IOP Conf. Series: Earth and Environmental Science **128** (2018) 012071 doi:10.1088/1755-1315/128/1/012071

Designing and Implementation of River Classification Assistant Management System

Yinjun Zhao [1,2], Wenyuan Jiang [1], RujunYang[3], Nan Yang[1], Haiyan Liu[1]

[1]School of Geography and Planning, Guangxi Teachers Education University, Guangxi, 530001, China
[2]Key Laboratory of Environment Change and Resources Use in Beibu Gulf, Ministry of Education, Guangxi, 530001, China
[3]Guangxi Information Center of Land and Resources, Guangxi, 530028, China

Corresponding author: Yinjun Zhao, crpp0104@163.com

Abstract. In an earlier publication, we proposed a new Decision Classifier (DCF) for Chinese river classification based on their structures. To expand, enhance and promote the application of the DCF, we build a computer system to support river classification named River Classification Assistant Management System. Based on ArcEngine and ArcServer platform, this system implements many functions such as data management, extraction of river network, river classification, and results publication under combining Client / Server with Browser /Server framework.

1. Introduction

River classification is to reveal the spatiotemporal disparities, according to the classification rules, and classify a river into many relatively similar river types. River classification is probably the first step in understanding a river complexity and also is the basic content of river management [1]. Since 1899, an American geomorphologist Davis first divided a river into three categories (young, mature and aged) based on the mature stage of landform, rivers classification has been widely paid attention. According to different classification criteria, dozens of rivers classification method have appeared successively [2]. On the whole, these river classification methods have the following characteristics in the developing trend: (1) the classification factors changed from single factor to multi-factors; (2) the disciplines background of leading factors of river classification becomes more diverse (such as Leopold [3], Schumm [4], Simon [5] and Thorp [6-7]); (3) the function of classification methods changed from a simple descriptive to with a prediction capability; (4) the method changed from a qualitative classification to a qualitative and quantitative classification (e.g., Rosgen [8]); (5) the method structure changed from single scale (Strachler [9]) to hierarchical classification. By comparison, China's researches about river classification is still rare, and the methods represented by Ning Qian's [10] and Xiquan Huang's [11] classification from Institute of Geography, Chinese Academy Sciences are in the early development stage. In addition, the river is seriously affected by human activities in many aspects at present, and this situation should be taken into consideration in the river classification.

Therefore, in our earlier publication [12], we proposed a Decision Classifier (DCF) to classify rivers for Chinese river based on their structures (Figure 1). In order to extend, enhance and deepen DCF and improve the practical application ability of DCF, this paper developed a river classification assistant management system (RCAMS) to use DCF based on GIS technology. The system uses C/S + B/S architecture that integrated the powerful functioning and stability from C/S and the lightweight, flexible and easy to maintain from B/S in the data release to meet different needs. The client layer is the core part of the whole system, accounting for most of the development workload. So the development work of this paper is aimed at the client layer.

2. Design system

2.1 Development environment
ArcEngine and ArcServer are secondary development platform launched by ESRI Company. Among them, ArcEngine becomes a mainstream tool for secondary development of GIS because of its mature and stable, complete functions, perfect help document and operability. ArcServer is the combination of GIS technology and Web technology that not only has released online map service functions, but also can provide flexible editing and powerful spatial analysis ability. So this paper selected using ArcEngine 10.1 + ArcServer technology platform and C# programming language in the Visual Studio 2010 integrated development environment (IDE) under the support of Window 7 operating system to develop a river classification assistant management system (RCAMS).

