Study on the Construction of Water Environment Promotion Joint Control and Joint Regulation System in Plain River Network Area

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Abstract. There are many river networks in Southeast plain cities of China, such as dense river network, many water projects, poor connectivity, strong pollution load into the river, and difficulty in regulation and control. The water environment problem of river network has become the bottleneck restricting the sustainable economic and social development of plain river network area. In order to improve the river water environment, it is very important to carry out reasonable intelligent regulation of regional river system. In view of the current situation that the water environment regulation is mainly based on manual operation and has not formed intelligent dispatching decision-making, this paper integrates the technology of water power and water quality joint control of urban river network, researches and develops the joint control and joint dispatching system of water environment improvement in plain river network area, and establishes a full coverage, full element three-dimensional monitoring and warning, dispatching and intelligent decision-making system, driven by monitoring data, with model as the core and remote control as the core with the goal of hydrodynamic, water level and water quality as the target, relying on the model cloud, the intelligent one click precise scheduling is realized.

Keywords: Plain river network, Water environment improvement, Intelligent dispatching, Joint control and joint commissioning system

1. Introduction

The river network of cities in the southeast plain of China is densely distributed (2.5 km of rivers per square kilometer in the Yangtze River Delta region), many water projects, poor connectivity (more than 10000 water conservancy projects in the Taihu Lake Basin), strong pollution load into the river (8-10 times that of European and American countries), and great difficulty in regulation and control [1-2]. The water environment problem of river network has become the bottleneck of economic and social sustainable development in plain river network area. In order to improve the river water environment, it is very important to make reasonable regulation of regional river system [3-6]. However, there are many deficiencies in manual scheduling. Therefore, it is urgent to build a multi-objective real-time monitoring, accurate simulation and intelligent mutual feedback joint control and commissioning system for water environment improvement [7-9]. Its necessity is reflected in the following aspects:

1.1. IOT Sensing System Monitoring Instead of Manual Observation

The transparency of river manual observation is greatly affected by human eye recognition, light and other factors, and the accuracy is not high. It is necessary to build water quality monitoring stations...
instead of manual observation; the water level, flow and water quality change effect is lagging after
the change of dispatching instructions, and manual observation can't be found in time, so it is
necessary to build the Internet of things perception system for real-time monitoring; whether the
dispatching instructions are implemented or not needs to be implemented through video The
monitoring equipment monitors the running state of the gate pump weir and gives real-time feedback.

1.2. Manual Scheduling Needs to Improve the Scheduling Accuracy and Response Speed
At present, the river water environment regulation in urban areas of China mainly relies on manual
scheduling, which has slow response time (about 5 minutes), low scheduling accuracy, and may have
the situation that the dispatching instructions have not been implemented. The dispatching effect is
closely related to the experience of the dispatchers. It is necessary to use the joint control and joint
commissioning system to absorb the experience of the dispatchers for many years, and improve the
scheduling scheme through the model The water system in the original river network area is staggered
and complex, and there are many gate and pump stations, so it is difficult to make overall planning for
manual operation. Some river sections are greatly affected by the operation of individual sluice pumps.
It is difficult to accurately perceive the effect of live water regulation and find possible problems by
relying on manual operation, and the manual operation has reached the bottleneck.

In view of the current situation that the water environment regulation is mainly based on manual
operation and has not formed intelligent dispatching decision-making, combined with the
characteristics of weak hydrodynamic force, small water level difference, dense engineering and
complex dispatching in urban river network area, integrated the technology of water power and water
quality joint control and joint dispatching of urban river network, developed the system platform of
urban river network active water joint control and joint dispatching, established full coverage, all
element three-dimensional monitoring, early warning, dispatching and intelligence It can make
decision system and realize intelligent one click precise scheduling is realized. The overall objectives are as
follows:
1) The IOT sensing system monitoring replaces manual observation to increase the reliability of
monitoring data;
2) The intelligent one key scheduling replaces manual scheduling to improve the scheduling
accuracy and further improve the water environment quality of urban rivers;
3) Forecast and early warning of water quality changes in the future to ensure the long-term
maintenance of high-quality water environment in the river.

2. Overall Structure and Functions of Joint Control and Commissioning System

2.1. Overall Structure
The framework of the platform mainly includes monitoring equipment layer, supporting platform layer
and business application layer as shown in figure 1.

The monitoring equipment layer adopts the Internet of things perception technology to build a
unified water level, flow, water quality and engineering conditions monitoring equipment network;
adopts remote control technology, and according to the functional needs of smooth flow of live water,
remote control is carried out for the new project and the original gate station project, and the control
means are increased; the video monitoring platform is designed by using the unified technology of
video monitoring system platform, integrating all kinds of built projects The video monitoring system
collects all video information to the dispatching center for unified management, and uses video
recognition technology to increase monitoring means to assist the monitoring of the Internet of things.

