Development of a Cloud-based Image Water Level Gauge

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Abstract

In this study, a cloud-based Image Water Level Gauge system called as the River Eye was developed, which combines two functions of video surveillance on river flow condition and water level measurement. The River Eye system is composed of four parts: hardware including on-site cameras and a cloud server, application system for clients, water level measurement software and a map-based web service. This system has been being in demonstrative operation to test performance and stability for four sites. Description of the system architecture and water level detection software with application results was briefly provided.

Keywords: Water Level Gauge, Correlation Analysis, Water Level Measurement, Cloud, CCTV

1 Introduction

Since it belongs to the East Asia monsoon climate region, Korea has physiographic environment in which occurrence of flood damage is prone due to heavy rainfall and typhoon during the summer rainy season. For this reason, water level observation using the watermark has long been made since pre-modern Joseon Dynasty Era. From the viewpoint of hydrology, continuous water level record is fundamental for streamflow estimation. Water level data are basic and important information for water resources management affairs including flood prediction and forecasting, design of flood protection facilities, and disaster prevention activities. Diversified efforts have been made for accurate and unceasing observation of water level. For this, various types of water level gauges have been developed and utilized, including pressure, bubble, ultrasonic and radar type gauges as well as conventional float-well gauges. Recently, for the purpose of acquiring accurate and continuous water level record for the primary gauging stations, so-called double observation is occasionally exercised. More than two independent water level gauges are concurrently used at the same gauging station. Various types of water level gauges are used in practice, but video surveillance is still required for live naked-eye monitoring of the critical situations such as flood flow and disaster accident. Thus, installation and utilization of video surveillance cameras (that is, CCTV) is increasing in the river management task. During flood, CCTV can be used for monitoring of water level, streamflow, inundation of riverine area, condition of public facilities as well as safety accident. On the contrary, at the time of low flow, it may be utilized for monitoring water quality and riverine environment. In addition, local government may also use CCTVs for monitoring of drainage pumping stations, detention ponds as well as safety of vacationers enjoying in mountain streams. For the same purposes, live video images are often serviced through internet to the public as well as managers. They give convenience and safety information to the citizens. Then, can we measure water level together with video surveillance at the same time? The Image Water Level Gauge was developed as an answer

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to this question. It is a technology that combines video surveillance and water level measurement. For water level measurement, the Image Water Level Gauge uses digital image processing on images taken by cameras or CCTVs. Thus where the CCTVs are installed, water level measurement can be made without additional water level sensors. The concept and technical development of similar image-based water level measurement devices already exist in other countries [4], [3]. In Korea, however, since the first development in 2005, the Image Water Level Gauge had been installed and operated at over 20 gauging stations [1], [2]. Since the first development, the Image Water Level Gauge was improved in part, but the big picture has not changed. At present, many years passed after the first development, water level measurement and video surveillance as the original purposes remain, but information and communication environment has changed a lot. Accordingly, in this study started from 2012, we newly developed the cloud-based Image Water Level Gauge by significantly improving the existing one. The name of it is the River Eye. The River Eye provides enhanced video surveillance performance compared with the existing embedded system. Water level measurement is done by the server. This paper briefly reports development and application of the River Eye.

Figure 1: The image water level gauge

2 Concept of the cloud-based image water level gauge

The cloud-based Image Water Level Gauge was developed to solve the problem of the existing embedded Image Water Level Gauge. In the existing system, all the hardware devices including a camera, an image processing device (that is a PC) and a telecommunication unit are installed in the field. Because of this, ex post management expenditure continuously occurs due to instrument trouble- shooting and repair and system maintenance like S/W update. To resolve these problems, the River Eye was designed and developed on the basis of cloud. Conceptually, cloud is composed of three elements, a client, a data center and distributed servers. In this study, the River Eye does not use a big data center nor distributed servers, but a server plays their roles in place of them, while managers use a client connected to the server via internet. In the River Eye system, water level measurement software is running on the server without regard to number and type of cameras. Thus it is one of the SaaS (Software as a Service) type cloud services (Figure 2).

