Transactions on Computational and Scientific Methods | Vol. 5, No. 3, 2025
ISSN: 2998-8780
https://pspress.org/index.php/tcsm
Pinnacle Science Press

# Application and Future Prospects of Geographic Information System (GIS) in Intelligent Transportation

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**Abstract:** Geographic Information System (GIS) is an advanced computer-based technology that integrates spatial data processing with three-dimensional geographic visualization. By combining disciplines such as geography, computer science, and statistics, GIS enables efficient collection, storage, analysis, and visualization of geographic information. This technology plays a crucial role in various domains, particularly in intelligent transportation systems, where it facilitates dynamic traffic monitoring, real-time navigation, and efficient route optimization.As modern transportation evolves, GIS is becoming an essential tool for enhancing data-driven decision-making, improving traffic management, and optimizing urban planning. The ability of GIS to integrate spatial and temporal data allows for the identification of traffic patterns, accident-prone areas, and congestion hotspots, providing valuable insights for transportation authorities. Furthermore, the integration of GIS with the Internet of Vehicles (IoV) represents a key future direction, enabling the creation of dynamic and adaptive transportation networks. By leveraging real-time data exchange, IoV and GIS together can offer solutions to major urban challenges such as traffic congestion, accident prevention, and improving overall travel efficiency.With the continuous advancement of technology, including artificial intelligence and cloud computing, GIS is expected to further evolve, leading to smarter and more adaptive transportation infrastructures. Its applications will extend beyond traffic management to support sustainable urban development, environmental monitoring, and emergency response planning. The integration of GIS with smart city initiatives will contribute to more efficient public transportation systems, reduced environmental impact, and enhanced urban mobility. As a result, GIS is positioned to be a key driver in the development of intelligent transportation networks and the future of smart cities.

**Keywords:** Internet of Vehicles; GIS; Application.

## 1. Introduction

Geographic Information System (GIS) technology is an advanced computer-based processing system that integrates data information with three-dimensional geographic images, combining multiple disciplines such as geography, computer science, and statistics [1]. As an essential spatial information system, GIS enables efficient data processing and analysis in a three-dimensional space, allowing users to manage vast amounts of geographic information. By leveraging computer hardware and software, GIS facilitates the collection, storage, computation, analysis, and application of geographically distributed data and related information, making it a crucial tool in various industries.

One of the primary functions of GIS is to process geographic information, including topographic maps. The system can transform spatial information of the ground into two-dimensional and three-dimensional images, enhancing the understanding of geographic environments. Additionally, GIS can store data in different formats, such as grids or vector files, ensuring flexibility and accessibility for various applications. This capability provides practical data support for the application and

management of subsequent databases [2].

GIS technology is widely used in fields such as urban planning, environmental monitoring, disaster management, and transportation. In urban planning, GIS aids in land-use analysis, infrastructure development, and zoning regulations. In environmental applications, it helps monitor changes in land cover, assess climate impact, and manage natural resources. Disaster management professionals utilize GIS for real-time tracking of natural disasters, risk assessment, and emergency response coordination. Moreover, GIS plays a crucial role in transportation, enabling traffic analysis, route optimization, and intelligent navigation systems.

With the advancement of modern science and technology, GIS is continuously evolving and integrating with new technologies such as artificial intelligence, remote sensing, and cloud computing. The combination of GIS with artificial intelligence enhances its analytical capabilities, allowing for predictive modeling and automated spatial data processing. Remote sensing technologies provide real-time updates for GIS databases, improving the accuracy of geographic data. Additionally, cloud computing facilitates efficient storage and sharing of geospatial information, making GIS more accessible and scalable.

In summary, GIS is an important technical tool that combines the unique visualization effect of maps with powerful spatial data analysis functions. Its ability to process and analyze large volumes of geographic data makes it indispensable for numerous industries and scientific research. As technology continues to evolve, GIS is expected to play an even greater role in addressing complex spatial challenges, improving intelligent decision-making, and contributing to advancements in fields such as smart cities and intelligent transportation systems.

## 1.1 Function

### 1.1.1 Management Function

Geographic Information System (GIS) has the powerful capabilities of information visualization and real-time information exchange, making it an essential tool for modern spatial data management. By integrating various types of geographic data, GIS provides an effective way to store, analyze, and manage spatial information in a structured database. This allows for efficient organization and retrieval of data, ensuring that users can access and utilize relevant geographic information as needed. With its ability to integrate multiple data sources, GIS enhances the accuracy and efficiency of decision-making processes across various industries.

