

## The Development History and Future Trend of the Digital Earth

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*Abstract: The digital earth is a new strategic direction for the quantitative study of the earth at the end of the 20th century. It is an interdisciplinary subject integrating space science and technology, information technology and earth science. The digital earth is the inevitable outcome of the global information technology. It will accelerate the pace of global information and make great contributions to the development of human society. This study briefly introduces the research significance, development status, research situation and international academic platform of digital earth, summarizes the achievements in its development, and discusses the application prospect of digital earth. Finally, the future development of digital earth is prospected.*

*Keywords:* Digital earth; development course; future tread.

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### 1. INTRODUCTION

At present, the earth is the only planet on which human beings rely for survival. It is the common responsibility of all mankind to reasonably develop and utilize the earth's resources and effectively protect and optimize the earth's environment. However, after experiencing the industrial revolution in recent years, human society has found that the supply of natural resources, the foundation of this powerful material civilization society, is in crisis. The earth environment on which human beings depend is being more and more seriously damaged by natural and man-made actions. A series of global and regional major resources and environmental problems are increasingly seriously threatening human survival and sustainable development. Therefore, there is an urgent need for human beings to have a deeper understanding of the earth, understand the earth, and then manage the earth well and protect the common home of mankind [1].

"Digital Earth" is a concept put forward by US Vice President Gore in his report "Digital Earth understanding our Planet in the 21st Century" on January 31, 1998 [2-4]. In 1999, Wang et al. looked forward to the broad prospect of "digital earth" to the research and development of earth system

science, and called for the establishment of China's "digital earth" as soon as possible. In 2002, Ma et al. pointed out that the "3S" technology in the digital earth era has become one of the core and basic technologies of the digital earth [6]. In the same year, Huang et al. expounded the relationship between digital city and digital earth by analyzing the present situation of the development of digital city. It also discusses the great role of the digital earth strategy in promoting the future urban development [7]. In 2009, Guo et al. further pointed out the important role of the digital earth and put forward the idea of constructing a digital geoscience platform [8]. In 2010, Li et al. designed the platform framework and typical applications of the Internet of things based on the full IP architecture, and looked forward to the trend and bright prospect of the development from a digital earth to a smart earth [9]. In 2011, Li et al. proposed that smart city is the product of the combination of digital city, Internet of things and cloud computing [10], discussed the inevitable trend of the development of digital city to smart city and prospected the bright prospect of smart city in the future [11]. In 2014, Guo et al. discussed big data's theory and method in the digital earth discipline from the perspective of time and space. [12]. In 2016, Li pointed out that geospatial informatics will face more development opportunities and arduous tasks in the big data era of building a smart earth and smart cities. It is bound to make greater contributions to the progress and sustainable development of human society [13]. In 2017, Zhang put forward the development trend from smart cities to new smart cities and future smart cities [14]. The so-called "digital earth" can be understood as a unified digital reproduction and understanding of the real earth and its related phenomena [15]. Popularly speaking, it is to load the earth, the activities on the earth and the space-time changes of the whole earth environment into the computer by digital method, so as to realize the circulation on the network, and make it serve the survival, sustainable development and daily work, life and entertainment of human beings to the greatest extent. Its core idea is to use digital means to deal with many aspects of the natural and social activities of the whole earth, and to maximize the use of resources. It is characterized by embedding massive data and realizing multi-resolution and three-dimensional description of the earth, that is, "virtual earth". The concept of digital earth can be summarized into the following three aspects:

- (1) Digital Earth refers to the digital three-dimensional display of the virtual earth, or the information-based earth, including digital, networked, smart and visual geo-technology system.
- (2) the implementation of the Digital Earth Project requires the concerted efforts of the government, enterprises and academia. The implementation of the Digital Earth Project is an act of society, which requires the concern and support of the whole society [18].
- (3) Digital Earth is a new technological revolution, which will change human production and way of life, further promote science and technology, economic development and social progress [19].

## 2. ACHIEVEMENTS OF DIGITAL EARTH

### 2.1 From 2D to 3D

Map has long been regarded as the best way or carrier to express, transmit and study geographic information, but this concept has been broken in recent years. As a three-dimensional earth information model, digital earth is considered to be the best way for human to grasp the earth surface

information so far. The emergence of it makes a qualitative leap in describing and analyzing the information of things in the surface space [20,21].

