

Research on Drainage Management System Development Based on SWMM, GIS, and Database Technique

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Abstract: Recent years, with the development of urbanization and the frequent appearance of extreme rainfall events, urban drainage system appears many serious problems and the urban flooding is taken place frequently. Economic losses and irreparable consequences are brought to the city. To solve the above problems, three technique of GIS (Geographic Information System), SWMM (Storm Water Management Model) and database are combined to build the urban drainage geographic information platform. The platform integrates management, simulation, analysis and data processing into a whole. The simulation and analysis of the water drainage pipe network system are carried out on the platform. The Beijing Capital International Airport Intelligent Drainage Information System is taken as a case study, and the detail is illustrated on the aspects of data collection, data management, software architecture design, software interface design and the integrative platform building. The intelligent management of drainage pipe system can be supported by the research.

1. Introduction

In recent years, the extreme rainfall events occurred frequently. It led to major urban flooding disasters, seriously affected the city construction, hindered the economic development of our country, destroyed the normal operation of traffic system and cost a lot of manpower and material resources.

The urban drainage network computing simulation has become the main method to solve the problem of urban flooding (Jain et al, 2007). Therefore, it becomes an inevitable trend to build the urban drainage pipe network model. Based on the data collection of the pipe network basic data and the pipe network professional data, a targeted data system can be set up.

The drainage pipe network model can be built up according to the data system and model technique. The information of drainage pipe network system, spatial structure analysis and dynamic display of model results can be shown on the system platform. The targets of urban flooding prediction, analysis and management can be got.

2. System Architecture Design

2.1 Drainage system platform architecture design

Building urban drainage geographic information system has become a trend of demand. For the complex urban drainage network and its increasing demand for analysis, management and simulation, designing a visual information platform with prefect functions, strong pertinences and large processing capacities is imminent for people.^[1,2] According to the data structure, pipe network

system characteristics and system functional requirements, the drainage system platform architecture is designed in Figure 1.

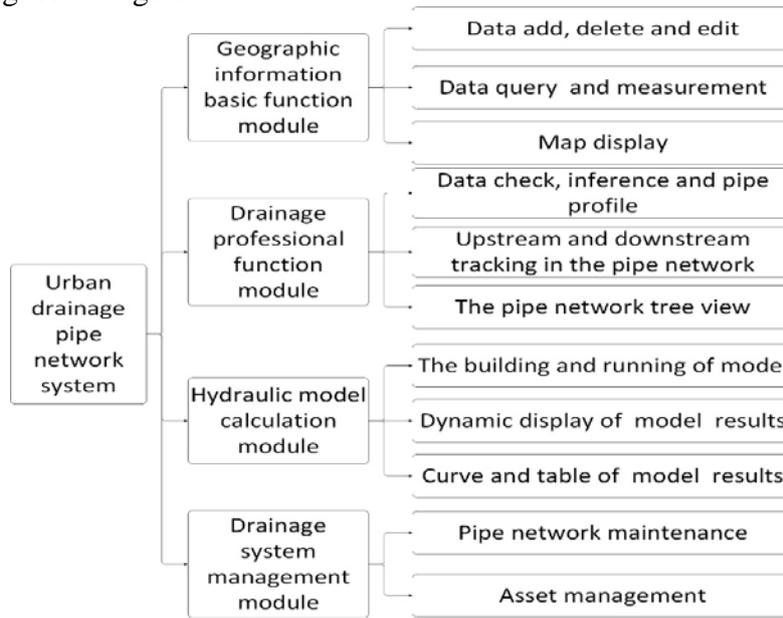


Figure 1 Drainage system platform architecture design

2.2 Database architecture design

The design of system data frame should be considered in the construction of information system, database, data exchange, data security, data quality, information services and other aspects of the standards and specifications. The urban drainage pipe network system data mainly includes basic geographic information database, drainage pipe network professional database, hydraulic model database and business working database. The database architecture design is shown in Figure 2.