One of the key advantages of GIS is its ability to facilitate the digitalization and intelligence of urban geographic information. Traditional methods of managing spatial data often involve paper-based maps and manual record-keeping, which can be time-consuming and prone to errors. GIS, on the other hand, enables the transformation of geographic data into digital formats, allowing for real-time updates and seamless integration with other digital systems. This digitalization process is crucial for smart city development, where GIS plays a vital role in urban planning, infrastructure management, and resource allocation.

Furthermore, GIS significantly enhances the level of data sharing and management across different sectors. In many industries, geographic data is often fragmented and stored in isolated databases, making it difficult for organizations to collaborate and share information efficiently. By using GIS, various departments, such as transportation, environmental protection, disaster management, and public health, can share and access the same spatial data platform. This improves coordination among agencies, facilitates data-driven decision-making, and ensures a more comprehensive understanding of spatial relationships.

Additionally, the integration of GIS with other emerging technologies, such as cloud computing, big data analytics, and the Internet of Things (IoT), further expands its potential applications. Cloud-based GIS solutions enable remote access to spatial data, allowing multiple users to work on the same dataset in real time. Big data analytics combined with GIS helps identify patterns and trends in geographic information, providing valuable insights for urban development, environmental monitoring, and disaster response. The IoT, when integrated with GIS, enables real-time data

collection from sensors and devices, improving the accuracy of location-based services and enhancing situational awareness.

In conclusion, GIS is a crucial technology for modern geographic data management, offering advanced capabilities for information visualization, real-time data exchange, and efficient data storage. Its application in practical work not only promotes the digitalization and intelligence of urban geographic information but also improves data sharing and management across various sectors. With continuous advancements in GIS and its integration with emerging technologies, its role in urban planning, disaster response, transportation, and other critical areas will continue to expand, contributing to the development of smarter and more efficient cities.

### 1.1.2 Prediction and Planning Function

Prediction planning is one of the most important applications of Geographic Information System (GIS), primarily reflected in its powerful data analysis capabilities. By utilizing the vast amounts of spatial and statistical data stored in GIS databases, urban planners and decision-makers can analyze patterns, identify trends, and forecast future urban developments with greater accuracy. This predictive capability is essential for optimizing city layouts, assessing land use efficiency, and improving overall urban management strategies.

Through advanced algorithms embedded in GIS, managers can evaluate the current status of urban planning, identify areas of congestion, and predict future expansion needs. By analyzing demographic trends, transportation patterns, environmental conditions, and infrastructure usage, GIS can generate simulations and models that offer valuable insights into how cities may evolve over time. These predictive models allow planners to anticipate potential issues such as overpopulation, traffic congestion, and environmental degradation, enabling them to develop proactive strategies to mitigate these challenges before they become critical problems.

One of the key applications of GIS in prediction planning is urban land use analysis. By examining historical land use patterns and integrating real-time data, GIS can assist in determining the best allocation of space for residential, commercial, industrial, and recreational purposes. This ensures sustainable development by balancing economic growth with environmental preservation. Additionally, GIS can be used to assess land suitability for various functions based on factors such as soil quality, proximity to transportation networks, and risk of natural disasters, ensuring that urban expansion is both strategic and sustainable.

Furthermore, GIS plays a crucial role in industrial division and economic planning. By analyzing economic activity distribution, workforce availability, and resource accessibility, GIS helps planners identify the most suitable locations for industrial zones, commercial centers, and business hubs. This not only optimizes economic efficiency but also reduces logistical costs and minimizes environmental impact. Additionally, GIS can predict future economic trends based on population growth, consumer behavior, and infrastructure development, allowing for better allocation of investments and resources.

In addition to land use and industrial planning, GIS-based prediction models also support the development of transportation networks. By analyzing traffic flow patterns, road congestion, and public transportation usage, GIS helps city planners design efficient transportation systems that accommodate future population growth. Predictive analysis can determine where new roads, highways, or public transit stations should be built to improve mobility and reduce travel time for residents. This is particularly useful for smart city initiatives, where GIS integrates with real-time traffic monitoring and IoT sensors to create adaptive transportation solutions.

Moreover, environmental sustainability is a crucial aspect of urban planning, and GIS enhances predictive capabilities for environmental management. By assessing factors such as air quality, water resources, and green space distribution, GIS helps city officials develop strategies to mitigate pollution, conserve natural resources, and enhance the overall quality of life. Climate change modeling within GIS can also predict potential risks such as rising sea levels, heatwaves, or flooding, allowing cities to implement proactive disaster preparedness and resilience plans.

