Remote Monitoring of Water Quality for Intensive Fish Culture

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Abstract. Water quality monitoring and forecasting plays an important role in modern intensive fish farming management. This paper describes an online water quality monitoring system for intensive fish culture in China, which is combined with web-server-embedded and mobile telecommunication technology. Based on historical data, this system is designed to forecast water quality with artificial neural networks (ANNs) and control the water quality in time to reduce catastrophic losses. The forecasting model for dissolved oxygen half an hour ahead has been validated with experimental data. The results demonstrate that multi-parametric, long-distance and online monitoring for water quality information can be accurately acquired and predicted by using this established monitoring system.

Keywords: water quality monitoring, intensive fish culture, wireless sensor network, LSSVR.

1 Introduction

Aquaculture is the fastest growing food-producing sector in the world, with an average annual growth rate of 8.9% since 1970 [1]. China is one of the most important contributors to world aquaculture production. 41.3 million tons, or 69.6% of the world production, was produced in China [2]. As a result of a significant shift from wild fishing to aquaculture in the 1980s, aquaculture development has accelerated throughout the country. The production of intensive fish culture has been increased rapidly in China from 1.6million tons in 1990 to 13.5million tons in 2005 [2,3].

Automatic remote monitoring and computer-controlled intensive culture is the future trend in aquaculture. In modern aquaculture management, water quality monitoring plays an important role. Appropriate control of water quality to keep the concentration of the water environment parameters in the optimal range can
enhance the fish growth rate, impact dietary utilization and reduce the occurrence of large-scale fish diseases [4,5]. Without gathering information regarding physical and chemical parameters of water quality together with the related ecological factors it is almost impossible to perform the appropriate water quality control at the right time and in the right place.

However, there are a few applications of systems which could carry out real-time water quality monitoring continuously in China. According to the conventional methods of water quality monitoring, samples of water are taken and transported to a chemical laboratory to analyze the hazardous substances. On the one hand, the maintenance of the measurements and control process is manual and influenced by the personal experience. On the other hand, the process of forecasting is time-consuming and some contamination episodes might be missed [5]. For example, fish mortality occurred overnight in one incident and was only detected the next morning, after huge losses had already been caused.

With the advent of new sensor technologies, data telemetry and wireless communication technology, various equipment has been developed to monitor remote areas in real-time [6-9]. At present, continuous monitoring of drinking water and wastewater quality at most treatment plants is applied in Europe, North America and Japan [10,11]. In China, online monitoring installations have been constructed for several large rivers, such as the Huanghe River and the Huaihe River, to provide real-time information to support environmental protection decision-makers [12]. However, the financial burden for building the fundamental hardware of these high-tech facilities may only be affordable to governments. Realizing real-time data collection in a secure, robust, manageable and low-cost manner, without long-distance cable connections, will likely become a bottleneck in the development of information monitoring in fish culture. Therefore, using web-server-embedded and next generation telecommunication technologies will become increasingly important in sensing networks.

In recent years, some researchers investigated integrated water quality remote monitoring systems [13,14] and management systems based on culture knowledge models and forecasting models [15-18], but these systems are not aimed at the present needs to develop aquaculture and not connected with any online monitoring system. Moreover, these installations cannot achieve real-time communication between data collection and control terminals, which is not yet a fully viable alternative for high-density, open, and dynamic fish breed circumstances.

In this work, water quality remote monitoring systems using a GPRS service combined with IPsec-based virtual private networking (VPN) functionality were developed for constructing a wireless sensing network on a countrywide scale. Integrated with a forecasting model on the basis of artificial neural networks (ANN), the system is able to provide real-time information and the dynamic trend of the water quality at different monitoring sites. The detected data can be collected and analyzed at any time via the Internet so as to know the status and changes of the system.