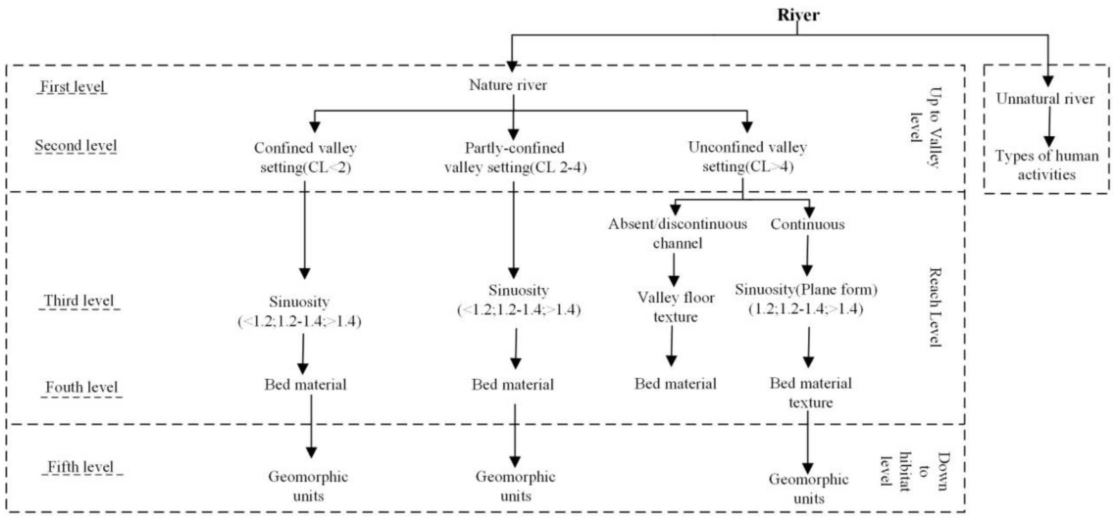


Figure 1. DCF to classify a river [12]

2.2 Design system architecture
RCAMS uses three layers structure (Client--Server--Browser) as shown in Figure 2. The client layer is the core part, and responsible for the specific work of river classification; the server layer is in charge data persistence, scheduling and results outputting; the browser is used to release the river classification results and other information online. The client is deployed on different computers to form the client cluster and communicate with each other and access the server through the local area network (LAN). Server side consists of File GeoDataBase (FGDB) database, ArcServer 10.1 server, Apache Tomcat server and the hardware. Specifically, FGDB is responsible for system data storage, ArcServer is responsible for interacting with the client, and Tomcat is responsible for handling the scheduling service via the internet browser request.

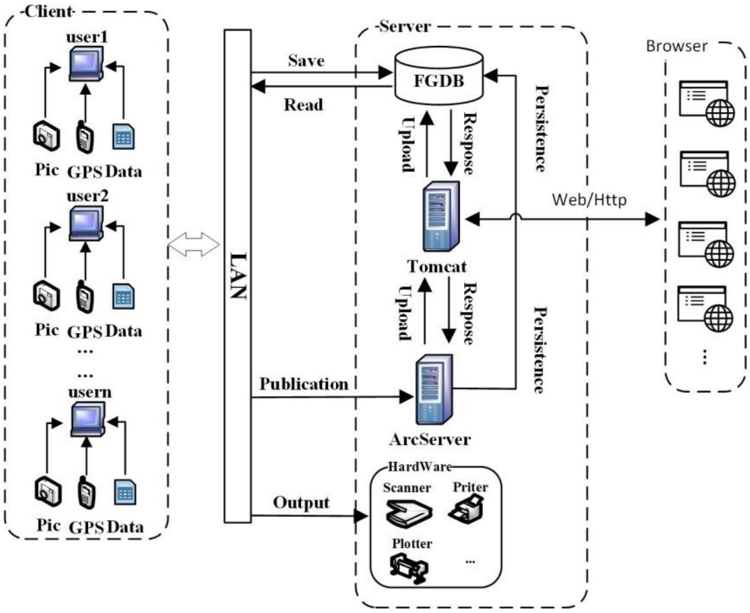


Figure 2. System architecture

2.3 Data sources

The data source of river classification system includes many study area data, such as DEM, satellite images, aerial photographs and other raster data, administrative zoning map, traffic map, land use map, hydrological maps, meteorological stations, geological map and other vector data ,GPS and pictures data in KML, SHP, text, table or image format. Therefore, these data can be divided into text data, vector data and raster data to input into FGED.

2.4 Design system functions

The client layer focuses on the core business of the system. In order to facilitate the use and management, eight modular were built according to the idea of modularization. First, the data management module is responsible for data management, accessing database and providing data channel for other module; Second, the data query module is responsible for querying data and exporting the result; Third, the core business module is responsible for handling the main business of river classification; Four, the result output module is responsible for releasing the result of river classification, follow-up plotting and building a river type tree, meanwhile provides a unified interface of the information publishing for other modules; Five, the statistics report module is responsible for statistical calculation of various types of river length and drainage area, and generating a report; Six, the spatial analysis module provides the function of spatial analysis; Seven, the visualization module is mainly responsible for data display and map operation; Finally, the system module is responsible for setting the system environment, user rights and help documentation (Figure 3).

