Remote Monitoring and Control System for Aquarium Based on Mobile Communication Platform

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Abstract. With the progress of information technology, The small aquarium and its auxiliary equipment, which are used to raise fish, have gradually developed from functionalization to intellectualization. The aquarium equipment which can realize remote automatic monitoring will change people's traditional ornamental fish culture to a large extent. The dynamic image of the aquarium collected by analog vidicon through the IMagineWorld service system will be stored and transmitted in this system. The user can monitor the growth of fish at any time and in any place via the network server platform of mobile communication terminal software platform. Meanwhile, users utilize RS485 transparent protocol to obtain the temperature data, and remotely operate the Oxygen increasing equipment, heating, lighting and filtration system through the I/O alarm output port of the video encoder. It is necessary to popularize this production, which has achieved great response in testing.

Keywords: Small aquarium · Remote monitoring · Mobile communication

1 Introduction

On the market, most aquariums can be manually operated by users, only a fraction of equipments are programmed to be automatic. Under the background of electronic information and remote control technologies development, the intelligent observation system of long-range, condition observation, device status observation and manipulation have been applied in precision agriculture, smart home industry and many other areas [1]. Although some types of aquariums can be controlled remotely, but multi-functional, integrated system is rarely used [2–7]. According to our survey, users are not near the aquariums most of the time and therefore the fish raised in the aquariums cannot be monitored in real-time, not to mention the real-time sensing and remote control of the working status of breeding and environmental conditioning equipments

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installed to the aquariums. This brings great difficulty to daily maintenance of the aquariums or can even causes economic loss [8].

Nowadays, mobile phone which has powerful communication abilities is the most popular electric device. With diversified functions, the portable phone has became an important tool of daily life. Thus the mobile phones can be used to revolutionize the fisheries information technology as the communication platform, which will reduce the cost and improve the intuitiveness and real-timeliness of the aquarium monitoring. Most importantly, by integrating the aquarium remote monitoring system to the mobile phones, remote aquarium monitoring and control will be an easy and widely popularized activity, especially in the 4G era. In a word, the mobile phone-based digital aquaculture system and peripheral facilities will be the major breakthrough of the industry.

We describe a remote monitoring and control system for aquarium based on mobile communication platform. This system enables remote video monitoring of the aquarium by using the conventional protocol interface of the video server, IMagineWorld service system, RS485 protocol and I/O ports (used for alarm input/output) under a network environment. The remote monitoring and control system for aquarium provides the temperature and working status monitoring solutions for environmental conditioning equipments (oxygen adding, warmer and filtering equipments). The system will have great significance in the field of aquarium manufacturing.

2 An Overview of the Remote Monitoring System

The remote monitoring and control system for aquarium mainly consists of video server, front-end video collection module, water quality monitoring module, equipment control module, network system platform and application of remote mobile client. The supervisory system is responsible for collecting the water temperature data and real time dynamic image information of the aquarium. The video encoder plays an important role, which performs other extended functions besides video collection and signal conversion. The I/O port of the video encoder is encapsulated into an I/O control module of the system and collect the control commands sent by the central server platform. Therefore, the remote sensing and switching operation of the conditioning equipments of the aquarium are realized. The remote control is mainly used to realize the management of the related control equipment (oxygen adding, warmer, filtering and illumination equipments). The water temperature data collected by the water temperature sensor is transmitted to the upper main server system by RS485 protocol after decoding, where the dynamic image data collected by the CCD image sensor are coded, compressed and transmitted to the network server platform. IMagineWorld software installed to the network server platform receives the water temperature and video data and forwards them to the mobile clients that make the request according to the setting. Utilizing network server platform, user can send their demands to front-end video encoder. For different mobile users, the client application based on the Android platform has been developed. Thus the users can monitor the aquarium remotely via GPRS or WIFI. To safeguard user security and privacy, a rigorous user authentication mechanism is designed. The monitoring and control manipulations by the mobile clients are not possible unless after passing the authentication. Figure 1 system structure design.

