Introduction to the "3S" of GIS

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Abstract. Geographic Information System (GIS), usually defined as a technical system that collects, stores, manages, calculates, analyzes, displays, and describes relevant geographic distribution data in the space of the whole or part of the Earth's surface layer (including the atmosphere) with the support of computer hardware and software systems [1]. This paper describes the relevant functions and applications of GIS from the perspectives of application system, science and service respectively, and concludes that geographic information is not just a simple system, but a symbiosis and coexistence of application system, science, and service. Application system is a tool of science, and science based on application system is a tool and technological means of geographic information. The application system is a tool of science, and the science based on the application system is a tool and technical means of geographic information service, and its service can contribute to the development and progress of such system tools and science.

Keywords: Geographic Information; Information Science; Space Science; Surveying and Mapping; Remote Sensing

1 Introduction

Since the 1960s, geographic information has evolved from a relatively single-function professional application to a multi-functional, shared and comprehensive application technology, which has become an essential technical support in various fields. From the initial strict restrictions on the disclosure of geographic information data to today's everyone is a consumer and producer of geographic information, the efficiency and practicality of GIS technology, as well as the lowering of the threshold of the industry, has allowed many small and medium-sized enterprises to benefit from it, while also providing great help for the development of the community and the economy. The development process from GISystem to GIScience to GIService is a gradual evolution from technology application to scientific theory to service provision.

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2 History of GIS

2.1 GISystem development history

GISystem is a specific spatial information system for capturing, storing, displaying, processing, analyzing and exporting geographic information, with an emphasis on technical implementation and application [2]. The development of GISystem can be divided into a pioneering period, a period of consolidation and development, a period of great technological development, an era of popularity and a phase of widespread application [3], Approximate information is as shown in Table 1.

However, in general, GISystem is often identified as technology-driven, as a technology for data storage and search applications, as a response to human information management and analysis needs, and geographic information technologies were not significantly developed, but more a consolidation of what had already been achieved. It was not until the 1980s, with the popularity and rapid development of computers, that GISystem technology matured and became widely used [4]. However, many of the innovations in GISystem involved user interfaces, and in the 1990s, the adoption of the WIMP interface greatly improved the ease of use of GISystem software and greatly reduced the difficulty of learning; tools for exploratory spatial data analysis also greatly improved the ability of GISystem to retrieve and analyse data from multiple perspectives [5].

Table 1. History of the development of GISystems [4]-[7]

stage of devel-opment	development period	consolida-tion and development period	period of great techno-logical development	ubiquitous era	Application diffusion stage
time	1960s	1970s	1980s	1990s	21st century
Hall-mark events	Roger Tom-linsonpi-oneered the world's first GIS, the Canadian Geographic Information System (CGIS).	ESRI de-veloped the ArcInfo software and held a series of interna-tional col-loquia on geographic information.	A variety of GIS-based software was developed, such as ArcIArcInfo, Genqmp, MicrMicrosta-tion, System9, etc. the National Center for Geographic Information and Analysis (NCGIA) was established in the U.S., and GIS began to be applied to solving globalization problems.	GIS is widely regarded as a universal geographic information technology tool. The former Vice-President of the United States of America introduced the concept of a 'digital earth'.	GIS has gradu-ally come into thousands of households, and the combination with the Inter-net has realized the sharing of huge resources in human society. Net-work GIS and mobile GIS are gradually popularized.

2.2 GIScience development history

GIScience is developed on the basis of geographic information systems (GIS), which is a cross-discipline integrating geography, computer science, information science and remote sensing technology and other fields. It focuses more on the research of scientific theories and methods of geographic information. With the continuous development and application of GIS technology, people began to explore the nature of geographic information, acquisition, processing, analysis and application in more depth, thus forming the discipline of geographic information science. GIScience not only covers the technology and methods of GIS, but also includes the spatial analysis of geographic information, spatial databases, spatial data quality, spatial data mining and other scientific theories and methods. methodology.

