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# 무선 고해상도 영상 전송 기술에 기반한 영상 감시 시스템의 설계

# Design of Visual Surveillance System based on Wireless High Definition Image Transmission Technology

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**요 약** 공공장소에서 의도적으로 유기하는 위험 물체를 감지하는 것은 사회 안전 목적에서 중요하다. 오늘날 영상 감시 시스템은 고해상도와 무선 연결 능력의 측면에서의 성능 향상이 요구되고 있다. 이 연구에서는 무선 고해상도 영상 전송 기술을 기반으로 사회 안전 목적의 유기물 감지를 위하여 영상 감시 시스템의 설계를 제안하고 있다. 또한 탐지 성능인 PED, PAT 지수를 향상시키기 위하여 이전의 영상 감시 소프트웨어 구조에 추적 알고리즘이 포함되도록 하였다. 실제 무선 고해상도 영상 전송 시스템 위에 제안된 설계 구조를 구현함으로써, 4.0 Gbps 속도의 전송 성능으로서 전체 시스템의 유효성을 보인다.

**Abstract** It is important to detect dangerous objects which are intentionally abandoned in public places. Nowadays visual surveillance system is required to enhance the performance in two ways : high resolution and wireless linking ability. In this study the design of visual surveillance system is newly proposed to detect abandoned objects for social security purpose based on wireless high resolution image transmission technology. Also, to enhance PED, PAT performance, the tracking algorithm is included in the previous visual surveillance software scheme. By implementing proposed design scheme on the real wireless high resolution image transmission system, the effectiveness of the overall system is shown with the transmission performance of 4.0 Gbps speed.

**Key Words :** visual surveillance, abandoned object, wireless link, high definition, millimeter wave

## Ⅰ. Introduction

It is important to detect dangerous objects which are intentionally abandoned in the public places such as airports, hotel lobbies, schools and so on because they are always crowded with people and possibly easy targets by hostile terrorists. For the purpose of security, there are a few previous researches to design visual surveillance systems to automatically detect abandoned objects such as [1]-[4]. Recently W. Kim designed an automatic detection system for dangerous abandoned objects based on vision technology in [5] and

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also proposed an enhanced system which discriminates motionless people from abandoned objects by using the human recognition technique in [6].

Nowadays visual surveillance system is required to enhance the performance in two ways : high resolution and wireless linking ability.


그림 1. 영상 감시에서 HD 해상도의 필요성
Fig 1. Necessity of HD resolution in visual surveillance

It is necessary to enhance the image resolution to HD(High-Definition) level to identify the abandoned object appearing in small portion of current interesting image region as illustrated in Fig. 1. Meanwhile HDMI cables are generally utilized to connect camera system to video surveillance computing server as illustrated in Fig. 2. The problem of conventional hard-wired method reduces the flexibility of the overall system in connectivity. Therefore, in this study the visual surveillance system is newly proposed to increase the linking flexibility and the image resolution to HD level based on wireless HD image transmission technology in millimeter wave.

## II. Design of Visual Surveillance System

The conceptual design is proposed to cover the two needs explained earlier in the illustration of Fig. 3. In the configuration a wireless link is proposed to connect a HD camera system to the video surveillance software in a computing server. The wireless system is comprised of Tx(Transmit) and Rx(Receive) links which are running in the bandwidth of over 3.0 Gbps(bits per second) to cover full HD image transmission in real-time.

Apparently, in Fig. 3 the visual surveillance software has a function of detecting abandoned object automatically in image streams captured by camera

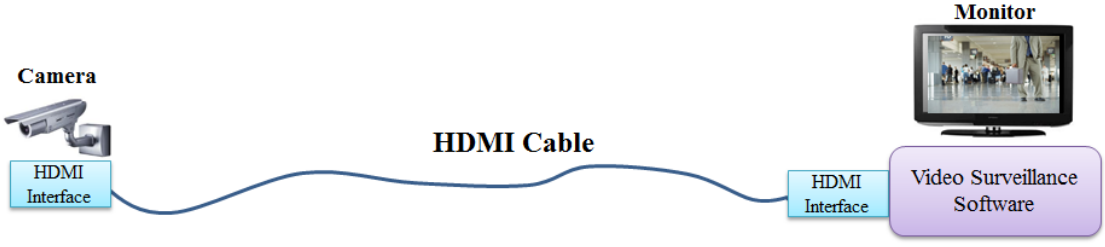


그림 2. HDMI 전선 연결 방식의 기존 영상 감시 시스템
Fig 2. Conventional video surveillance system on wired HDMI linking method

