The GDUT Maritime Silk Road Project (2014-2015) as a case study for VSMM in Museum Settings in China

Liu Danyun
School of Art and Design
Guangdong University of Technology
Guangzhou, China
Liudanyun@gdut.edu.cn

Yu Yongquan &Wen Chaodan
School of Computer Science
Guangdong University of Technology
Guangzhou, China
13802901724@163.com

Zhang Zhongpeng
School of Political Science and Law
Guangdong University of Technology
Guangzhou, China
907253408@qq.com

***Abstract* – This case study focuses on the Digital Maritime Silk Road as referring to Chinese scholarly publications. The purpose is to allow museum visitors to experience the evolution of the concept of the Maritime Silk Road in China through the use of new technologies. Thus, an interactive visual and dynamic historical GIS (geographic information systems) approach has been created to be applied within a granularity retrieval platform.**

This project was conducted by an interdisciplinary team from digital media, computer science and history at the Guangdong University of Technology (GDUT) in 2014 and 2015.

Keywords–Granularity Retrieval; Interactive Platform; Information Visualization; Dynamic GIS of Maritime Silk Road

I. Introduction

The interest of Chinese scholars in Maritime Silk Road has been present at least since 1998 when UNESCO first initiated the “Road of Dialogues: an integrity study on Maritime Silk Road” study [1]. PRC President Xi Jinping’s "One Belt and One Road"[2] (Fig. 1) development strategy and framework in 2013, even increased the interest in the Maritime Silk Road exponentially. Presently, research has spread in the areas of archaeology, cultural heritage, history, economy, politics and other related fields of study.

On one hand, according to Song Ping (2014), a Chinese researcher in the field, the interaction between the historical and cultural relics concerning Maritime Silk Road, are insufficient in China [3]. This problem has stayed even though Chinese domestic cities along the Maritime Silk Road have jointly held exhibitions on the topic of *Across the Sea - Cultural Heritage Exhibition of Nine Cities along the Maritime Silk Road* [4]. The reason behind the apparent failure of these exhibitions is that they were static only based on the local scope (which started from each city's own perspective) and lacked a comprehensive systematic digital platform for the purpose of public interaction.

On the other hand, existing techniques for interaction design in visual analytics rely upon visual metaphors developed more than a decade ago. [5] Currently, interactive collaborative techniques are used to explore large-scale datasets and lack adequate experimental development essential to the construction of knowledge in analytic discourse. [6] As the research on a new method of visualizing data is a vital opportunity offered by interactive and computational technologies for enhanced cognitive exploration and interrogation of high dimension, data still needs to be realized within the domain of interactivity and retrieve for digital humanities. [7]In recent years, more and more digital preservation dataset projects in Silk Road are being created in China. For instance, Digital Silk Roads project (2003) [8] enables digital archiving of various historical documents; the International Dunhuang Project: *The Silk Road Online*（1994）[9] designed by of The International Dunhuang Project (IDP), was a website of information and images of all manuscripts, paintings, textiles and artifacts from Dunhuang. Another case study of a digital exhibition of Dunhuang murals in Hong Kong，*Pure Land: Inside the Mogao Grottoes at Dunhuang* [10], was a collaborative project between Dunhuang Academy and Hong Kong University and cultural institutes in 2012.Those projects were either mainly on collecting information on collaborative libraries of Silk Road or Dunhuang under the context of Silk Road, or adopting 3D technology to re-present the Mogao Cave 220 [11].

With lack of digital dynamic visual platform for Maritime Silk Road in China, the research team has conducted the study on digital platform of Maritime Silk Road since 2014 till 2015. In this regard, we have worked on the dynamic historical and geographic information system of Maritime Silk Road (Fig.2-a), to explore and compare information already present. This research on the GIS of Maritime Silk Road provides a holistic view of the dataset through four characteristics, allowing users to browse information at various levels:

1) An overview shows overall routes chronologically from Qin dynasty to present (Qin, Han, Tang, Song, Yuan, Ming, and Qing) and major ports of dynasties till now in China (Fig.2-b). With the help of this overview, users can further study different timelines to see accompanied dynamic memorabilia, such as the story of *Xu Fu’s Voyage to Japan* [12] in 219 BC (Fig.2-c). It also summarizes the evolution of each dynasty.