As early as 1987, the research field suggested that geographic information might encompass five major potential areas: spatial analysis and spatial statistics, spatial relationships and database structures, artificial intelligence and expert systems, visualization, and social, economic and institutional issues. These five areas are in turn new disciplines that include geography, statistics, computer science, cartography, economics and political science, with multidisciplinary overlaps and reorganizations [5]. By the 1990s, the information economy and the information industry had grown exponentially, and geographic information science was first defined in 1992.The establishment of the NSDI National Spatial Data Infrastructure (NSDI) in the U.S. in 1993 was followed by the formation of the University Consortium for Geographic Information Science (UCGIS), and the concurrent development of various components to support metadata standards, geoportals, and search mechanisms for the widespread sharing of geographic information. The Open Geospatial Consortium was launched in 1995, and the web standards WMS, WFS, WCS, WPS became the basic pillars of web-based geographic information services [6]. In 1998 geo-digital spatial databases, geo-libraries, began to be presented. Geographic information began to span multiple disciplines and domains, and the demand for geographic data grew. It would be too narrow to define geographic information simply as hardware and software technologies for storing and searching applications, and the 'science' of geographic information seemed more relevant and progressed more smoothly than'systems'. Moving from systems to science, then, by establishing geographic information as an intersection of a set of disciplines with common interests, supported by a technological toolkit, and in turn supporting the technology through its underlying research, geographic information comes closer to being a science.

In recent years, there has been a growing difference between the two areas of geographic information, spatial information and spatial analysis. Spatial information emphasizes large inventory databases and gives a role to geolocation as an access mechanism, while spatial analysis emphasizes rich functionality and a range of data models and gives geography a fundamental role in analysis and modelling. Spatial analysis can also be understood as the process of performing various processing calculations on spatial information to derive information and knowledge from it, which can be expressed in mathematical formulas as: $Y = Fun(X)$,where X is the geospatial information to be analyzed, a known dataset with spatial structure characteristics; Fun(x) is the spatial analysis method; and Y is the output spatial analysis result. However, this does not convince people of the existence of this field of science, and proving this point requires a more macro level, including data models, cognition, reasoning, interfaces to human-computer interaction, and visualization, to show how they are linked together by traditional means [7].

GIScience is an extremely cross-cutting discipline, which is related to geography, surveying and mapping engineering, computer applications, and industry-related disciplines (e.g., traffic engineering, civil engineering, resources and environment, etc.). However, there is one tenet, that is, geographic information science is always closely focused on spatially relevant data to carry out research, and its practicality is extremely strong and multi-disciplinary penetration, which involves a number of fields such as surveying and mapping, remote sensing, positioning, analysis, management, and expression, etc., with the ultimate aim of serving the economy, industry, and the life of the general public. There are various approaches on how to define Geographic Information Science, but all of them convey a similar signal: GIS is the science behind the system, in other words, GIS indexing schemes, or algorithms that provide solutions to problems such as polygon coverage or finding the shortest path. Geographic information science can also be defined as an approach to the infinite complexity of a set of fundamental questions posed by technology or key questions that arise when using technology [6].

2.3 GIService development history

What kind of technology system is used to support the "service" of GIService? It can be developed from the aspect of information acquisition technology, processing technology, transmission technology, terminal technology and performance technology. The rapid acquisition and updating of information is the most critical problem that restricts the development of geographic information industry [8], from the perspective of information service, information acquisition must be real-time, comprehensive and accurate. Information processing technology needs to cover the collection, cleaning, storage, management, analysis and calculation of information, geographic information system software technology and database technology are the necessary basic support. Geographic information often includes a large amount of spatial data and image data, the computer network and communication network requirements are very high. The approximate development history of geographic information service (GIService) is shown in Figure 1. The real significance of the service presentation is after the 21st century, many international software vendors will Web service technology into their own software products, the emergence of geographic information Web services related to the typical software platform. Numerous enterprises with geographic information follow the common data standards and technical service interfaces to provide distributed geographic information distribution services and realise professional geographic information application development.