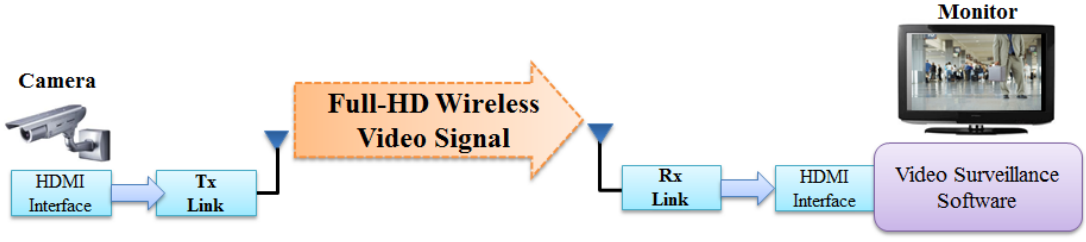


그림 3. 무선 HD 영상 전송에 기반한 제안된 영상 감시 시스템
Fig 3. Proposed video surveillance system based on wireless HD image transmission

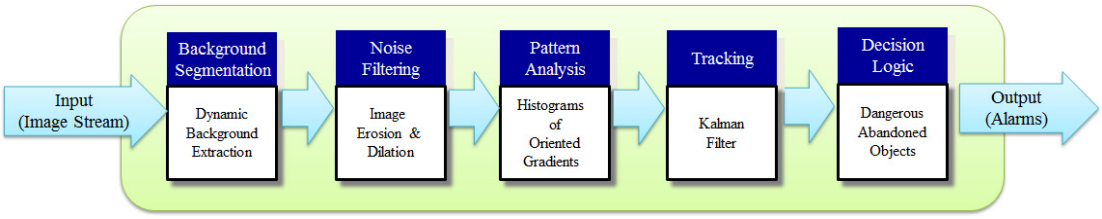


그림 4. 영상 감시 소프트웨어의 제안된 구조
Fig 4. Proposed structure of visual surveillance software

systems. In the previous study of [5], there are four steps for abandoned object detection such as *background segmentation, noise filtering, pattern analysis and decision logic*. Foreground objects are obtained by subtracting background image from current importing image. Here, the background image means the stationary pure background image without the objects such as people and moving things. Therefore, extracting the background image is the essential process to obtain foreground objects stably. One of the useful background extraction technique is Dynamic Background Extraction(DBE) method proposed by Kong et al.[7]. After obtaining the background image, foreground objects are easily obtained by subtracting this from the current importing image at each step. After obtaining foreground objects, it is necessary to discriminate human shapes to increase PED and PAT performances which are discussed in Chapter Ⅳ. Mohan et al. tried to detect humans with Harr wavelets and SVM(Support Vector Machine) classifier in [8]. Also Viola et al. used adaBoost classifier to detect pedestrians in streets in [9]. Moreover, Mikolajczyk utilized adaBoost classifier to robustly detect human part in [10]. To detect the human shapes in foreground objects HOG(Histogram of Oriented Gradient) is utilized in the base of the approach of Dalal and B. Triggs in [11]. The decision logic can be designed to determine whether the detected objects from the previous stages are short-term or long-term thing. The robust decision logic is proposed in [12] by using fuzzy logic algorithm.

One of the problem of the previous study in [5] is that the detection performance is unsatisfactory to apply the system to real world. To solve this problem, a new design structure is proposed in Fig. 4 to make the visual surveillance software more reliable. In this new design, a Kalman filter logic is included in the previous research of [6] to track human objects in image stream to improve detection rates when considering human occlusion for abandoned objects behind because Kalman filter can give the information of human positions by tracking them from the initial points obtained from the previous HOG stage.

## Ⅲ. Implementation of the proposed design

The overall system is proposed to construct the configuration which integrates the visual surveillance system with wireless HD image transmission system as illustrated in Fig. 5. HD video signal captured by a camera system is transferred to the video surveillance system explained in Chapter Ⅱ in air by a wireless HD image link. A wireless link was proposed to cover HD image transmission in the previous study of [13], in which the hardware system is implemented by the generation 1 chipset of *Sibeam* corporation. The performance is unsatisfactory in the phase of transmission distance and power consumption.

In this study new wireless HD image link is proposed on the results of the previous researches in [14] and [15], in which the wireless link is designed and implemented on the generation 2 chipset of *Sibeam* corporation. In the link, there are two subsystems : *Transmitting system* and *Receiving system* as

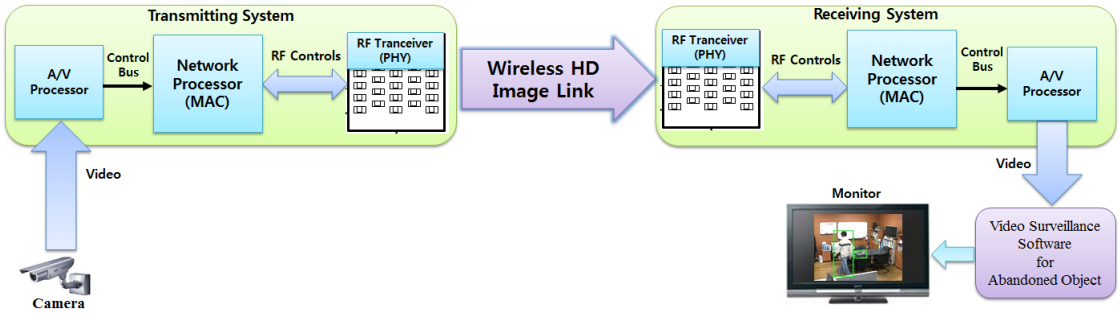


그림 5. 제안된 설계 구조에 대한 구현 시스템의 구성
Fig 5. Configuration of implemented system for the proposed design scheme