In conclusion, prediction planning through GIS provides urban managers with a powerful tool for forecasting development trends, optimizing land use, improving industrial division, and enhancing transportation and environmental sustainability. By leveraging vast data resources and advanced analytical models, GIS offers a more scientific and reliable basis for decision-making in urban planning. As technology continues to advance, the integration of artificial intelligence, big data, and IoT with GIS will further enhance predictive planning capabilities, ensuring smarter, more efficient, and sustainable urban development.

### 1.1.3 Analysis and Evaluation Function

Staff need to establish a data model and an auxiliary decision support system based on urban geographic information to enhance the efficiency and accuracy of urban planning and management [2]. Geographic Information System (GIS) plays a crucial role in building such models by integrating spatial and statistical data, enabling real-time analysis and predictive capabilities. By developing comprehensive data models, urban planners and decision-makers can systematically organize and analyze geographic information, leading to more informed and data-driven decisions.

The establishment of a data model within GIS involves the collection, classification, and structuring of spatial data related to land use, transportation networks, population distribution, environmental factors, and infrastructure. These models provide a detailed representation of urban areas, allowing planners to simulate different development scenarios and assess the impact of various planning decisions. Through spatial analysis, GIS can identify trends, detect patterns, and highlight potential challenges in urban development.

In addition to creating data models, an auxiliary decision support system enhances the ability of urban managers to evaluate multiple planning strategies efficiently. By integrating GIS with decision support tools, city planners can conduct multi-criteria analysis, optimize resource allocation, and improve risk assessment. For example, GIS-based decision support systems can assist in identifying the most suitable locations for new public facilities, analyzing traffic congestion patterns, and predicting future urban expansion trends.

Furthermore, these systems facilitate better coordination among different government departments and stakeholders. By providing a centralized platform for accessing and sharing urban geographic information, GIS-based decision support systems ensure that all relevant agencies work with the same data, reducing inconsistencies and improving collaboration. This is particularly useful in large-scale urban projects where multiple sectors, such as transportation, housing, and environmental protection, need to be considered simultaneously.

Another key advantage of GIS-based decision support systems is their ability to integrate real-time data from IoT sensors, satellite imagery, and remote sensing technologies. This allows for dynamic updates to urban data models, ensuring that planning decisions are based on the most current and accurate information. For instance, real-time traffic data can be used to optimize transportation planning, while real-time environmental data can help monitor pollution levels and guide sustainable development efforts.

Moreover, GIS-based decision support systems enhance disaster preparedness and emergency response planning. By analyzing historical disaster data and real-time environmental conditions, these systems can predict potential risks such as flooding, earthquakes, or landslides, allowing city officials to take proactive measures. Emergency response teams can also use GIS models to plan evacuation routes, allocate resources efficiently, and coordinate rescue operations in the event of a crisis.

In conclusion, the establishment of data models and auxiliary decision support systems based on urban geographic information is essential for effective city planning and management [2]. GIS technology provides a robust framework for collecting, analyzing, and visualizing spatial data, enabling more accurate decision-making processes. By integrating real-time data, multi-criteria analysis, and predictive modeling, GIS-based decision support systems help urban planners optimize resource distribution, enhance collaboration, and address challenges such as traffic congestion, environmental sustainability, and disaster management. As GIS technology continues to

evolve, its role in supporting intelligent urban development will become even more significant.

### 1.2 Structural Composition

Different classification methods in Geographic Information System (GIS) will lead to varying classification results, as GIS is a multidisciplinary field with diverse applications. Depending on the perspective from which it is analyzed, GIS can be classified based on academic disciplines or system components, each offering a unique understanding of its structure and functionality.

From the perspective of academic disciplines, GIS is primarily composed of four main fields: computer science, geography, statistics, and big data processing. Computer science provides the foundational technological framework for GIS, including software development, algorithms, and data structures that support spatial data processing and visualization. Geography contributes spatial analysis techniques, cartographic principles, and an understanding of natural and built environments, which are essential for effective GIS applications. Statistics plays a crucial role in data modeling, predictive analysis, and pattern recognition, allowing for accurate interpretation of spatial information. Finally, big data processing has become an increasingly important aspect of GIS, as modern GIS systems handle vast amounts of real-time data from sources such as remote sensing, IoT devices, and GPS tracking, requiring efficient storage, management, and analysis techniques.