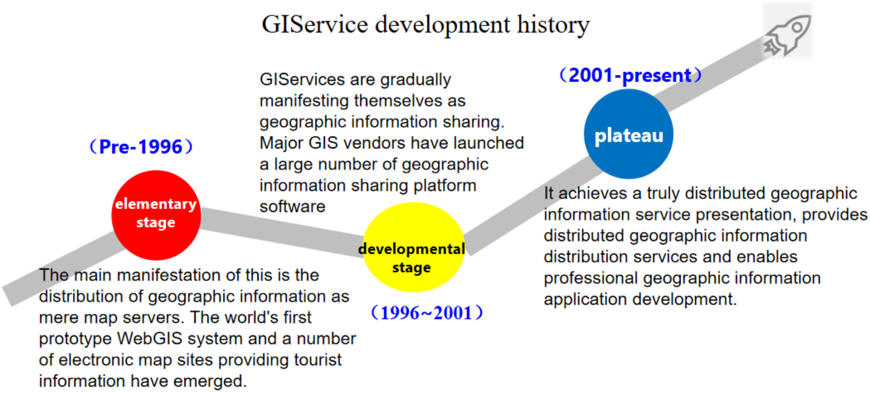

Fig. 1. GIService development history

Most of the current geographic information services are provided to all kinds of users in the form of web portals and service interfaces [9]. The service interface is an open access interface for all kinds of services, facing all kinds of application developers, for them to use the interface to call all kinds of service resources and basic functions, to achieve value-added development, and to meet diversified application needs [9]. Such as sky maps, Google maps, Microsoft virtual earth, so that almost anyone can access digital geographic information.

Nowadays, GIS is widely used, and used by almost everyone, for asset management, marketing management, business location, smart public security, smart transportation, smart environmental protection, smart gardening, smart logistics, disaster warning, and battlefield control in the military, etc. [10]-[13] .Not only is GIS becoming more and more widely used, but it is also becoming easier to use; as well as a variety of tools are being developed, which have greatly improved the ability to check the accuracy of the data from multiple perspectives to check the accuracy of data. The following is a brief application analysis of five broad areas:

Table 2. Application areas of GIService

Natural resources spatial information services	Intelligent Transport Services	Intelligent Operation and Management of Assets	Smart Environmental Services	Integrated Administrative Law Enforcement Smart Management
One map for territorial spatial planning. Spatial information query, toponymic address query, overlay analysis, spatial relationship analysis, concurrent analysis of massive geographic data. Thematic ser-	Grid integrated command and scheduling, intelligent traffic data sharing, traffic OD analysis, intersection file management, traffic safety (accident) analysis, traffic engineering project management,	One map for the full distribution of assets. Building a multi-dimensional data analysis model for building space data, professional analysis of data, in-depth understanding of industry behavioural characteristics, assessment of perfor-	Aggregate urban ecological environment, geographic environment, meteorological environment, pollution monitoring, polluting enterprises, residential population and other data to give itself the ability of	Real-time, dynamic, visual and intensive management of data, analysis of massive historical data, research and analysis of high incidence of cases, dynamic setting of research and

vices include: road network density analysis, forest coverage analysis, school coverage analysis, accessibility analysis, etc.	intelligent traffic professional operation services, equipment operation and maintenance management, intelligent traffic simulation decision support.	mance, as well as industry behavioural characteristics insight, competitive strategy perspective, brand effect and other multi-scenario analysis.	real-time alarms, emergency response, intelligent early warning, scenario restoration, pollution traceability, decision-making support and so on.	analysis parameters, automatic analysis and early warning.

3 Analytical comparison between the ‘3S’ of geographic information

3.1 Definitions and Functions

GISystem is a specific spatial information system, which uses computer hardware and software systems to collect, store, manage, calculate, analyse, display and describe geographic distribution data in the space of the Earth's surface layer (including the atmosphere) [14]. It is a comprehensive technical system capable of processing and analyzing massive spatial data and providing data support and information services for various spatial decision-making.

GIScience is a cross-discipline integrating geography, computer science, information science and remote sensing technology, focusing on the study of basic theories, principles and methods of geographic information, and exploring the nature of geographic information, expression models, cognitive processes, etc. It focuses on the scientific foundation of geographic information technology, aiming to promote the innovation and upgrading of geographic information system technology. It focuses on the scientific basis of geographic information technology and aims to promote the continuous innovation and upgrading of geographic information system technology.

GIService emphasises the application methods of geographic information, especially the application of GISystem technology to various related industries, and provides information services oriented towards socialization, networking and diversification. It focuses on transforming the theories and methods of geographic information science into practical application services to meet the information needs of users in the fields of natural resources management, urban planning, disaster monitoring and environmental protection. It focuses on information standards, management, industrial policies and large-scale integrated applications, aiming to promote the development of the geographic information industry.