3 Development of River Eye system

3.1 System architecture

In the cloud-based Image Water Level Gauge system, on-site devices are simplified, while water level measurement software is integratedly running on the server. Simplification of on-site devices enables

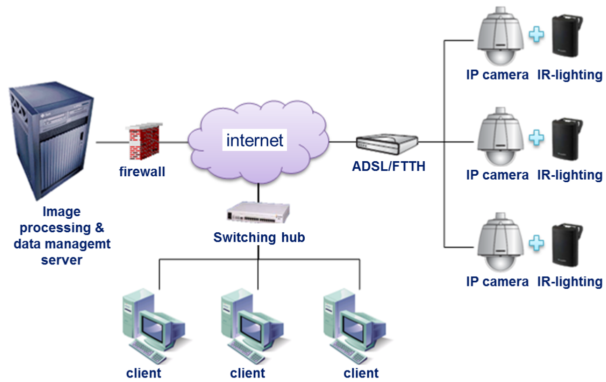

Figure 2: Concept of cloud-based River Eye system

minimization of possibility of malfunction and reduces troubles of the system. Moreover, operation of the software based on the server may provide enhanced water level measurement performance by continuous maintenance of the software including debugging and application of new algorithms. Update of software on the server has a simultaneous effect on all the connected sites. The system architecture of the River Eye is shown in Figure 3.

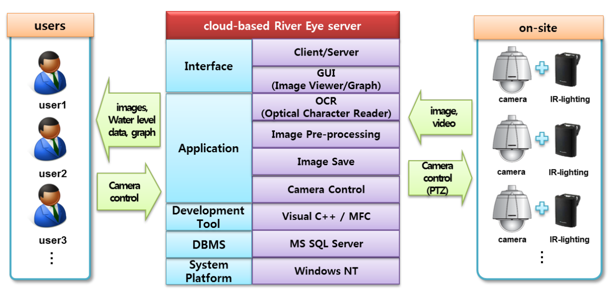

Figure 3: The River Eye system architecture

3.2 River Eye hardware and network

Simply speaking, the River Eye hardware is composed of a video camera, a server, and internet devices. Network dome cameras which support full high definition (1,920*1,080p) video streaming with remote PTZ (Pan/Tilt/Zoom) function are installed at every site. However, in case there are existing IP cameras connected, they can also be used as a part of the River Eye system without additional devices. The Windows 2008 ServerTM operating system was used for image processing and database management softwares. The server may be expanded in correspondence to increase of sites and users. If enhancement of video monitoring performance is required, video streaming servers may be added. For high definition video surveillance, the River Eye system uses a cabled broad-band communication line. In the demonstration system, VDSL (very high rate asymmetric digital subscriber line) and optic fiber cable line called as FTTH (fiber to the home) are adopted. At least 1 frame of full HD image per second can be transmitted on these cables. For regions without the broad-band line, wireless communication based on the 3G or LTE network may be utilized.

3.3 The River Eye application

The cloud-based Image Water Level Gauge system consists of the three parts: field sites in which video cameras are operating, a server in which digital images are saved and processed, and a controlling office in which users or managers see the video image and measured water level data. The River Eye application which is a core part of the River Eye system can provide concurrent display and control on multiple CCTVs. The screen shows simultaneous display of 6 cameras. The system automatically and periodically saves preset watermark and riverine images of each site, computing water level using water level detection software. Measured data and related images can be viewed in the client program installed at user's PC (Figure 4).

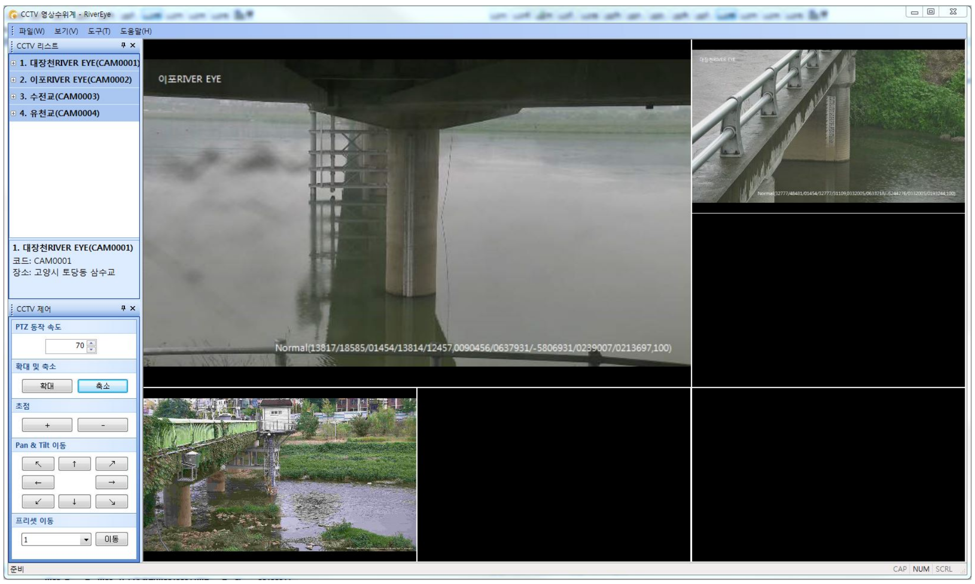

Figure 4: The River Eye system client screen (CCTV)