illustrated in Fig. 5. Each subsystem is comprised of *A/V processor, Network Processor* and *RF Tranceiver(PHY)*. In transmitting system, the A/V processor delivers video signal to the network processor which functions as MAC and the RF tranceiver actually transmits the video signal in digital format on 60 GHz millimeter band. Meanwhile, in the receiving system *A/V processor, Network Processor* and *RF Tranceiver(PHY)* function in reverse way compared with the transmitting system.

In real hardware, SB9220 and SB9210 chips of *Sibeam* corporation are used for the network processor and the RF tranceiver, respectively in the transmitting system, while SiI9135 of *Silicon Image* corporation is chosen as the AV processor. Similarly for the receiving system SB9221 and SB9211 chips of the *Sibeam* corporation are used for the network processor and the RF tranceiver, respectively while SiI9134 of *Silicon Image* corporation is selected as the AV processor.

## Ⅳ. Experimental Results

The overall system is evaluated on the test image stream of which feature is summarized in Table 1. Image streams for a meeting room was captured to include 6 essential situations which include the image scenes in which an object is intentionally abandoned on a table by a person and occlusions happen by multiple persons who are entering the meeting room. The details on the image streams is described in [6] as a testing condition.

표 1. 실험을 위한 영상 입력 조건
Table 1. Image stream condition for the experiment

| Evaluation Item | Image Stream for Experiment |
|---|---|
| Detection performance for abandoned object | o Image stream obtained in a meeting room<br>o 6 situations to test the visual surveillance system<br>o Indoor environment test |


그림 6. 유기물의 탐지 과정
Fig 6. Detection process of an abandoned object

Detection process is illustrated in Fig. 6 in which a person is tracked and marked with the green rectangle and the abandoned bag is detected and marked with the red rectangle automatically by the proposed visual surveillance system. Because occlusion problem is one of the major factors in false alarms to the entire detections, it is necessary to design a robust visual surveillance system which is insensitive to occlusion situations as illustrated in Fig. 7.

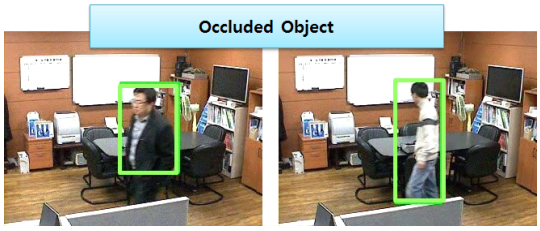


그림 7. 실험에서 유기물의 가려짐 현상
Fig 7. Occlusion of the abandoned object in the experiment

As an important performance index, Percent Events Detected(PED) in [1] is evaluated for visual surveillance systems because it measures the sensitivity for real alarm events even though there may be false alarms in the results. Generally, PED is defined as follows :

$$PED = \frac{\#of\,Real\,Alrams\,Detected}{\#of\,Real\,Alrams}. \quad (1)$$

Meanwhile, as an accurate performance index, Percent Alarms True(PAT) should be evaluated according to the following equation,

$$PAT = \frac{\#of\,Real\,Alrams\,Detected}{\#of\,All\,Detected\,Alrams}. \quad (2)$$

표 2. 이전 설계과 제안된 설계간의 성능 지수 비교
Table 2. Comparison of the performance indices between the previous design and the proposed design

| Evaluation Items | Unit | Performance indices | |
|---|---|---|---|
| | | Previous design based on [6]+[10] configuration | Proposed design |
| PED(Percent Events Detected) | % | 90 | 95 |
| PAT(Percent Alarm True) | % | 75 | 79 |
| Transmission distance | meters | 10 | 30 |
| Consuming power | Watt | 20 | 10 |
| Transmission bandwidth | Gbps | 3.0 | 4.0 |

Finally the experimental results in this study are summarized in Table 2. The results of the proposed system in this study is compared with the previous design configuration in which the visual surveillance algorithm of [6] and the wireless HD link of [13] are combined as a reference system to show the enhancement of the proposed system in performance. PED and PAT in this study are better than the previous design and the wireless transmission performances are also improved.

## V. Conclusion

In this study the design of visual surveillance system is newly proposed to detect abandoned objects for social security purpose based on wireless high resolution image transmission technology in millimeter wave. To enhance PED, PAT performance, the tracking algorithm is included in the previous visual surveillance software scheme. By implementing proposed design scheme on the real wireless high resolution image transmission system, the effectiveness of the overall system is shown with the transmission performance of 4.0 Gbps speed.

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