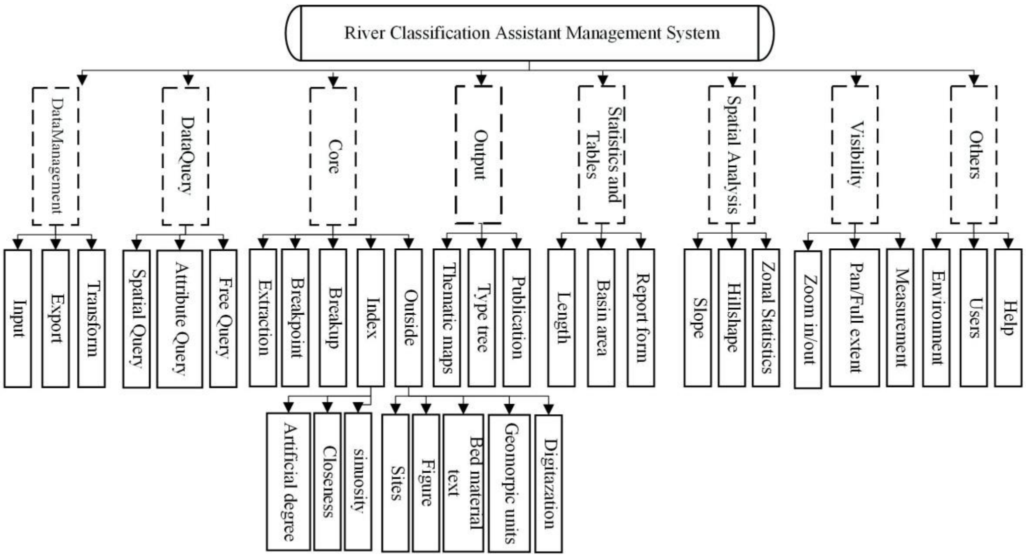


Figure 3. System function structure chart

3. System implementation

According to system design, RCAMS at the client was developed after coding and debugging. The whole system was followed with windows style and the main interface was shown in Figure 4. The servers configured parameters and build the service and the database for ArcServer server, Tomcat server and FGDB database. The Web client is written in JavaScript programming language, and the website is finally deployed in the Tomcat server.

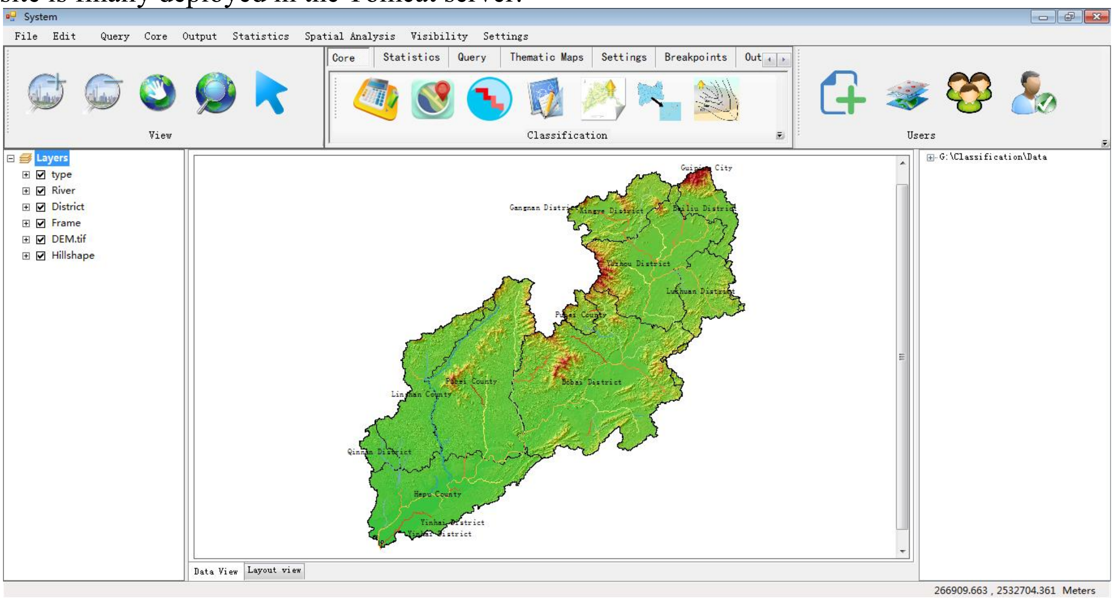


Figure 4. The main interface of RCAMS at the client. The basin is Nanliu river basin.