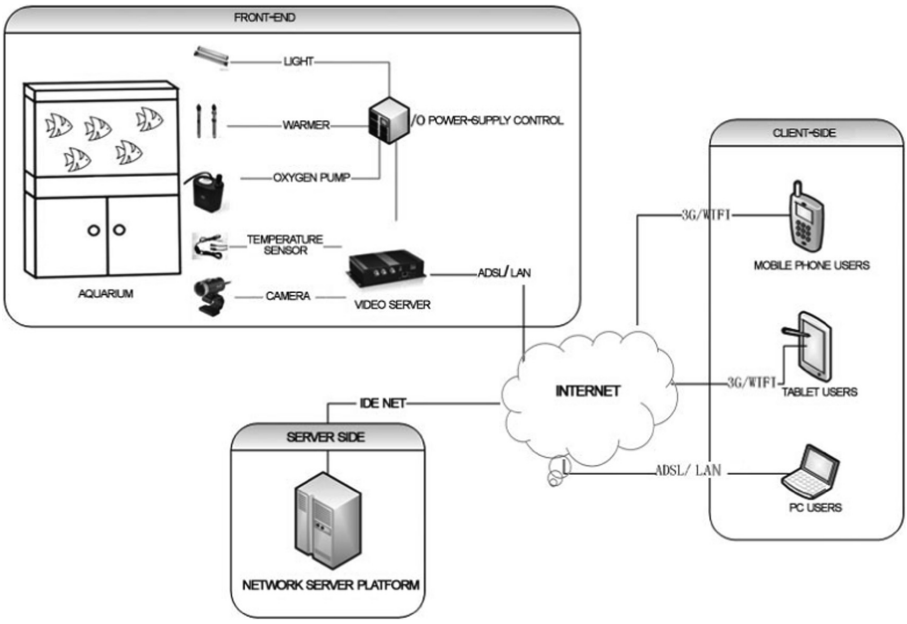

Fig. 1. System architecture

3 System Realization

3.1 Hardware Components

Hardware components of the system include video server, front-end video collection module, water quality monitoring module, equipment control module and network server.

3.1.1 Video Server

Video encoder which has found extensive application in field of remote monitoring and security is a medium and small-sized integrated equipment capable of collecting, converting, compressing and processing video and audio data. It consists of audio & video collection unit, analog-to-digital converter, Network interface, digital compression coding, input channel and output channel, RS485/RS232 serial interface, transmission protocol interface, audio/video interface and application software interface.

High-performance single-channel video server, which has high-reliability and low-power-consumption SOC chip, is equipped in this system. H.264 encoding technology is used at the front-end. The definition and speed of video transmission under low bandwidth are guaranteed by using the high-ratio compression algorithm, and the video images have high quality. Moreover, the number of frames transmission can be regulated dynamically according to the bandwidth to ensure the best view effect. PAL or NTSC format is supported. The maximum image resolution of 704 $\times$ 576 pixels, the compression rate of 32 kbps−8 mbps dynamic image, and the maximum frame rate can

reach 30 frames per second. The 4-channel signal input (semaphore) and 4-channel signal output (switching value) are supported. The RJ45 10 M/100 M adaptive Ethernet port is equipped and the RS485 protocol is implemented. The dynamic DNS clients can be configured into second level domain to suit the needs of family IP users. DC12 V/2A ballast supplies power to the video server.

The video encoder is designed with an I/O extended power supply controller to support remote sensing and switching operations of different conditioning equipments of the aquarium. The main components are gauge cover, roof box, card track and connecting terminal. All of the electrical switching components inside are electrical appliances with 9 mm modulus that are installed to the card track. The grounding is robust, reliable and safe. There are 4 sets of 10 A socket, 12 V 5 A switching power supply, 4 way 12 V relay. The 4 way I/O switch controls 4 way relays respectively, and the 12 V switching power supplies power to the RS485 water temperature sensor and the 4 way relay.

3.1.2 Front-End Video Collection Module

The water quality monitoring module is mainly used for collecting real-time video data of the fish and the living environment in the aquarium; the water temperature is monitored in real-time as well.