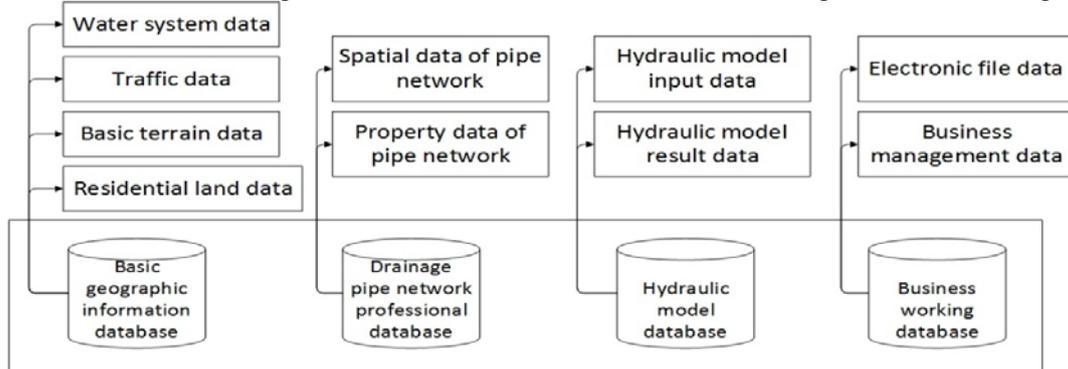


Figure 2 Database architecture design

Base on geospatial framework database, the basic geographic information database many kind of information concerned about by enterprises and institutions. It involves Water system, traffic, residential land, boundary and administrative area, landform and basic terrain data. Professional database of drainage pipe network mainly has the spatial data of pipe network and the property data of pipe network. Based on the basic geographic information database, the pipe network spatial data is processed by the construction unit to build the spatial database, and to enrich the property data of the network. Hydraulic model data is consisted of the model input data and model result data. Business working data includes electronic file data and business management data.^[3,4] The electronic file data mainly obtained by scanning the paper archives and its digital processing and storage. Business management data includes emergency command, daily custody, asset management, project management and other daily business work data.

3. Second Development Technique

3.1 SWMM development technique

SWMM (Storm Water Management Model) is an urban drainage system simulation software which developed by the United States Environmental Protection Agency. The software is simulated in three parts of rainfall, surface runoff and pipe network, and combine the three parts to form a complete drainage pipe network simulation system (Knighton et al, 2016; Gong et al, 2016). SWMM provides the DLL (Dynamic Link Library) for the users to make the second development. Through using the interface function in the DLL, the second development can be implemented and the mode result can be obtained. The model result (such as flows, velocities and capacities of pipes, the water depths and head of manholes) can be sent to each system module in order to provide the support to the management function of the system. The interface structure is shown in Figure 3.

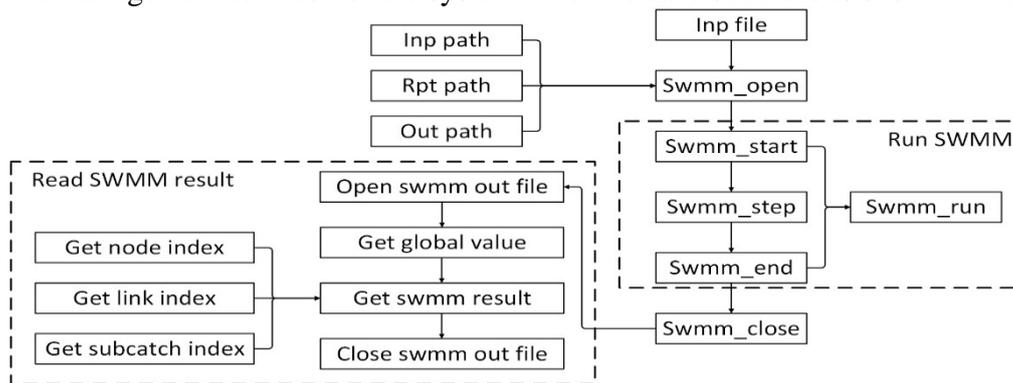


Figure 3 SWMM interface structure

As shown in Fig. 3, the model input file can be opened by swmm_open. Running simulation can be implement by the combination of swmm_start, swmm_step and swmm_end (The three interface function can replaced by swmm_run). After the simulation was finished, the output file will be created and the model results can be read by the interface functions of result reading.