3.1 Main using process of RCAMS at the client

Figure 5 shows a complete process of river classification supported by RCAMS at the client. The process is mainly divided into four stages (data pre-processing, indoor preliminary classification, field validation classification and releasing the result). Data pre-processing mainly includes inputting basic data, using ArcGIS tools to extract the river network, identifying the breakpoint and break up the river network. In indoor preliminary classification stage, rivers can be divided into natural river or unnatural rivers according to the degree of the human activity interference on the river. Then calculate the closeness and sinuosity indexes, and predict the bed material texture and geomorphic units to create a preliminary classification result. Based on the preliminary result, design the field investigation points and makes a field trip plan. In field validation classification stage, we observe and measure classification indexes to validate the indoor classified river types according to DCF and adjust the boundary lines of river types along the river. In releasing results stage, we update the river type tree, create thematic maps, and publish the result online under the support of RCAMS (Figure 5).

3.2 Key points in RCAMS

3.2.1 Founding breakpoints. Breakpoints is the points that may have big changes in river system structure, including geomorphic breakpoints such as major changes in elevation, closeness, sinuosity, the converging point of the river system, and artificial point from direct water conservancy projects [12]. All breakpoints are selected to break a river network into many classification units (river types reaches). With the elevation of breakpoint identification as an example, the InterpolateShape() function of the ISurface interface provided by ArcEngine to read the Dem (cell values) to plot the longitudinal profile after a given distance, then visually select elevation breakpoints and add these into breakpoints list (Figure 6).

3.2.2 Calculating closeness index. Closeness (CL) is expressed as the ratio of valley bottom width to full channel width. For natural rivers, CL roughly determines the river space and the lateral movement. The smaller CL is more intense restriction on channel given by the valley [12]. Here, the key point is to extract the bottom line. According to the breakpoints of the slope between the valley wall and the valley floor, the algorithm proposed in the study is designed to automatically separate a valley floor with a valley wall and auto-measure the valley floor width. The algorithm includes five steps: 1) Data preprocessing, 2) Linear reach extraction, 3) Extracting perpendiculars of reaches, 4) Delineating the outlines of the valley floor and 5) Calculating the width of the valley floor. Figure 7 shows an example of automatic extracting valley bottom lines. Figure 8 shows a measure tool from ArcEngine to measure a channel width. Finally, all the results will be stored in the database for subsequent analysis.