From the perspective of system theory, GIS can be divided into four key subsystems: computer system, database system, application management system, and actual system management personnel. The computer system includes the hardware and software components required for GIS operations, such as servers, workstations, and GIS software platforms. The database system is responsible for storing and managing spatial and non-spatial data, ensuring data integrity, accessibility, and security. The application management system encompasses the various GIS applications and tools used for data analysis, visualization, and decision-making, tailored to specific domains such as urban planning, environmental monitoring, or disaster management. Lastly, the actual system management personnel refers to the professionals and experts who operate, maintain, and apply GIS technology in real-world scenarios, including GIS analysts, urban planners, environmental scientists, and decision-makers.

The classification of GIS based on these two perspectives highlights the multidisciplinary nature of the system, illustrating its complexity and versatility. Understanding GIS from both academic and system-based viewpoints provides a comprehensive framework for its study and application, enabling researchers, engineers, and policymakers to effectively develop and utilize GIS technology for diverse spatial analysis and decision-making tasks. As GIS continues to evolve, integrating advancements in artificial intelligence, cloud computing, and real-time data processing, its classification methods may further expand, reflecting new technological and theoretical developments in the field.

## 2. Overview of Internet of Vehicles

### 2.1 Definition

The main body of the Internet of vehicles is an interactive network composed of various vehicles, accompanied by a series of information such as path path, location, driving speed, and driving route generated by vehicles in the process of driving, which is a more intelligent, efficient, and more informative vehicle-network joint technology. Through RFID, laser radar, camera, sensor, millimeter wave radar, image processing and other electronic equipment in the sensing layer, the information of people, vehicles and roads can be collected; At the same time, it complies with certain communication network protocols to conduct wireless communication or information exchange. [3] It is also considered as the core component of the future intelligent transportation system. The arrival of the 5G era has greatly accelerated the communication capability, which has also greatly enhanced the transmission capability of the Internet of Vehicles technology and shortened the transmission time. At the same time, with the development of society and economy, the number of vehicles owned by residents has gradually increased, which will also make the Internet of Vehicles technology become one of the practical technologies with broad application prospects. It is also one of the effective

intelligent technologies to improve the current traffic and pedestrian safety, vehicle congestion and other phenomena, and is also an indispensable technical means to achieve automatic driving and driverless driving.

### 2.2 Structure

The structure of the Internet of Vehicles system is roughly divided into three layers from bottom to top: perception layer, network layer and application layer.

#### 2.2.1 Perception Layer

In short, the perception layer is to sense all kinds of data. Through various sensors, collect the sensed data, collect the traffic information of vehicles, roads and people, such as driving speed, traffic flow distribution, population distribution, route and so on, so as to comprehensively analyze the operation of vehicles and pedestrians through vehicle sensor network, road sensor network and other networks, store the traffic information and road information, and lay the foundation for future applications.

#### 2.2.2 Network Layer

The network layer, as its name implies, is to sort out the information collected by the sensing layer, form a data network and database system, play a transitional role between the application layer and the sensing layer, and then transmit information for the later application layer through 5G communication technology, vehicle communication and other technical means. [4]

#### 2.2.3 Application Layer

The main function of the application layer is to analyze and apply data, that is, use cloud computing and other algorithms to calculate, process and analyze perceived data, so as to provide users with rich and practical Internet of Vehicles applications [5].

## 3. Key Technologies

### 3.1 RFID Technology

Radio frequency identification (RFID) technology is a technology that realizes object recognition through radio frequency signals. In addition to the function of sensing the position of objects, it can also sense and track the moving space status of objects in space. RFID technology has been widely used in the field of intelligent transportation, and in most cases it will be used in combination with wireless communication technologies such as database, cloud computing, fog computing, etc. [6].

### 3.2 Sensor Network Technology

Sensor network is the network processing of the information collected by sensors, based on the support and application of data, and the analysis, processing, collection and storage of various sensors. Different sensors are uploaded to the group data acquisition system through the acquisition system to dynamically and real-time collect various intuitive data required by the Internet of Vehicles service, such as vehicle speed, conventional route, dynamic track, traffic information, etc. Currently, sensors have evolved from a single or several sensors to a sensor network composed of a large number of sensors, and can be customized according to different services. Provide data source for the server, and provide high-quality services for vehicles as various business data after analysis and processing. [6].