According to the overall requirements of technology unification and architecture platform
unification, the support platform layer adopts the Internet of things, big data, cloud platform and other
advanced technologies to establish an application support platform based on workflow, intelligent
form, message middleware, and integrates unified database, unified user management, unified authentication service, unified security protection and unified platform display. According to the specific requirements of the planning scope and in accordance with the relevant specifications and standards, water conservancy geographic database and water conservancy engineering database are constructed. Taking the hydrologic hydrodynamic numerical model of urban river network as the core, the monitoring data of Internet of things and the remote control of water conservancy projects are combined to realize the optimization of regional project scheduling.

The business application layer is user-oriented and provides a visual interface to realize the user's business process, including information query, real-time monitoring, forecasting and early warning, project scheduling and other application services.

![Overall architecture of joint control and commissioning system.

2.2. Functions
The business system functions of the platform mainly include the following aspects: Construction of water quality, water level, video monitoring equipment to collect monitoring data, construction of real-time monitoring management subsystem, online forecasting and early warning subsystem, dispatching model management subsystem, joint control and joint commissioning control subsystem, joint control and joint commissioning system management subsystem and joint control and joint commissioning mobile application subsystem.

2.2.1. Collect Water Quality, Water Level and Video Monitoring Data. Automatic monitoring instruments such as water level, water quality and video are installed to realize full coverage and automatic real-time monitoring of urban rainwater engineering, providing basic data support for model calculation and water conservancy project scheduling.

Efficient, fast and accurate water quality automatic monitoring system is the need of water environment protection informatization and economic and social development, and also the requirement of transformation from traditional environmental monitoring to modern environmental monitoring. As an important part of water resources information collection system, water quality monitoring urgently needs to adopt modern technical means to provide water resources quality change information in time. The diversification and immediacy of water resources information demand makes
the water quality monitoring parameters continuously expand, the monitoring workload increases significantly, and the timeliness requirements of monitoring results transmission are constantly improved. The traditional water sample collection and laboratory detection method cycle is too long, it is difficult to timely and accurately reflect the water quality change process, and water pollution can’t be effectively monitored. Therefore, the establishment of automatic water quality monitoring equipment is an effective means to grasp the quality of water resources in real time and accurately.

In the process of platform construction, according to the characteristics of water level in the region, automatic water level monitoring equipment is installed in the planned water conservancy project, gate station, pump station and other water conservancy projects, as well as in the river section where the urban living water is mainly concerned. Through the construction of the automatic water level monitoring equipment, the river level information can be obtained in real time, which provides real-time water regime data support for regional water conservancy project dispatching the further calibration and verification of the model provide basic data support.

In order to ensure the real-time monitoring of water conservancy projects and provide real-time and intuitive river water quality monitoring and water conservancy project operation monitoring information, video monitoring equipment is newly built at key river nodes in urban area and new and reconstructed projects of live water expansion project, and video monitoring software platform is provided to realize unified browsing, control and management of all video monitoring points.

2.2.2. Real Time Monitoring Function. The system shared information source is used to manage the real-time water and rain situation, engineering situation, water quality and video information collected by the monitoring system. Combined with the needs of collaborative decision-making management, real-time monitoring and evaluation of regional water and rain situation, water environment, project operation status and temporal and spatial distribution are monitored and evaluated. The system has the functions of query and statistical analysis. It can display the real-time monitoring data in various forms, and give alarm to the situation of water situation over alarm, water quality deterioration, monitoring equipment abnormal, project operation abnormal and so on.

2.2.3. Online Forecast and Early Warning Function. After the operation condition of sluice pump changes in the region, the water quality and flow velocity of river network have several hours or even several days lag. Therefore, the forecast period of forecast and early warning model should be more than 3 days. The on-line forecast and early warning system can transmit the received real-time monitoring data of water, rain and engineering conditions to the urban hydrology hydrodynamic water quality integrated model. On the basis of these data, combined with rainfall forecast data, real-time online rolling calculation can be carried out to forecast the water flow movement and water quality changes in the river network in a period of time in the future Statistical reports and other forms of display.

2.2.4. Scheduling Model Management Function. Through the analysis of water conservancy project monitoring, the specific status of all water conservancy projects in urban area is understood, and the relevant parameters and dispatching rules of sluice, pump station, overflow weir and other related parameters in the model network are modified online. After the modification of hydraulic engineering parameters and relevant dispatching rules, they are updated into the model water conservancy project and dispatching rule model database to realize water conservancy the project and scheduling rules are modified to form a new model network scheme.