## **2.2 Observation and Analysis of Multi-resolution and Multi-tenses of the Earth**

Digital earth is an important means to serve scientists, especially geologists, who study the earth and its environment digitally. Crustal movement, geological phenomena, earthquake prediction, meteorological prediction, land dynamic monitoring, resource survey, disaster prediction and prevention, environmental protection, etc. all need to make use of the digital earth. And the continuous accumulation of data will eventually enable human beings to better understand and understand the planet that lives and lives. It is no longer a dream to use massive earth information to describe the earth in multi-resolution, multi-space-time and multi-kinds.

## **2.3 Visualization and Measurability based on Real Image**

The proposal of digital earth promotes the three-dimensional visualization of spatial data based on graphics and images. 3D visualization based on graphics can be used for spatial analysis of 3D GIS, such as path selection, noise and pollution model analysis. 3D terrain and city models with real textures can be used for landscape analysis, virtual geographic environment and digital cultural heritage. The image-based 3D real image model can form a large area seamless stereo orthophoto image and real image along the street, which can be used for visualization and on-demand measurement implemented by users. The organic combination of the two methods can make up for the deficiency of network electronic map, and can directly provide high-precision map data, all-element information and m-resolution image data to public security, municipal, traffic, navigation, LBS and other industries. This kind of close-range image data of "visual, measurable and minable" is called measurable real-scene image. Combined with network electronic map products, it can build an "image earth" with orthophoto image and real-scene image as the main shared data source. The measurable real scene image is put together with the stereo image forward rendezvous algorithm on the Internet, and the users on any terminal can measure and interpret according to their own needs.

## **2.4 Spatial Information Sharing and Smart Service based on Web Service**

In the field of geo-spatial information, various spatial information resources can be registered and online services can be provided by using Web Service technology. It includes geo-spatial information resource registration service, sensor service, spatial information transmission service, spatial data service, spatial information processing service, spatial information resource combination service, spatial information service quality, spatial information smart search service, spatial information distribution service, spatial information visualization service and so on. The combination of various service resources can process and extract more advanced information and provide more smart services. As a spatial information integration platform, digital earth can integrate all kinds of social and economic information related to geospatial information from the network environment, and then provide smart services to society and professional departments through WebService technology.

## **2.5 From Digital Earth to Smart Earth**

Peng, CEO of IBM, put forward the concept of "Smart Earth" for the first time, suggesting that the new government invest in a new generation of smart infrastructure. The main content of this concept is to fully apply the new generation of IT technology to various industries, that is, to equip sensors

into all kinds of objects in people's lives, and connect them to form the "Internet of things", and integrate the "Internet of things" through supercomputers and cloud computing, so as to realize the integration of online digital earth and human social and physical systems. On this basis, human beings can manage production and life in a more precise and dynamic way, so as to achieve a state of "wisdom". On the smart earth, people will see smart medical treatment, smart power grid, smart oil field, smart city, smart enterprise and so on.

### **3. APPLICATION PROSPECT OF DIGITAL EARTH**

#### **3.1 Global change and Social Sustainable Development**

Global change and social sustainable development have become important issues of concern to people in the world today, and the digitally represented earth provides very favorable conditions for us to study this problem. The use of digital earth in the computer can simulate and simulate the process, laws, effects and countermeasures of global change, so as to improve the ability of human beings to cope with global change. Digital Earth can be widely used to monitor global climate change, sea level change, desertification, ecological and environmental change, and land use change. At the same time, using the digital earth, we can also comprehensively analyze and predict many problems of social sustainable development, such as natural resources and economic development, population growth and social development, disaster prediction and prevention and so on.

#### **3.2 Land Management**

Land management is the basic component of e-government, the overall goal is to achieve the dynamic balance of the total amount of cultivated land and improve the science, accuracy and timeliness of land management. With the use of digital earth, people can grasp the spatial distribution information of land, including land use type, quantity, area, quality and so on, so as to lay a foundation for the daily management of land. The digital earth can also be used to complete the dynamic monitoring related to land use, such as mutual transformation of land use types, area change, quality change, ownership change, agricultural internal structure adjustment and so on. thus it provides a reliable guarantee for reflecting the current situation of land use quickly and in real time and realizing the change management of land.

