URPWS: An Urban Road Ponding Monitoring and Warning System Based on Surveillance Video

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Abstract. Efficient and accurate monitoring urban ponding by surveillance video is of great significance to reduce the risk of inundation and urban traffic. The previous work lacks consideration of real-time performance and integration of a unified management platform, which leads to low monitoring efficiency. This demo presents an urban road ponding monitoring and warning system (URPWS) based on surveillance video. URPWS provides a platform that integrates intelligent monitoring, real-time warning and unified management, which realizes the real-time and manageability of monitoring. In this demo, we bring forth the application of URPWS in Nanning of Guangxi Province, which delivers a new feasible solution for urban road ponding monitoring and management.

Keywords: Road ponding monitoring · Real-time warning · Management system.

1 Introduction

With the increasingly drastic global climate change, the frequency of extreme rainfall is increasing [2]. At the same time, the rapid development of urbanization has greatly changed the conditions of the underlying surface, making the problem of urban ponding and inundation more prominent. Safe, real-time and accurate monitoring of urban ponding is of great significance to reduce the risk of inundation, urban traffic and public safety [1].

As the "eyes" of modern cities, video surveillance contains real-time and useful information [4], which is widely used to road ponding monitoring. However, the traditional method relying on the manual cannot guarantee the accuracy of monitoring and real-time warning. How to monitor the road ponding in real-time and accurately from the video surveillance is a difficult task for the city management department.

Deep learning has preponderance in data processing, which is beneficial to solving urban anomaly detection and disaster management [5]. Recent works

have applied deep learning techniques to automatic monitoring of ponding [1, 3]. However, they are not only under-optimized for efficiency in practical applications, but also lack a systematic solution for unified monitoring and management.

In this demo, we throw light on the Urban Road Ponding Monitoring and Warning System (URPWS), which integrates intelligent ponding monitoring, real-time warning and unified management. And, an optimized lightweight semantic segmentation network is introduced into the proposed system to improve the efficiency of road ponding monitoring. In addition, the proposed system is capable of flexible configuration and management service integration. Practical applications show that URPWS provides real-time monitoring and automatic warning of road ponding segments, improving the productivity of urban management.

2 System Overview

Fig. 1 shows the architecture of URPWS. The system consists of client module, video streaming module, server module, storage module and ponding detection module. Firstly, URPWS uniformly accesses surveillance videos from the video streaming module under the user-specified configuration. Then, the server module schedules the video stream, identifies and segments the road ponding through the ponding detection module. The detection results and their scene photos are stored into the storage module to provide support for the warning service. Finally, URFDWS provides relevant services according to the requirements of users. The detailed description of each module are as follows.

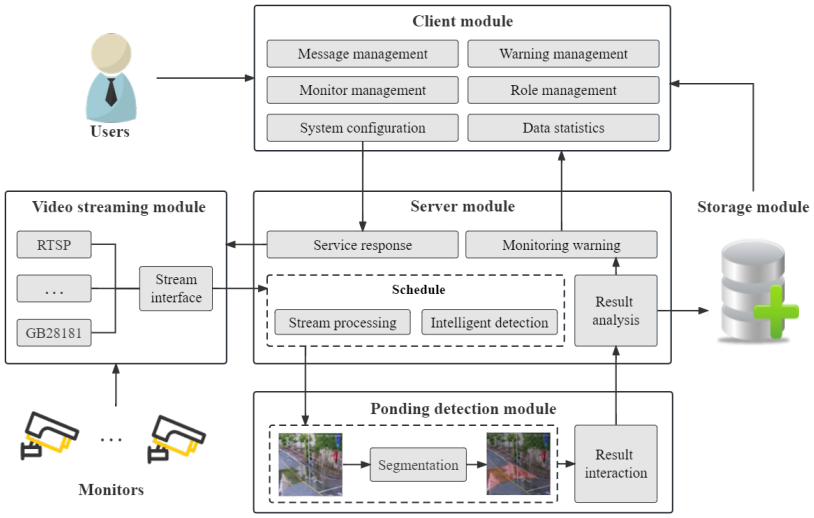

Fig. 1. System architecture

Client module: In URPWS, the user interacts directly with the system through the client module. The client module provides users with the functions of message management, warning management, monitor management, role management, system configuration and data statistics. The diversity of URPWS configuration and management allows users to respond to different scenarios according to their actual needs.

Video streaming module: To manage and schedule video stream uniformly, URPWS designs video stream module. This module not only supports the access of multiple video streams, but also provides a unified interface for the server module to schedule and use.

Server module: As the hub of URPWS, the server module responds to the requests of the client module to provide services for users, and it schedules the modules in the background of the system to realize monitoring and warning. Specifically, the module collects the video stream and samples the key frames, then sends the frame image to the ponding detection module for intelligent segmentation, and stores the returned result to the storage module. According to the system configuration, the server module performs monitoring and early warning in the form of message queue.

Storage module: This module is used to store the detection results, including ponding time, ponding road location, event level, scene photos and other information. In addition, all of this stored information is also used as a reference for early warning and user inspection of the event situation.