3.2 ArcGIS development technique

ArcGIS provide a scalable and comprehensive GIS platform which includes a large number of programmable components, and integrates comprehensive GIS functionalities for developers. Every ArcGIS product built with Arc Objects provides developers with a container for application development, which including ArcGIS Desktop, ArcGIS Engine and ArcGIS Server. The Arc Engine development interface is shown in Figure 4.

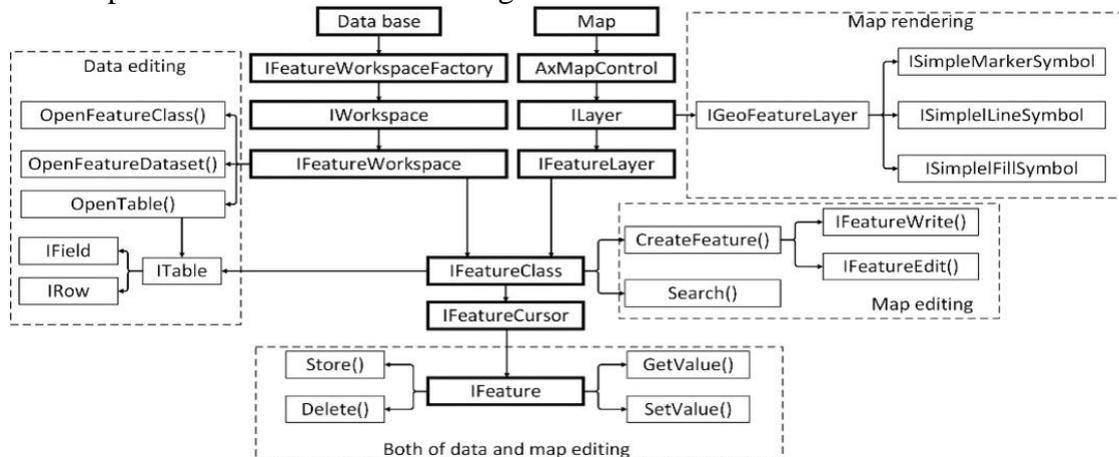


Figure 4 Arc Engine development interface

Base on the second development technique of ArcGIS, a geographic information integrated platform of urban drainage system can be established, which includes the geographic information basic module, pipe network system simulation module and pipe network integrated management

module(Mentis et al, 2016; MacMillan et al, 2016).

4. Establishment of drainage system platform

Based on the technical research and platform framework design above, the Beijing Capital International Airport Intelligent Drainage Information System is taken as an example to implement system frame design and module function development.^[5] The main 4 modules include geographic information basic function module, drainage professional function module, hydraulic model calculation module and drainage system management module. The development environment includes C# language, Arc Engine, SWMM and Oracle database. The main system interface is shown in Figure 5.