2) Elaborated information and statistical features of each port along the Maritime Silk Road such as population, climate, architectures, customs, trade, history and local geographical location etc. (Fig.2-d).

3) Multi-layering historical map with a coordinated dynamic GIS, offers an in-depth analysis of geographical

978-1-4673-8993- 8/16/$31.00 ©2016 IEEE

information where users can see original appearances (Fig.2-e).

4) Intelligent data retrieval technology helps users to fast browse from present position to arbitrary hierarchical location for the purpose of exploring other ports (Fig.2-f).

These four characteristics are seamlessly coordinated with a rich set of interactions, supported by interactive animation, video, navigation and geographic information system, which can simulate the real evolution process of Maritime Silk Road. It can also reshape and restore the historical relics of Maritime Silk Road and provide with a multi-scope insight for the discovery analysis which might help Maritime Silk Road researchers to extract data with ease.

Dynamics GIS [13] embedded related geographical information and visualization technologies can provide the platform for understanding geographically integrated complex systems. Through the research of dynamic GIS digital platform, it integrates the map with a dynamic visual effect and geographic information with a powerful database, so as to realize the visualized, operable, and interactive geographic information system. Simultaneously, it takes fine-granularity information extraction using granularity retrieval technology to realize the integrity and comprehensiveness of the information visualization system. As a result, the research on the dynamic historical and geographic information system of Maritime Silk Road expands the limitations of the present study and enriches the visibility, flexibility and interest of the historical and geographic information system. It also plays a promoting role in the construction and development of the Maritime Silk Road. The key idea behind our approach is to exploit digital platform to restore the data of Maritime Silk Road and allow users to interactively retrieve and simulate the real evolution process of Maritime Silk Road on their own interests.

This dynamic GIS platform can become a large repository of multimedia cultural resources and can be compared to animation storage platform where various digitized materials can be stored and utilized by a wide variety of organizations like museums where research and educational activities related to the heritage of the Maritime Silk Road are a subject of study.

Fig.1. Maritime Silk Road
Source:http://www.conmatrix.com/2015/11/22/the-silk-road-economic-belt-and-the-21st-century-maritime-silk-road/

II. DATA COLLECTION

While studying dynamic GIS of Maritime Silk Road, first important component of the work was the historical data collection. Regarding the data and visual analytics, one approach focused on the dynamic GIS, having emphases on the spatial data and spatial interaction in time [14]. Another approach focused on the interaction and retrieval between the Granularity Retrieval System and users as well as their impacts to the system.

Guangdong museum, Shandong museum provided important information of artifacts, objects, memorabilia and ports of Maritime Silk Road have been crowd sourced over last 2 years. The routes and maps of chronologically studied dynasties were mainly from books: *Zheng He's Voyage Map* [15], *The Overall Survey of the Ocean Shores* [16], *The Atlas of Chinese Historical Map* [17], *Han Geography Selection* [18], *Selected Papers on Maritime Silk Road in 20th Century China* [19] and *Maritime Silk Road Studies in 20th Century China* [20].

Since Maritime Silk Road is a dynamic multi-dimensional system dedicated to multiple routes (Fig.3), multilateral trade and diverse communication, as well as a lot of data have been irretrievable with time. The historical data collection of Maritime Silk Road is huge and data classification is complicated. Obtaining accurate and useful information becomes a conundrum. Besides, the record of each ports of each dynasty including features like population, climate, memorabilia, artifacts, custom, architecture, and environment is inadequate, the data of the ports is incomplete, and information varies. That is why other digital interactive platforms cannot be used for comparison. Therefore, we collected samples and data from major ports like Nanjing, Quanzhou, Fuzhou, Ningbo, Guangzhou, Xuwen, Hepu in China; Sumatra, Java, Surabaya, Palembang in Indonesia; Champa, Khmer, Cochi in Vietnam; Siam (Thailand), Malacca (Malaysia), Dragon's Teeth Gate (Singapore), Ceylan, Cochin, Calicut, (India), Colombo (Sri Lanka), Bengal (Bangladesh), Hormuz (Iran), Mecca (Saudi Arabia), Alexandria (Egypt), Sicily (Italy), Somalia (Somalia) were collected, but were not complete. Besides, the original animations about the Memorabilia along Maritime Silk Road were based on the stories such as *Xu Fu's voyage to Japan, Zheng He's Voyage, and Monk Jian Zhen's East Journey.* [21]

Since the data collection was quite difficult, the collaboration with specialists from archaeology, history, anthropology and cultural studies was necessary for the project.