#### **3.3 Disaster Monitoring**

First, digital earth provides us with a rich data platform for the natural and socio-economic conditions of the earth surface, as well as a technical system for the physical, chemical, biological and social motion analysis and Simulation of the earth surface system. Using this data platform and technology system, we can make us have the ability to make the occurrence and development of virtual disasters as real as possible in the computer environment, as well as the interaction law of natural disaster phenomena and human society, so that we can better understand some essential laws of disaster system to provide the basis for disaster prediction. Secondly, digital earth provides us with a large number of location and quantitative natural environment and socio-economic background data in disaster areas. By using GIS and computer simulation technology, the loss caused by disasters can be caused by comprehensive analysis of remote sensing and ground monitoring data and various basic background data obtained during disaster occurrence The situation of disaster development and the

impact of disasters on the ecological environment and social development are evaluated. Third, when disasters occur, the data platform and technical system provided by digital earth can help decision makers of disaster management departments to quickly know the location and extent of the occurrence of the dangerous situation, formulate scientific and reasonable rescue measures and personnel material dispersion plan, which can avoid casualties and social wealth loss to the greatest extent. Fourthly, after the disaster event is over, digital earth can help us to formulate and implement scientific and reasonable post disaster reconstruction plan and long-term disaster reduction plan in view of the natural environment characteristics and social and economic development of the disaster area, so as to realize the sustainable development of the region.

### **3.4 Smart Transportation**

The smart transportation system is based on the digital earth to establish the pavement management system, bridge management system, traffic congestion, traffic safety and highway monitoring system of the country, provinces, cities and autonomous regions. Electronic control technology and computer processing technology are effectively integrated and applied to the whole ground transportation management system, and a real-time, accurate and efficient comprehensive transportation and management system is established, which can play a role in a wide range and in all directions, and realize the smart operation function of transportation tools on the road. So that the public can use the highway transportation facilities and energy efficiently.

### **3.5 City Management**

As the political, economic and cultural center of the region, the city is bound to become the focus of the digital earth and the most complex part of the digital earth. Digital Earth can promote urban information service to enter a new era in terms of mode, content, means, speed, effect and so on. First of all, as far as the government is concerned, the digital earth will help to improve the daily office efficiency of the city government and improve the level of government management. Secondly, as far as education and other social welfare departments are concerned, the digital earth will also promote its development. For human beings, who are increasingly tense about the contradictions among population, resources, environment and development, the social welfare departments that pay most attention to these issues can make full use of the digital earth to carry out their work.

### **3.6 Modern Warfare**

Digital Earth is of great significance in modern warfare and national defense construction. The establishment of various military geographic information systems serving strategies, tactics and campaigns, and the use of virtual reality technology to establish a digital battlefield is the application of digital earth in the construction of national defense. This includes terrain and geomorphology reconnaissance, military target tracking and surveillance, aircraft positioning, navigation, weapon guidance, strike effect reconnaissance, battlefield simulation, combat command and so on. It puts forward extremely high requirements for the collection, processing and updating of space information. Before the beginning of the war, it is necessary to establish the military geographic information system of the war zone and its surrounding areas; to use GPS, RS and GIS for battlefield reconnaissance, information update, military command and dispatch, precision guidance of weapons; and to evaluate the effectiveness of military strikes in wartime and post-war, and so on. Moreover,

the digital earth is a typical system engineering that combines peacetime and wartime and the army and the people. The construction of China's digital geo-engineering accords with the development direction of China's national defense construction.

#### 4. DIGITAL EARTH IN THE FUTURE

In the future, "Digital Earth" will be a powerful visual "sphere", which will become a form of world information organization. Through the "sphere", we can get insight into the information inside the building, underground and underwater in the form of three-dimensional, four-dimensional and even n-dimensional. Based on historical data and comprehensive models, digital earth will present the physical characteristics of the earth in the past and future in the form of visualization. At that time, time will be a key dimension for the understanding and analysis of the earth. Therefore, it will be crucial to preserve the digital past and the digital present of the earth. Digital earth will be a comprehensive dynamic and interactive development and utilization process of information flow from sensors and human beings. Digital earth will be a process of systematizing heterogeneous information and establishing quality standards for data input and output. Smart earth and smart city are the development focus in the future, and the establishment of digital earth provides basic data and technical support for them.

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