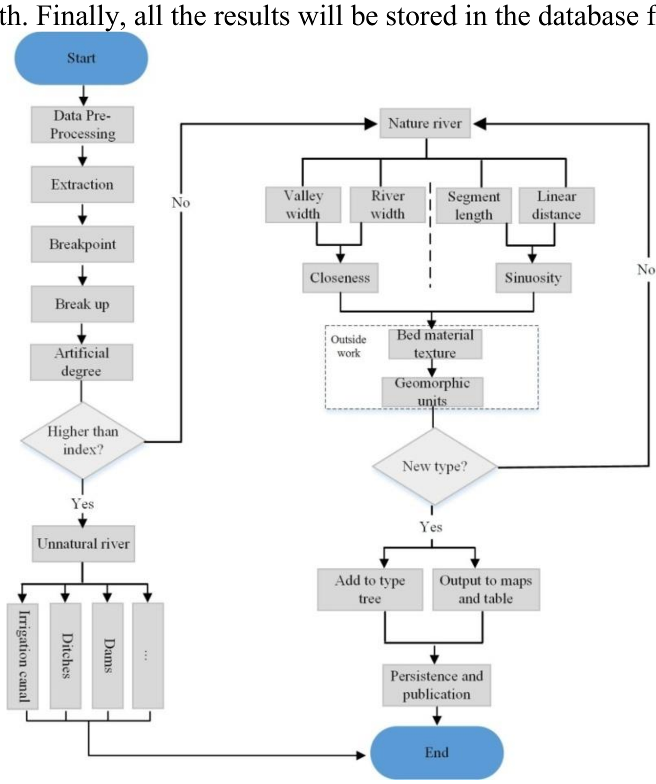


Figure 5. The main flow of river classification in RCAMS

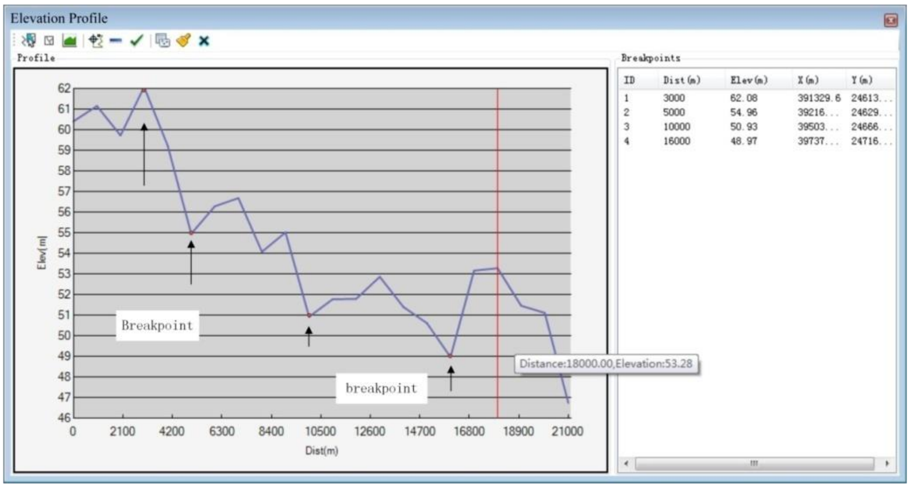
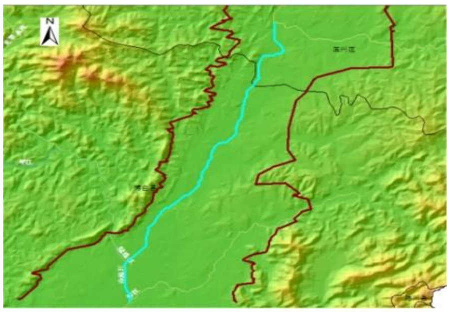


Figure 6. Plotting the elevation breakpoints



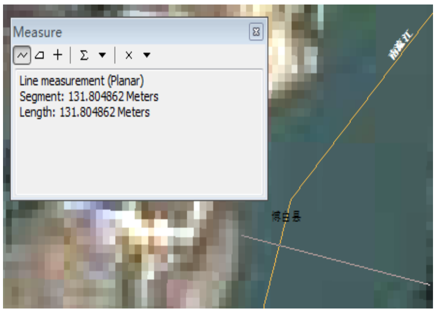


Figure 7. Extracting valley bottom line **Figure 8.** Measuring channel width

4. Conclusions

This paper has developed a RCAMS using "Client - Server -Browser" framework based on ArcEngine and ArcServer. RCAMS has basically realized the whole process of river classification and result publication. Under the assistance of RCAMS, we can quickly finish the river classification with routinization, normalization and semi- automation and reduce the difficulty and workload of river classification.

Acknowledgments

The authors would like to thank the anonymous reviewers for their constructive comments to the revision of this paper. In addition, this study is supported by the Natural Science Foundation of China (41461021, 41661085), the Guangxi Natural Science Foundation (2016GXNSFAA380094).

References

[1] He P, Shi P, Liu S, Gao J and Li X. 2008 Advances in water science. Classification of river systems **19** 434-442
[2] Zhao Y. 2016 Water Resources and power. Progress and prospects of river classification research **34** 26-29
[3] Leopold L B and Wolman M G. 1963 Professional Geographer. River Channel Patterns - Braided, Meandering and Straight **9** 39-85
[4] Schumm S A.1977 The Fluvial System (New York: John Wiley＆Sons).
[5] Simon A and Hupp C R. 1986 Fourth federal interagency sedimentation conference, Channel evolution in modified Tennessee channels 2 571-582

[6] Thorp J H, Thomes M C and Delong M D. 2006 River Research and Application. The riverine ecosystem synthesis:biocomplexity in river network across space and time **22** 123-147
[7] Thorp J, Flotemersch J and Delong M. 2010 Bio Science. Linking ecosystem services,rehabilitation, and river hydrogeomorphology **60** 67-74
[8] Rosgen D . 1994 Catena. Classification of natural rivers **22** 169-199
[9] Strachler A. 1957 American Geophysical Union Transaction. Quantitative Analysis of Watershed Geomorphology **8** 913-920
[10] Qian N. 1985 ACTA Geographica sinica. On the classification and causes of formation of different channel patterns **40** 1-10
[11] Huang X, Su F and Mei A. 1995 Chine rivers (Beijing:The commercial press)
[12] Zhao Y and Ding A. 2016 Water Science & Technology. A decision classifier to classify rivers for river management based on their structure in China: an example from the Yongding river **74** 1539-1552