Fig. 2-a. The Interface of Maritime Silk Road Dynamic GIS system

Fig. 2-b. The chronological timeline from Qin dynasty to present

Fig. 2-c. The animation of Xu Fu's Voyage to Japan

Fig. 2-d. The Elaborated Information of Siam Port

Fig. 2-e. The multi-layer and evolution

Fig. 2-f. The Intelligent data retrieval technology

III. THE DYNAMIC GIS OF MARITIME SILK ROAD

The majority of GIS represents static and much lesser degree to deal with data. Although the discipline of geography has adopted to the notion of process almost 100 years ago, it failed almost completely to scrutinize the fundamental role of time. Incorporating time into the raster and vector data models is seen as the obvious solution to represent dynamics [13]. However, as argued by Peuquet (1994) [22], time and space exhibit important differences that do not comply with the neat addition of dimensions. As Kemp (1997) notes, "In order to fully integrate the two we need to add dynamics and continuity to our understanding of spatial data and spatial interaction and functionality to the environmental models" [23]. The project conducts design on the dynamic historical GIS based on the theory of spatial data and spatial interaction in time.

Based on the maps from *The Atlas of Chinese Historical Map* [17], we drew seven dynasty maps, four layer ports maps and eight route layers which were all newly elaborated maps in proportion from Qin dynasty to Qing dynasty (BC221-1912) to the Platform. The platform consists of seven dynasty maps which embedded with four layer ports maps and routes layers in each dynasty.

Hence, our project produced original animations which enabled geographical networks develop narratives in a multi-hierarchical dimension. It also carried on digital discussion from comprehensive level and possesses breakthrough innovation in dynamic historical GIS, historical evolutions, spatio-temporal dimensions, narratives, interactivity and visual design and chronology Chinese dynasties.

A. Space and Time

Digital interactive platform covers dynamic evolution process of past dynasties' major historical events in the previous dynasties. All contents of animation are the original cartoon image and story series, and they vary even more along with the change of dynasties to some degree; hence embodying the differences and progress of Maritime Silk Road on a temporal.

The system continues the complete historical process of Maritime Silk Road since Qin Dynasty up to now in the evolution of history reveals the information of each port along the timeline in each dynasty and reflects the integrity and evolution in the aspect of history and geography.

In the dynamic historical and cultural geographic information system, with the geographical latitude, longitude and coordinate information as a reference, it can timely provide multi-spatial historical information data with the analysis method of geographic information data model. At the same time, it adds animation and video in the GIS system, and displays information more clearly; thus making the original static GIS become dynamic.

Narratives enhance the understanding of causality by relating it to time and place and of the exceptional. The system offers users to explore the network and narratives though the Intelligent Search Engine-Granularity Retrieval, helping users to reshape and reconstruct the narratives via Maritime Silk Road network.

To close the gap between research and application, under the project, geographically integrated history methods have been developed with dynamic GIS to overcome these limits by addressing the importance of "Spatio-temporal" "Place"-to integrate data as the foundation of knowledge creation about how humans, events, and environments were connected to form historical narratives within and across places and spatio-temporal using Maritime Silk Road as a case study.