The 420 line resolution CCD camera is encapsulated and used for front-end video collection, in PAL or NTSC format. The wide-angle optical lens of the camera can maximally reduce the spherical aberration. The camera dock is optimized as a sucked type base, and the camera is fixed to it by a universal joint. The strengthened suction cup tightly immobilizes the camera to the external wall of the aquarium. The place of fixation and the view angle can be adjusted by the users. The camera is interfaced with a video converter using the 1.0Vp–p/75 Omega/BNC conversion interface.

3.1.3 Water Quality Monitoring Module

The aquarium is equipped with a miniature special temperature sensor, using the RS485 protocol. The DS18B20 sensor is encapsulated in a waterproof case with the wire led out to connect to the video server. The measurement range is −55°C to +125° C, and the measuring precision is ±0.5°C under the −10°C to 85°C working condition. The water temperature data is converted in the video encoder and communicated to the remote network server platform via ADSL/LAN using RS485 protocol. When the video encoder sends the command of checking the water temperature to the temperature sensor, the temperature sensor will transmit back the codes of the water temperature data. Upon receiving the data, the video encoder will transmit them to the network management software via the RS485 protocol. The codes are parsed and displayed on the client application. Users accord their own need to set uploading time interval of water temperature data, then the data will automatically update on client application.

3.1.4 Equipment Control Module

The control module of the equipment is designed to control the oxygen supply device and heating filtration system of aquarium. Each equipment is controlled by an independent circuit. For each equipment a separate control button and display of the

working status are available on the remote client application. The circuit controlling each equipment is connected with the I/O control interface of the Video encoder through the socket type centralized power supply controller. Thus the I/O control interface of Video encoder can directly control the power supply of the circuits.

3.2 Software Platform

3.2.1 Software Platform of Network Server

The network server provides the network services via the IMagineWorld software, the core management software, which stores and forwards the real time dynamic images.

The background administrator first authenticates the user access to the video encoder and adds a video encoder device identity to the system service table. This identity is the only ID of the terminal video server. Only those with registered ID in the system service table are allowed to upload the real-time dynamic image to the network server, which stores the image and forwards it to the remote designated client. The system is configured with a set of authentication rules. The accounts created by the users on the network version are authenticated by the administrator, and one or more control equipments are bound to each account. It is only after authentication and binding that the user can log in and remotely monitor the aquarium. The user can also access by entering the IP address on IE from a remote PC, thus monitoring the aquarium and controlling the switches remotely so as to obtain the real-time water temperature data.

3.2.2 Software on the Mobile Client-Side Application

To overcome the limitations of time and space, we develop a client application based on Android platform that enables a remote monitoring and control of the aquarium. For any registered and authenticated users, remote monitoring and control of the aquarium can be realized on the Android mobile phones or tablet computers equipped with the client application. In addition to the video images of the fish raised in the aquarium, real-time water temperature monitoring & display and remote control of the conditioning equipments, the software on the mobile client-side application also provides snapshots and recordings. Through the system network server to effectively compress the transmission data and optimized control of network resources occupation and data traffic ensure a fast and reliable transmission and remote sensing and manipulation under GPRS or WIFI environment.

4 Conclusion

We propose a remote monitoring and control system for aquarium based on mobile communication platform. This system is simple, reliable and has passed strict testing and trials. Remote control of the aquarium equipments overcomes the limitations of time and space on aquarium breeding. The resources are saved and the breeding efficiency is greatly increased with this new system that enables the users to know the current status of the fish raised in the aquarium in real-time and to make dynamic adjustment of the breeding environment. Considering the application scenarios and

user features, the design of the front-end hardware is optimized so that it has a light weight, an aesthetic appearance, a user-friendly interface and higher operability. The priority of further research is placed on standardized industrial design of the system hardware in order to meet the needs of mass production and to enhance the practicability. The control circuits will be extended for the convenience of modular design that enables the users to define the system modules according to their demands. Another goal of our research is to extend the mobile client operation platform and to improving the portability of application software. We will develop the specialized remote automatic monitoring and control system for industrial aquaculture and commercial operation, thus further expanding the application scope.

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