2.2.5. Function of Dispatching Control System. The optimized dispatching system of water conservancy project is connected with real-time monitoring equipment and monitoring data of sluice pump project through standardized interface. Combined with the operation of water conservancy projects in urban area, it has the functions of information data collection and evaluation, smooth flow
operation scheme optimization, intelligent regulation control, operation effect evaluation, intelligent management and manual operation Pre sum scheme can run fault tolerance and other functions.

2.2.6. System Management Function. In order to ensure the coordination, security and unified management of authority of each business system, and increase the system management, it is necessary to establish a system management platform with the functions of group authority and user management, background log management, information format customization and database backup.

2.2.7. Application function of Mobile System. Combined with GIS, GPS, intelligent perception and other technical means, based on the general development platform, we will build and support all kinds of mainstream intelligent handheld operating systems, customize and develop cross platform mobile integrated business application system, provide water workers with convenient and fast mobile business information processing platform anytime, anywhere, and form service automation, office networking, scientific management and supervision informatization Mobile water management function.

3. Key Technologies of Joint Control and Commissioning

3.1. Construction of Plan Set for Live Water Dispatching
The conventional plan of artesian water is based on the conditions of water source, water quality and rainfall forecast to generate a series of conventional plans for artesian water, which can meet the daily use of live water dispatching. The formulation of the conventional plan needs to consider the inflow of different water sources and adjust the project scheduling in the urban area. In terms of water quality, different water sources have different water quality indicators in different periods. The formulation of the conventional plan needs to consider the water quality of different sources and the supply scope of each source. In addition, considering the impact of rainfall, the conventional plan should consider different situations such as high-water level operation, low water level operation, high water level difference operation and low water level difference operation.

Emergency dispatching plan is a kind of emergency response plan when dealing with a series of emergencies. Generally, a series of emergency response plans are formed based on the location of water pollution incidents, the level of water pollution incidents and the number of water pollution incidents.

The following aspects should be considered in the formulation of emergency response plan:

- The location of the water pollution incident. The location of water pollution events should cover all rivers in the urban area, and for the river section with long flow, it is necessary to cut the river channel by sections based on the node with water exchange, so as to take into account the possible water pollution events in all river sections.
- The level of water pollution incidents. According to the pollution control standards of each river section, the water pollution incidents should be dealt with according to the pollution control standards of each river section, with dilution first, transfer second and other auxiliary means last.
- The occurrence of water pollution events may be non-single. In the case of multiple water pollution incidents occurring at the same time, the priority of different water pollution events should be considered. Based on solving all the problems, the primary and secondary problems should be divided.

3.2. Intelligent Model Classification Technology
At the same time, the simulation and prediction of plain river network area also involves many levels of river basin, region, city and street. In order to realize the rapid, accurate and adaptive simulation of the whole process of multi-scale classification of river basin, region and town, it is necessary to develop intelligent model classification technology. The two-way nested hydrodynamic simulation of river networks with different spatial scales, such as river basins, regions and towns, is realized to
improve the flexibility of the selection of simulation range at different spatial scales, and the
timeliness of dynamic calculation and prediction and early warning. The main contents are as follows:

3.2.1. Spatiotemporal Multi-Scale Classification and Bidirectional Nested Simulation of
Hydrodynamic in Plain River Network Area. Drawing on the idea of hierarchical display of GIS layers,
according to the classification of natural and social attributes of river network, this paper studies the
model network construction, hierarchical management, discrete modeling, model network library
construction of time tag, automatic coarsening and refinement of model network hierarchical
management, automatic extraction of lower river channel storage in the process of coarsening, and
correction of river connected topological relationship in the process of coarsening and refining. To
improve the hydrodynamic calculation engine of plain river network area and realize the bidirectional
nested simulation of river network with different spatial and temporal scales of basin region town.

3.2.2. Multi Source Data Assimilation and Intelligent Identification of Model Parameters. In view of
the characteristics of spatiotemporal multi-scale classification and bidirectional nested simulation of
water dynamics in plain river network area under changing environment, based on multi-source
information data extraction, fusion and assimilation analysis technology based on variational and
Kalman filtering assimilation algorithm, multi-source information data sets of water, rain, engineering
and social conditions are constructed to realize the initial information of hydrodynamic simulation.
Based on genetic algorithm, particle swarm optimization (PSO) and partial differential equation (PDE)
optimization control theory algorithm, multi parameter real-time dynamic correction intelligent
identification technology is established, which provides technical support for rapid, accurate and
adaptive simulation of heterogeneous models.

3.2.3. Fine Hydrodynamic Simulation Technology of Water Network in Urbanization Area. According
to the connection and hydraulic connection characteristics of plain river network area, the multi-scale
hydrodynamic coupling model between river network and surface is established. The simulation
function can reflect the hydraulic characteristics of sluice, pump station, culvert, weir flow, pipeline
and other hydraulic projects. It can simulate the operation and dispatching scheme of any boundary
conditions and structures, and provide the hydrodynamic elements such as river network, pipe channel
flow, water level, velocity, etc. The operation process of sluice pump is coupled with the two-
dimensional flood model and related hydrological mechanism to solve the problem of two-
dimensional waterlogging water recession in polder area and urban area, and realize the whole process
fine simulation of multi-scale classification of river network in urbanization area.