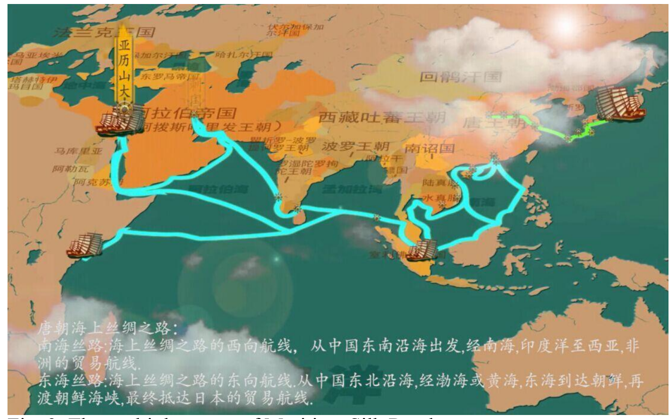

Fig. 3. The multiple routes of Maritime Silk Road

B. Interactivity and Visual Design

With the development of an integrated set of web-based digital map platform using GIS geographic information system, interactive visualization tools such as interactive graphs, animation, and video are also used to simulate the real evolution process of Maritime Silk Road, and to facilitate users of better experience and more useful narratives.

Interaction permits the user to first gain a global overview of all the maps and locations on the right bottom and then to zoom in to that location, search for and filter out relevant records, and retrieve required details. The structure and dynamics of data can be explored at multiple orders of magnitude. In particular, any part of the analysis workflow and any layers of the visualization design can be modified via user input.

C. Dynamic GIS of Maritime Silk Road

On the basis of GIS system, dynamic historical and geographic information system of Maritime Silk Road also combines historical maps and makes the GIS system refer back into time even though it has been originally designed to show modern geographic information. Users only need to click the port they want to visit, and then they can refer to the historical culture and geographic information of the port. Users can skip the four-layer map by scaling the size of layers as well, so as to obtain the detailed information of the route of Maritime Silk Road and the ports throughout the journey so that they can more deeply understand its history and culture.

The historical and cultural information of Maritime Silk Road integrated with the animation, video and other multimedia techniques were intuitively shown. It can provide arbitrary playback and can be viewed according to the user's interest, offering pluralistic interaction experience for users.

C.1 GIS Map Layering Technology

According to the Historians Jack Owens and Laura Woodworth-Ney indicated, "Geographic Information Systems and related Information Technologies (IT) provide an unrivaled means to explore, analyze, and visualize historical resources, the interactions among them, and their relationship to space and time... “[24].

There have been some researches devoted to the information system and technical solution regarding the history and geography of the Silk Road based on spatial information technology in China. By choosing Han Dynasty and Tang Dynasty as the temporal domain and the ancient Silk Road in the region of Xinjiang as the spatial domain, Luo Guilin [25] from Central South University has utilized ArcGIS software and remote sensing image of Xinjiang to design the MXD map. She has also designed and developed the information network for the history and geography of Xinjiang during the period of the Silk Road based on the spatial information technology. Moreover, the process of temporal and spatial evolution of the Silk Road during Han Dynasty and Tang Dynasty has been also simulated.

Some researchers, including Luo Guilin [25], Bi Jiantao and Wang Xingxing [26], have collected and analyzed data from Silk Road in China to apply spatial information technology in the Historical evolution of the Silk Road. The relevant information has been stored in MySQL. With the aid of GIS and RS techniques, they have designed an electronic map and provided the services about local map. Comparatively, our system is based on the spatial domain of Maritime Silk Road, a dynamic GIS system devoted to the Maritime Silk Road with many dynasties. In addition, it also has integrated multi-dimensional historical and cultural information including the planar map, video, animation and ports data.

Researchers Xiang Hongmei and Li Yue [27] have built a multimedia GIS which can provide the applications for geographic information, video, audio, map and animation.

Kunming Surveying and Mapping Research Institute develops Kunming Multi-media Geographic Information System for Traffic and Tourism which can function as an electronic map mainly and also integrate various advanced technologies such as visualization technology, multimedia technology, geographic information system, remote sensing system and 3D animation.

However, all of these GIS systems have not combined with the Maritime Silk Road. In this regard, our system is of some innovative value in terms of technical solution and functional feature.

C.2 Map layer Processing

Layers are one or more overlays atop base images, which can be a map or graph that augments images by adding information that relates to features within. Each layer represents some aspect of visualization that can be considered separately or in combination with other layers.