3.4 Map-based web service

Recently, information on flood related disaster is often serviced to public. By doing this, safety consciousness of citizens may be promoted. It is also helpful for prevention of accidents and evacuation from hazardous situations such as flood and urban area inundation. In a similar respect, information on water level of rivers may be helpful to local residents and visitors. The River Eye system gives public web services as well as closed client-server services which are developed for river managers (Figure 5). In the River Eye web service, video images and water level data are shown together in connection with Google MapTM. This service was developed in compliance with HTML5 standard, so the web site can also be viewed by the smartphone every time and everywhere.

4 Development of the River Eye Software

The Image Water Level Gauge plays a dual role as a CCTV and a water level sensor. Of the two, water level measurement is made by the River Eye water level detection software. It was developed as a set of DLL files and running under the control of the daemon program in the server. The River Eye system starts with the image acquisition step using the on-site camera. Two types of images are used: motion images used for status monitoring and still cut images water level detection. Streaming proxy service developed uniquely for the River Eye system saves images in real-time and distributes them to clients while preventing probable speed decline due to direct connection to on-site cameras. Still cut images for different purposes are obtained according to the schedule pre-determined in the server. By site, day, time and purpose, they are saved as JPEG(Joint Picture Experts Group) format files to the server. Images including the water staff in them are used for water level detection. Measured water level values are recorded in the database of the server and may be under inquiry in reply to client demands.

Figure 5: The River Eye web service

Water level is measured by two detection methods. One method is based on the character recognition algorithm. It was also used by the existing image water level gauge and does image processing of a single image in which a specially designed watermark (water level plate) is included. The other is a method using the plural images of time difference. In this method, water level is measured via correlation analysis for different images (Figure 6). Images taken from the sites where there are ordinary watermarks used, are to be analyzed via the second method. By using these two methods, water level can be measured under the normal and abnormal conditions.

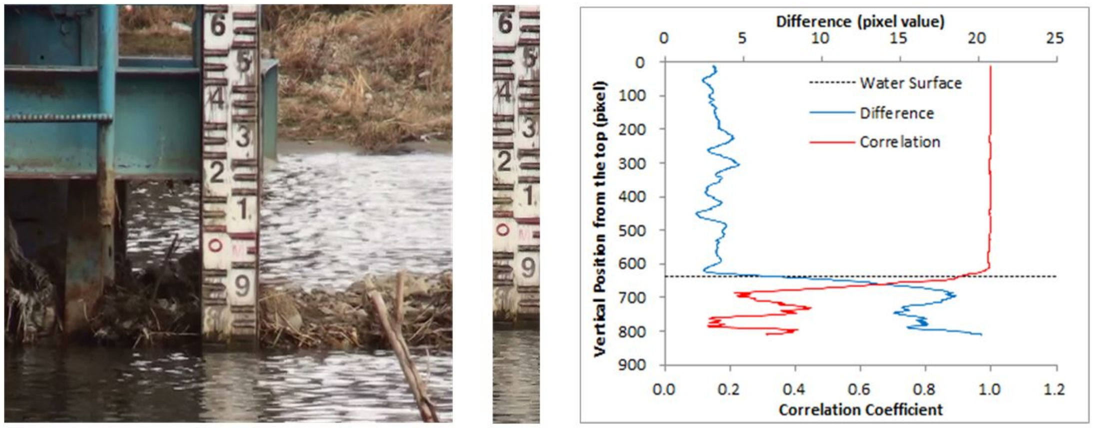

Figure 6: Water level recognition by correlation analysis (Left : image, Right : correlation)

5 Field application

The River Eye system will be practically serviced soon. Therefore monitoring for applicability and stability is essential. Accordingly, field operation of this system began at October 2012. At present (September 2013), this system have been in field test for 4 sites (Table 1). Figure 7 shows an example of Ipo Br. site.

Site	Ipo Br.	Samsoo Br.	Sujeon Br.	Yuchon Br.
River	Han River	Daejang R.	Dalcheon R.	Gwangju R.
Location	Yeoju 127-32-15/37-24-04	Goyang 126-48-24/37-37-32	Goesan 127-50-33/36-46-05	Gwangju 126-51-32/35-09-51
Internet line	FTTH	FTTH	VDSL	FTTH
Camera	Full-HD Network dome camera	Full-HD Network dome camera	Full-HD Network dome camera	Full-HD Network dome camera
Server	IBM x3250 M4, Quadcore Xeon (3.1GHz), 16GB DDR3 Memory			
Operation since	2012-10	2013-05	2013-07	2013-08

Table 1: List of demonstration sites

Demonstrative operation showed smooth motion image streaming in Ipo, Samsoo and Yuchon Brs. where the FTTH line is provided. Sujeon Br. Located in a rural area where the optical fiber line is not supported due to local condition showed a slight delay in image streaming. This means network speed is one of the important elements in the operation of the River Eye system. Since the beginning of the operation, there is few missing data due to H/W malfunction. Average measurement inaccuracy ratio is about 10 %.