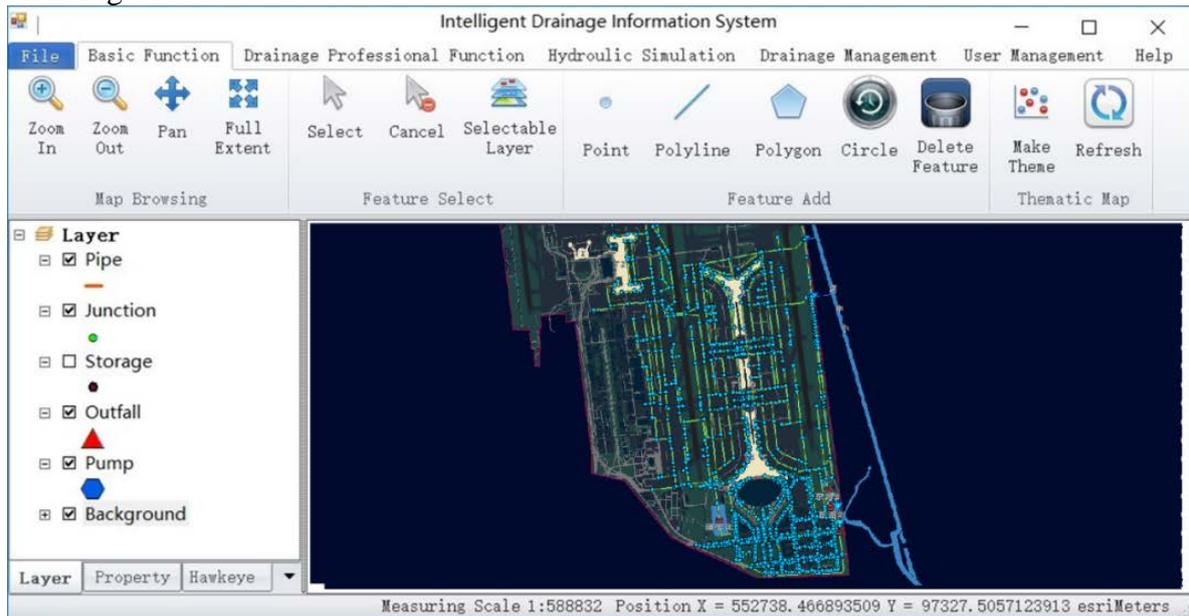
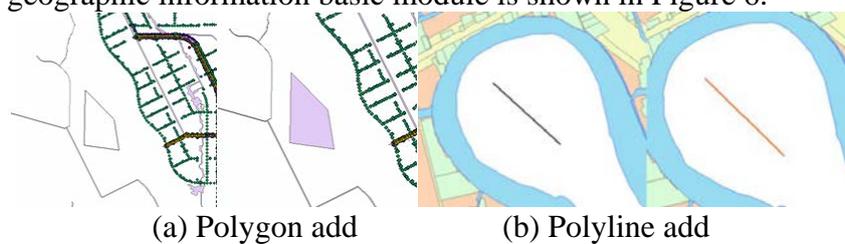


Figure 5 Main system interface of Beijing Capital International Airport Intelligent Drainage Information System

4.1 geographic information basic module

The management, integration, analysis and visualization of GIS spatial data (such as coordinates, elevation, length, etc.) are successfully applied in the field of drainage engineering. The system will be effective collection of various data drainage network system to operate on one software. The main function of geographic information basic module include the data edit, data query and map display. The drainage features can be added or deleted through the data edit and their information can be queried quickly through the data query. The area, distance and angle on the map can also be measured. The map display involves the function of zoom out, zoom in, Hawkeye and etc. The main function of geographic information basic module is shown in Figure 6.