This system has adopted the GIS map layering technology. It consists of four layers (Fig.4). Each layer can present a portion of geographic or traffic information (Fig.5-a, Fig.5-b, Fig.5-c). The lower the layer is, the more detailed the information will be. The map layering technology can advance the map display, increase the efficiency of the map switch as well as reduce the burden on the system. Moreover, it can also make the map provide more detailed information without influencing the map of other layers. There are also some other maps adopting the layering design. For example, Baidu Map can only display the modern geographic information merely in the form of map. In contrast, this system leans towards the design of historical map. It has focused on the design of geographic information and cultural information in those ports along the Maritime Silk Road during different dynasties. What is more impressive is that the addition of animation and video has made the GIS system more vivid. It has set this GIS system apart from other geographic information systems in the market. Through the layering design, we can gain a better view of the architectural difference in many dynasties and the evolution in the route of the Maritime Silk Road.

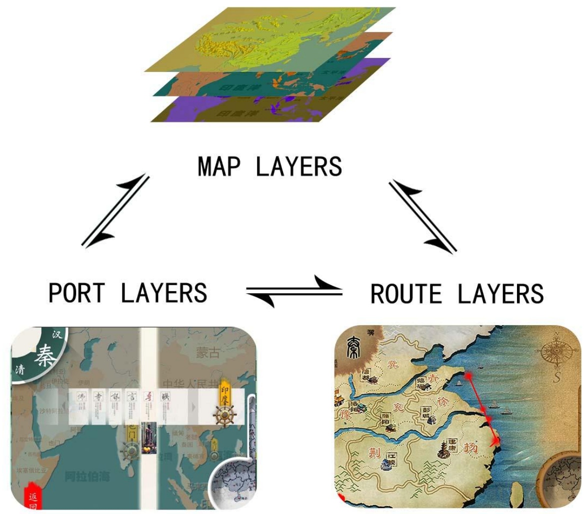

Fig. 4. Map layers

Fig. 5-a. Map layer 1 of Maritime Silk Road Dynamic GIS System

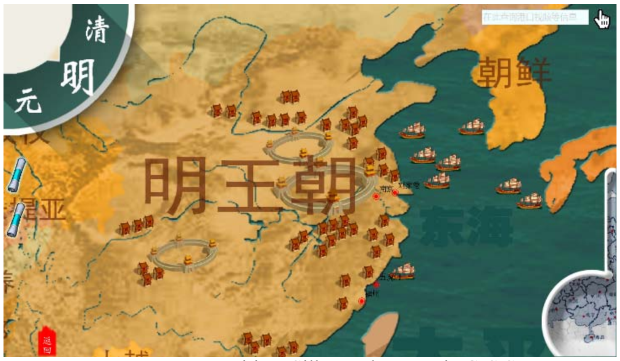

Fig. 5-b. Map layer 2 of Maritime Silk Road Dynamic GIS System

Fig. 5-c. Map layer 3 of Maritime Silk Road Dynamic GIS

The core code of Map layer processing is as follows.

```
private void loadFlashFromFile(string flashPath)
      {
         axShockwaveFlash2.Movie = flashPath;
         axShockwaveFlash2.Visible = true;
         axShockwaveFlash2.Location = new
System.Drawing.Point(0, 0);
         axShockwaveFlash2.Height = size.Height;
         axShockwaveFlash2.Width = size.Width;
      }
```

C.3 Search Engine-Granularity Retrieval in China

Combined with the intelligent information retrieval system, platform can accurately and effectively search for the needed information content when it is being used, thus meeting the users' demand for rapid access to historical and cultural information(Fig.6).

Dynamic geographic information system adopts the retrieval technology of Multi-granularity [28] information which can quickly distinguish subordinate-level categories and break away from hierarchical relationship, extract information, and point to the results. This retrieval method is significantly superior to the retrieval method based on the tree structure of hierarchical relationship, and can more accurately and efficiently find out the needed information content and significantly improve the accuracy of the results.

It takes advantage of granularity retrieval technology to provide users with intelligent retrieval system. When users are in the process of retrieval and query, they can click from one information point to another. They can also realize arbitrary turning in the longitudinal and horizontal historic axis and does not need to return a layer to enter another layer. Thus, the technology is of high maneuverability.