6 Summary and prospect

In this study, the cloud-based River Eye system was developed through the significant improvement of hardware and software of the existing image water level gauge. Practically, it may be utilized as a CCTV and an image-based water level gauge. The River Eye system is composed of hardware including a camera and a server, application system, water level measurement software and a map-based web

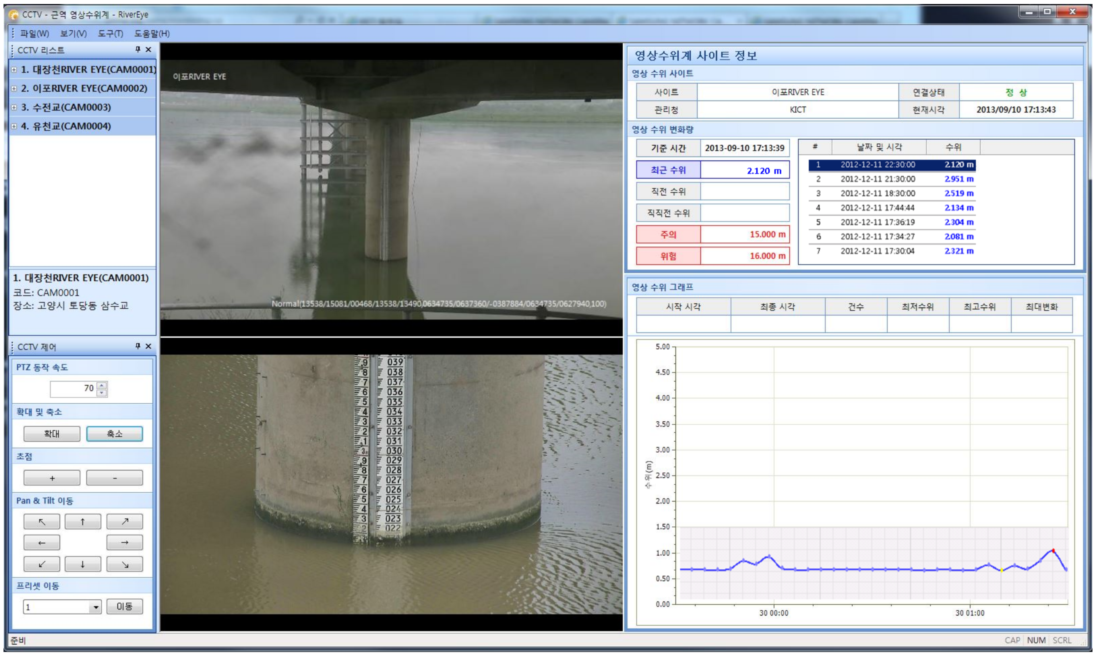

Figure 7: Live video images and water level data of the Ipo Br. site

service. System architecture, water level detection software and demonstrative operation results for 4 test sites were provided. The River Eye system is expected to be in practical use of the flood control office and municipal government for river and flood management. The web-based River Eye system interface may also be useful to public by sharing river management information.

References

[1] W. Kim, C. Y. Kim, D. G. Kim, and C. J. Lee. Development of image water level meter using image processing technique. In *Proc. of the 2006 Annual Conference of Korea Water Resources Association (KWRA'06), Jeju, Korea*, pages 500–504, May 2006.

[2] W. Kim, C. Y. Kim, C. J. Lee, and D. G. Kim. Practicization of image water level gauge. In *Proc. of the 2007 Annual Conference of Korea Water Resources Association (KWRA 2007), Jeju, Korea*, pages 560–564, May 2007.

[3] A. Saito and M. Iwahashi. Water level detection algorithm based on synchronous frame addition and filtering. In *Proc. of of the 19th Workshop on Circuits and Systems (WCS'05), Karuizawa, Japan*, pages 525–530, 2005.

[4] Y. Takagi, A. Tsujikawa, M. Takato, T. Saito, and M. Kaida. Development of a noncontact liquid level measurement system using image processing. *Water Science and Technology*, 37(12):381–387, December 1998. in Korean.

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