3.2 Research

GISystem mainly studies how to use computer technology to manage, analyse and display geographic information, including data collection, editing, storage management, query and spatial analysis, etc. GISystem is widely used in urban planning, environmental protection, disaster monitoring, traffic management and other fields, providing scientific basis for decision-making support.

GIScience not only studies the theory and methods of geographic information technology, but also explores the nature of geographic information, acquisition, processing, analysis and application. It focuses on the theoretical basis of GIS, spatial analysis, spatial database, spatial data quality, spatial data mining and other scientific theories and methods. GIScience is closely related to a number of disciplines, such as computer science, geography, information science, remote sensing technology, etc., and promotes the development and upgrading of GIS software and deepens the knowledge and understanding of geographical phenomena.

GIService mainly studies how to apply the theories and methods of geographic information science to actual information services, including GIS data service, GIS function service, etc. It focuses on the standardization and personalisation of geographic information service, and aims to improve the quality and efficiency of geographic information service. It focuses on the standardization, personalisation and intelligence of information services, aiming to improve the quality and efficiency of geographic information services. GIService is widely used in many fields, such as natural resources management, urban planning, disaster monitoring, environmental protection, traffic management, etc., providing users with real-time, accurate and reliable geographic information support [12] [13].

3.3 Disciplinary development and areas of application

GISystem has experienced an evolutionary process from the pioneering period, the consolidation and development period, the period of great technological development to the era of popularization. With the continuous development of big data, cloud computing, artificial intelligence and other technologies, the GISystem will pay more attention to the real-time, dynamic and intelligent processing of data. In the future, GISystem will achieve more efficient, intelligent and convenient data processing and analysis functions. GISystem's functions and application fields are also expanding, playing an important role in resource management, regional and urban-rural planning, disaster monitoring, environmental assessment and other fields.

With the rise of remote sensing technology, big data, cloud computing and other technologies, GIScience has ushered in a new opportunity for development, and is moving in the direction of more intelligent and automated. In the future, GIScience will pay more attention to the fusion and mining of data, and promote the continuous innovation and upgrading of geographic information science. GIScience is not only applied to the traditional field of geographic information system, but also expanded to agriculture, forestry, water conservancy, military and other fields. By applying the theories and methods of GIScience, we can better understand the operating laws of the earth system, predict and respond to natural disasters, optimize resource allocation and improve production efficiency.

GIService is developing towards a more networked and service-oriented direction. In the future, GIService will pay more attention to information sharing and collaboration, promote the standardization and large-scale application of geographic information services, and at the same time will achieve more intelligent and personalized information services and more real-time, accurate and reliable information support.

In summary, there exists a close connection and mutual promotion between GISystem, GIScience and GIService. The development of GISystem technology promotes the formation and development of GIScience, while the research of GIScience provides a solid theoretical foundation and scientific basis for the application of GISystem technology and the provision of geographic information service (GIService). The development of GISystem technology promotes the formation and development of GIScience, while the research of GIScience provides a solid theoretical foundation and scientific basis for the application of GISystem technology and the provision of GIService. At the same time, the demand for GIService also promotes the continuous progress and innovation of GISystem technology and GIScience.

4 Conclusion

Overall, as technology advances, geographic information will make it possible to know where everything is at all times. This includes the movement trajectories of people and vehicles, a building, a road, a tree, etc. The precise location can be known. Everyone is a consumer and producer of geographic information. Data will be provided by all, RS data, sensor network data, trajectory data, socio-economic statistics data, opinion and behaviour data, transaction data, survey data and so on. Services are faster, more accurate and efficient. Monitoring of almost everything on the earth's surface in terms of features and land-forms is more comprehensive, more accurate, more timely, and applications will be more widespread. Global data will be shared in an integrated manner to comprehensively address development issues in all dimensions of society, economy and environment, complementing each other, thus supporting GIS to develop in a better direction, and enabling mankind to move towards the path of sustainable development in a comprehensive manner.

The successful application of geographic information places greater emphasis on the role of the organizational system and the human factor, which is always the technical glue that connects a large number of collaborators. This, in turn, is required by the complexity and multidisciplinary nature of GIS. Therefore, the'3S'(system, science, service) of geographic information can be understood as symbiotic, GIS is a tool of science, geographic information is a science based on an information system, GIS is in turn a powerful tool and an effective technical means of geographic information service [8], and geographic information service is also a tool of this kind of system tool, this science development progress indispensable and powerful pusher.

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