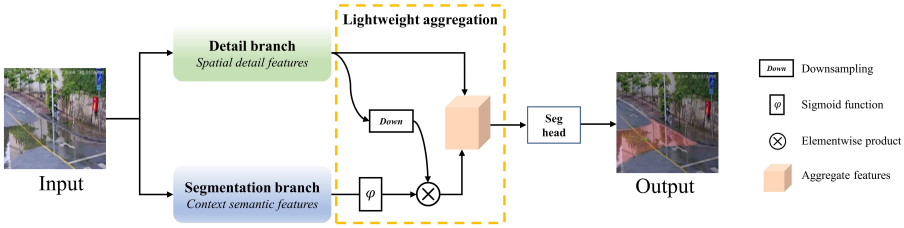

Fig. 2. Lightweight semantic segmentation network

Ponding detection module: This module designs an optimized lightweight semantic segmentation network based on BiSeNet V2 [6] to segment the ponding area. As shown in Fig. 2, the optimized network consists of three main components: the spatial detail branch, the contextual semantic branch and the lightweight aggregation components. Specifically, the detail branch is used to capture of low-level details and generate high-resolution feature representations, and the segmentation branch is used to focus on the acquisition of high-level

semantic contexts. The lightweight aggregation component guides the aggregation layer to enhance the interconnectivity and merge the above two types of feature representations. The inference speed of the proposed optimized network in practical application is 27.39 FPS, which is an improvement of 1.7 FPS over the origin method. And, the result is only 2.6 FPS lower than the 30 FPS of the original video. The lightweight design of the network ensures efficient performance while maintaining recognition accuracy, which is crucial for the real-time monitoring of the system.

3 Demonstration Scenarios

URPWS is encapsulated well with a friendly interface that users can use with simple click. Take Nanning of Guangxi Province as an example, this demo employs live video from street surveillance cameras in downtown Nanning to illustrate some noteworthy functions and examples of road ponding monitoring and warning. Fig. 3 shows the user interface of URPWS.

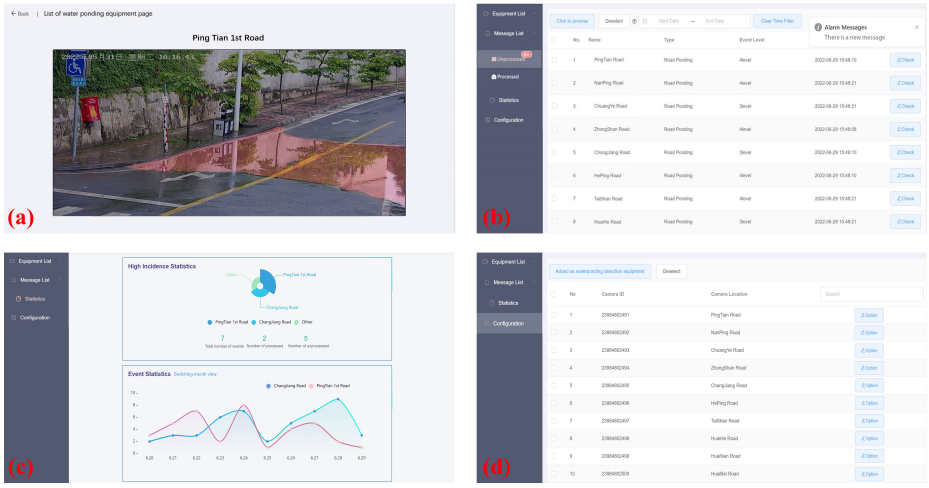

Fig. 3. Demonstration of URPWS

Fig. 3(a) shows the road ponding monitoring of surveillance video. This web page provides the road location, event time and detection result image. The ponding area in the image is segmented by red mask. All the information helps users to understand the situation of road ponding in time for further decision-making and prevention.

Fig. 3(b) shows the message list of the ponding events. The list displays event information such as the time and location. Users can view detailed pictures of the ponding detection, which is consistent with the segmentation results in

Fig. 3(a). In particular, whenever there is a ponding event occurs, the top right corner of the page will be timely pop-up reminder. In addition, URPWS provides statistical function. As shown in Fig. 3(c), this page provides statistics on the road of frequently occurring events and supports viewing the frequency of events in terms of diverse time dimensions. These assist users to spot water-prone roads and times of day, and make a strategic decision timely to avoid inundation.

Fig. 3(d) shows the configuration page. Users can adjust and manage the surveillance video according to their actual needs to cope with different scenarios, such as increasing the frequency of monitoring during the plum rain season or adding surveillance cameras to areas prone to ponding.

4 Conclusion

In this demo, we design an urban road ponding monitoring and warning system based on surveillance video, called URPWS. URPWS performs ponding monitoring through a lightweight semantic segmentation network and integrates warning, and management functions. The demonstration scenarios indicate the feasibility of our system in ponding monitoring and warning. URPWS provides a new solution for relevant departments in urban management.

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