^{-7}, C=10[sec], Lt=24[hours/day]= 86400[seconds/day], Nave=24[images/day] per remote station.

From (2) and (3), we have

$$Tc = 55 \quad (4)$$

$$Rn \leqq Lt / (Tc \times Nave) = 65.5 \quad (5)$$

Then, as a rough estimation in this case, we can tell that it is possible to effectively use remote stations up to 65 units. If we consider the worse condition of bit error rate 1.0×10^{-4}, we can calculate that about 56 units of remote stations are effective.

4 CONCLUSION

We have developed a compact wireless remote monitoring system that is capable of outdoor image acquisition in all weather and all day. The remote station has a built-in CPU and a camera, which is attached by a solar battery for power feeding. The built-in camera can acquire images using auto focus, auto iris, lens zooming, and night vision functions. It can automatically change into an infrared one, depending on the lightness. The remote station is usually based on an event driven method, i.e., it runs according to the wireless sensor's signal. Since each wireless sensor transmits its own radio ID signal, the remote station can control the viewpoint of camera according to the signal. Because of those functions and the compactness of the remote station, multi remote stations can be flexibly installed as a multivision system in arbitrary configuration.

The base station also can control the remote station by giving a compulsory command signal, so it can obtain monitored images periodically or at any time from the remote stations.

The proposed monitoring system is adopted by more than 20 local governments in Japan and is currently running well.

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