C.3.1 Baidu and other Search Engine

The traditional search engine is defined as a system which can offer the relevant documents according to the given query. However, such search engine cannot adapt to the diversity of the data in the modern world. Instead of providing a simple document, most of those search engines can assist users to find the data in any form. Baidu has enriched the definition of search engine by helping those people find what they need more easily. What they need is more than the document. Upon receiving the query of a small game, the system will offer a Flash page of the game rather than merely provide the descriptive words. We have also adopted to a search engine which can offer a wide variety of data such as animations and videos.

C.3.2 *The Utilization of Granular Computing in China*

In 1997, Zadeh in his paper [29] first mentioned the concept of fuzzy information granularity. Taken in its broader sense, the concept of information granularity occurs under various guises in a variety of fields. In particular, it bears a close relation to the concept of aggregation in economic, to decomposition and partition in the theory of automata and system theory, to bounded uncertainties in optimal control [30，31].

Granular computing [32] is an emerging research direction in the field of artificial intelligence. Granular computing is a comprehensive system which covers all theories, methods, techniques and tools related to granularity. Roughly speaking, granular computing can be seen as a superset of fuzzy information granularity. The rough set and interval arithmetic is the subset of granular mathematics. The essence of granular computing lies in the simple accessibility and low cost. Moreover, it is aimed at the bulk of inaccurate, incomplete and uncertain information to create the easy processing, robustness and low cost of intelligent system control in return.

The granularity can be used to describe the fuzzy and uncertain object. Granular computing is a concept and computing paradigm for information processing. It has included all the theories, techniques, methods and tools relevant to granularity. It is mainly devoted to the intelligent processing of massive fuzzy information which is uncertain and incomplete.

In terms of the Granularity Retrieval, Zhang Xia studied deeply with the application of fuzzy granularity calculation in text soft clustering in her book *Application of Granularity Computing in Data Mining* [33]. She applied the Granularity computing into data mining. In contrast, we applied it into retrieval of dynastic port nodes.

The use of granularity concept has laid the foundation for most search engines available. After absorbing the thoughts of granular computing, our platform can realize the search with greater relevancy by taking advantage of the relationship between text segmentation granularity and search engine. For the search engine, the text segmentation is one of the most basic but also most important problems of natural language. However, most of those search engines, such as Sina.com, are based on the directory search. According to a certain mode of classification (such as disciplinary classification), the directory search can build a subject tree-shaped viewing system. The information gained will be indexed and then put under the major and minor category of the viewing system. The information chain will take the tree-shaped structure, consisting of the main directory, subject directory, link and website. The search engine should return to the main directory layer by layer before skipping to another subject directory. It has greatly reduced the searching efficiency. Therefore, this system has adopted a new searching technique. The concept of layer, which is one of the basic elements of granular computing, has been used to replace the tree-shaped structure and thus improve the searching efficiency.

The granule which is of minimal size and cannot be divided is referred to as the elementary granule. The granule exists in a certain layer. Different types of granule should be researched in different layers accordingly. Those granules are related to each other. There is an overlapping relationship or intersectional relationship between those granules in the same layer. They are the main research object in the layer. Each granule in the layer has represented a certain granular view. All of those granular views are complementary to each other, thus describing the same problem in the layer to the full. Those layers at the upper level have contained those at the lower level. The upper layer will also provide background and constraint for the lower layer. Each layer is independent of each other in some degree. The connection and interaction between any two layers can be reflected in the transitivity and bridging principle of the partial ordering relation. Hence, the skip between any two layers will be realized.

C.3.3 *Application of Granularity Retrieval in the GDUT Platform*

From the perspective of historical timeline, this system has involved many dynasties. There is also a large quantity of the information regarding the port node in the horizontal route axis for each dynasty. In order to improve the efficiency of searching, we have proposed to combine the granularity retrieval technology with GIS system. Some basic problems should be taken into consideration when defining the granule and layer. The first is the definition of the granule as well as the relationship between layer and layering structure. The second is expressing their relationship accurately.

There are three layers according to granularity for our system. According to the ascending order of layering, they are listed as dynastic map, route and port node. The progressive relationship between the three layers has reflected the change of the information from being superficial to in-depth as well as from being rough to detail. Different layers will focus on different granular features, also neglecting the unnecessary and irrelevant details. The maps of different dynasties have remained at the top layer. The map of each dynasty can be viewed as a granularity. Each map has included some routes. Therefore, each granularity in the map has contained some small granules, namely the route. In other words, the route layer is the second layer.