3.2.4. Configuration Coupling Technology of Hydrodynamics Heterogeneous Model. A multi-scale,
hydrological and hydrodynamic multi-attribute heterogeneous model library of plain river network
basin region town with different regions and application business requirements is established. Through
automatic matching and coupling assembly of heterogeneous modules, the self-adaptive generation of
hydrodynamic function model of plain river network supporting different functional application
purposes and adapting to arbitrary complex underlying surface boundary topography is realized, and
the definition and number of open model interface are solved. According to the standardization of
components and interface, To carry out hydrological and hydrodynamic fine simulation, test and
improve the multi-scale classification and bidirectional nested simulation model technology of plain
river network, so as to provide technical support for the development of the platform.

4. Benefit Analysis

4.1. Clear Water in Key Rivers
According to the model calculation, after the completion of the clean water project, relying on the joint
control and commissioning system, the water body of key rivers can be clear, the transparency of
rivers in key areas can be significantly improved, and the transparency of other rivers can be improved steadily.

4.2. Improving Decision Making Ability of Urban Water Conservancy Comprehensive Dispatching
The construction of the project will realize the thorough perception of the urban rainfall, water level, water quality and other all-round elements, as well as the comprehensive sensing and control of important gates and pumping stations. Through the gradual establishment of a scientific hydrodynamic water quality model, under the support of a unified data service platform and technical framework, the ability of emergency dispatching and command and decision-making of urban river network for live water and pollution reduction will be greatly improved.

4.3. Realize the Sharing of Information Resources and Bring into Play the Investment Benefits
Through the integration and management of information resources, reduce data redundancy, improve the utilization rate of resources, and realize the sharing of information resources. At the same time, it provides the basis for the investment direction of water conservancy informatization. By sharing data and services, it can avoid repeated construction, reasonably and efficiently use funds, and play its due investment benefits.

4.4. Improve Project Management Ability and Save Operation and Maintenance Cost
Realize the water conservancy project perception all-weather, business coverage, monitoring the whole process. To achieve scientific and accurate water management, optimize the management structure, save the cost of human and material resources, establish information sharing channels between project management and project group supervision, and realize the unified scheduling and operation and maintenance of clean water and live water in the whole city.

4.5. Improve Project Management Ability and Save Operation and Maintenance Cost Improve Work Style and Save Office Cost
Changing the traditional working mode, the information system has become the main working platform, which realizes the information exchange and seamless connection between the water conservancy department and the relevant responsible departments, so as to effectively carry out collaborative office work; the in-depth development of information resources can realize the informatization of management and scientific decision-making, meet the development and refined management requirements of water conservancy, and improve the utilization rate of water resources.

5. Conclusion
The research results of joint control and joint dispatching system have been applied in many plain river network cities such as Suzhou, Shanghai, Changzhou, Wuxi and so on as shown in figure 2. The intelligent precise dispatching has been realized instead of manual dispatching. The prediction accuracy and prediction period have been greatly improved. The accuracy error of water level regulation has been reduced to centimeter level. The response time of hydrodynamic regulation has been optimized from manual operation to intelligent operation under the current conditions. It has promoted the modern management level and scientific decision-making ability of urban flood control, waterlogging drainage and water environment treatment, effectively promoted the modernization of urban water conservancy and the construction of water ecological civilization in the Yangtze River Delta region, and played an active role in serving the people's livelihood and harmonious coexistence of human and natural environment.
Figure 2. Joint control and commissioning system for water environment improvement in the Expo.

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Reference
[1] Yang K 2006 Study on Water System Structure Characteristics and Urbanization Response in Plain River Network Area [D] East China Normal University.
[2] Tang J, Song T, Jiang X, et al. 1998 World Geographic Research 2: 114-119.
[3] Cai M, Li M, et al. 2018 People’s Pearl River, 039 (002): 60-64
[4] Chen C, Zhang W 2012 People’s Yangtze River 43
[5] Sun J, Ruan X 2008 China Rural Water Conservancy and Hydropower 3: 29-31
[6] Hao W, Tang C, Hua L, et al. 2012 Journal of Hehai University (Natural Science Edition) 40 (2): 129-133
[7] Zhang Z, et al. 2020 Municipal Technology 38(3): 243-248, 253
[8] Liu B Y, Liu X F, Wang W 2020 Environmental Science Research 33(5): 1276-1283
[9] Wei D M, Sun Y H, Chen Y, et al. 2018 China Environmental Protection Industry 12: 54-56