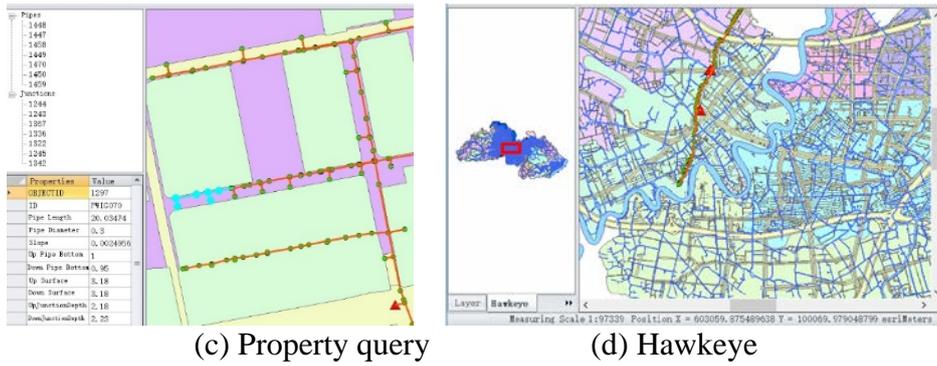


Figure 6 Geographic information basic module

4.2 Drainage professional function module

After the pipe network system basic data input, the data need to be checked in order to make sure the data is reasonable. According to the characteristics of pipe network spatial structure and the demand of pipe network analysis, the drainage professional function is designed and includes the function of data check, pipe profile, upstream and downstream pipe tracking and pipe network tree view. Through these functions, the system can check it out that if the structure of pipe network has wrong data. Some of these functions are shown in Figure 7.

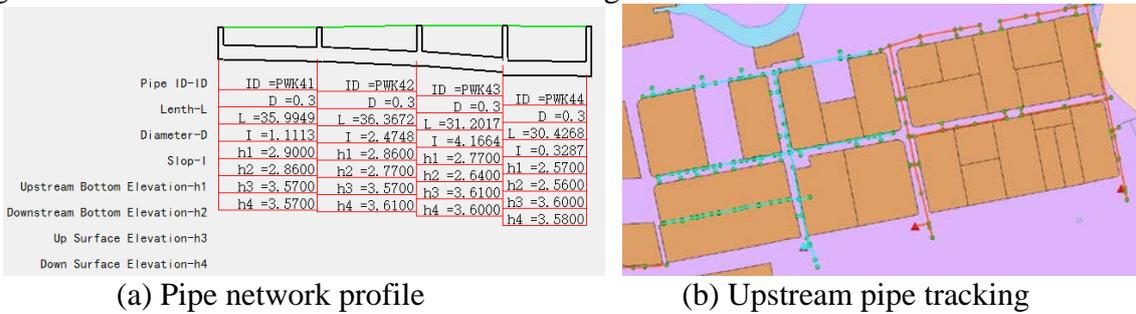


Figure 7 Drainage professional function module functions

4.3 Hydraulic model calculation module

The hydraulic model calculation use the geographic information data, drainage pipe network professional data and the data of model to build the urban drainage pipe model intelligently. The model is run by the system and the model results is displayed on the system platform. Depend on the dynamic demonstration of model result, the operation condition of the pipe network can be got. Dynamic demonstration of model result is shown in Figure 8.



Figure 8 Dynamic demonstration of junction flow

4.4 Drainage system management module

The drainage system management module is used to implement the functions of pipe network maintenance. According to the subjective and arbitrary of the network maintenance scheme and the

difficulty to realize the characteristics of scientific and systematic, build the pipe network maintenance and management functions to solve the operation and maintenance of drainage pipe network facilities. To solve the problem, the thematic map of pipe network maintenance is created in the system. The maintenance condition can be check through the thematic map, and it is shown in Figure 9.



Figure 9 Drainage pipe network system maintenance

5. Conclusion

This paper mainly introduces the development status of urban drainage system. Base on three aspects of construction of basic information database of urban drainage pipe network, architecture design of urban drainage information platform and development technique of GIS and SWMM, the urban drainage information platform is introduced and the Beijing Capital International Airport Intelligent Drainage Information System is taken as a case study. The conclusion is obtained as following: 1) it is necessary to establish urban drainage pipe network information database. Based on the complexity and diversity of the urban drainage pipe network information data, the pipe data should be classified on purpose and designed on level. 2) Architecture design of urban drainage information platform is necessary for intelligent management. Single modeling work can not satisfy the management demands of urban drainage pipe. The basic information display of pipe network, network analysis, hydraulic model simulation and pipe network maintenance should be set on one system platform. The system should be built with complete function, comprehensive analysis and convenient operation.

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