### 3.3 Satellite Positioning Technology

GPS system provides accurate space services for vehicle positioning, navigation and path planning, which makes it an important part of the technical basis of the Internet of Vehicles technology. With the completion of the Beidou navigation system in China, the Internet of Vehicles technology can not only rely on GPS, but also rely on the Beidou navigation system independently developed by China, which also gives the development of China's Internet of Vehicles a new direction of development and gradually realizes localization. [6].

## 4. Application

### 4.1 Application of GIS in Perception Layer

The most important application of GIS in the perception layer of the Internet of Vehicles is the convenient collection of geographical data and the establishment of a database, so as to realize the visualization of map data and spatial data analysis. The file and data types of GIS include dem, grid, vector, etc. The characteristics of these data are different from the traditional database types. They can not only flexibly modify all kinds of information in the spatial map, but also display data in the form of various visual maps such as traffic planning map, location topographic map, etc., to realize the visualization and synchronous matching of data and map. In addition, the spatial analysis function of GIS is also an important core function of GIS. It can put the traditional two-dimensional plane data into the three-dimensional space for analysis, which is more in line with the actual situation of our three-dimensional space life, and this is also the main reason for applying GIS to various fields. At present, GIS has become the core technology of the Internet of Vehicles, and its application in the Internet of Vehicles system is a landmark development of transportation and geography. [7]

### 4.2 Application of GIS in Network Layer

The application of GIS in the network layer is mainly used in data processing and integration. At present, the most extensive application is map matching. Map matching refers to the process of positioning the human-vehicle-road through GNSS, GPS Beidou navigation system, and comparing the measured positioning and path results with the database built by GIS [8]. The biggest integration of GIS and transportation is the use of maps, so the matching degree between maps and actual conditions is crucial. The progress of location acquisition and mobile computing technology has produced spatial trajectory data, which reflects the movement regularity of various real objects, and plays a vital role in many fields such as real-time path planning, road network update, travel law discovery and so on. After the completion of the GIS database construction, during the vehicle driving process, it is necessary to determine the position of the vehicle in the map according to the accuracy of the sensor information, so that the theoretical spatial data and the actual spatial location coincide with each other, and complete the map matching.. However, there are still some problems: (1) The algorithm matching time is not only related to the route track, but also closely related to the actual traffic and road conditions. The higher sampling rate and road complexity bring more time-consuming calculation process; (2) At complex road sections such as intersections, because moving objects usually move at a low speed, the distance between track points is smaller than that of other areas, which is also easy to cause incorrect matching [9]. Therefore, GIS has better accuracy and convenience in data processing and integration, and GIS database is more efficient and easier to store and share than traditional database.

### 4.3 Application of GIS in Application Layer

The main application of GIS in the application layer is to carry out spatial analysis of data to assist in path planning and facilitate real-time dynamic update of data. The main goal of path planning is to find the shortest path, and provide the best path for vehicles based on the expected values of the shortest travel time, the lowest operating cost, and the shortest distance. Traditional classical algorithms include Dijkstra algorithm, ant colony algorithm, etc. However, these traditional algorithms are not widely used in today's society with huge amount of data, and the calculation time is long. GIS database can effectively integrate these data to find the shortest path.

Real-time dynamic update of data refers to the update of traffic flow information, population travel demand, route allocation and other required information over time. The importance of real-time data updating lies in the inevitable error between actual life and theoretical prediction. For example, the roadside conditions of the medium highway will usually be caused by some force majeure factors, such as various traffic accidents and other factors, which may lead to complex road conditions and changes in driving conditions. If the vehicle still drives according to the previous route, it will lead to reduced traffic efficiency and longer queuing time. With the rise and arrival of the fifth generation of communication technology, with the help of 5G technology and GIS technology in the future, vehicle driving data and traffic system data closer to the actual situation can be collected more conveniently

and effectively [9].

## 5. Conclusion and Prospect

GIS is a comprehensive technology for intelligent processing, flexible storage and rapid analysis of traffic data and terrain data. It is an organic combination of spatial data and spatial geography. It is also an important achievement in the development of computer technology and geographic information technology. With the continuous improvement of modern science and technology and economic conditions, people's functional requirements for vehicles will not be limited to simple mobile vehicles, but to strengthen the intelligence of vehicles. This requires us to use GIS to establish dynamic data that is different from traditional databases. Therefore, the combination of geographic information system and the Internet of Vehicles is an important trend in the development of intelligent transportation in the future, which can not only facilitate the collection and storage of traffic data The comprehensive and intelligent evaluation of the analysis, processing and traffic planning scheme can also be of great help to solve various urban traffic problems such as traffic congestion, car accidents, and low travel efficiency.

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