Each route in the route layer includes the information of port node which comprises another layer. As the information of port node is the smallest unit in the system, it has remained at the bottom layer. The information of port node is the elementary granule. Although there are three layers, every two of them can skip to each other at will. During the process of retrieval and query, the user can skip from one port information node to another in the same dynasty. In the vertical historical axis, the skip can also be realized at will. In a word, it can spare the trouble of having to skip to the root node for the access to the class before changing the dynasty in the tree-shaped structure.

Fig. 6. Granularity Retrieval of Maritime Silk Road Dynamic GIS system

The core code of granularity retrieval is as follows.

```
private void reloadMap()
    {
        DeleteAllLayers();
        reinit();
        dynastyMapPath=
SqlHelper.getDynasty(DnsMapData.DNS_NUM[dynastyId]).dnsPath;//新地图
        loadMapFromFile(currentDirectory + @dynastyMapPath);
        resetting();
    }
private void resetting()
    {
        //捕获功能
        map = axMapControl1.Map;
        activeView = map as IActiveView;
        layer = GetLayerByName(snapLayer, axMapControl1);
        if (layer != null)
        {
            featureLayer = layer as IFeatureLayer;
```

```
            featureClass = featureLayer.FeatureClass;
            fieldPosition = featureClass.FindField("Id");
        }
            activeView.ShowScrollBars = false;
//隐藏滚动条
        movEnvelope = axMapControl1.Extent;

            //清空列表数据
        if (airLineList != null)
        {
            airLineList.Clear();
            airLineList = null;
        }
        if(allusionList!=null)
        {
            allusionList.Clear();
            allusionList = null;
        }
        isFirst = true;
       pictureBox1.Visible = false;
        pictureBox2.Visible = false;
        pictureBox3.Visible = false;
        pictureBox4.Visible = false;
        pictureBox5.Visible = false;
        pictureBox9.Visible = false;
        pictureBox10.Visible = false;
        pictureBox11.Visible = false;
        pictureBox12.Visible = false;
        pictureBox13.Visible = false;
        pictureBox15.Visible = false;
        pictureBox17.Visible = false;
        pictureBox18.Visible = false;
         button1.Visible = false;
    }
```

IV. CHALLENGES

When developing the GIS system, we encountered two technical problems which were quite demanding. Firstly, it is difficult to lay out the map. Starting from Qin Dynasty, the Maritime Silk Road has involved a long history. However, there is limited record about it in the history. With the lack of detailed records such as the geographic information of the port, it has added to the difficulty in obtaining the necessary information. Hence, we could only collect some archives by searching in Baidu and Google as well as reading various literatures in the libraries or museums. Secondly, the map click is not compatible with the mobile function. C# is used as the programming language for this system. The class library in C# cannot support the map click and mobile function. Therefore, we had to overload it so as to solve the problem.

Data collection and classification were complicated. In terms of technology, the digital interactive platform of Maritime Silk Road is divided into online and standalone versions. Due to the large amount of information data, the three-dimensional maps, video animation and so forth must be reset by the two versions, increasing the difficulty of the research. Therefore, it puts forward to use granularity retrieval and other information technology to solve the technical difficulties.

V. CONCLUSION

The data and content of the system, including the trade route, influencing sphere, the place of origin and sale, the exchange between envoy and immigrant, religious communication, modern coverage, economic data and export trade, cannot be well expressed due to limitation of the word and static pictures. With the aid of digital animation, 3D geographic information collection, multi-media interaction and network technologies, this project can digitalize the relevant archives, pictures, texts, video and data perpetually. The platform has also utilized the virtual and dynamic techniques to present them to the public.

The digital interaction platform has combined with the network technology and historical research. By taking advantage of the connection between the port, time and space, this project has simulated the evolution of maritime interconnection. The data of time and space has also been restructured to inherit the historical and cultural heritage according to the concept of integrating time and space as well as realizing the horizontal and vertical combination. Moreover, this project has also discussed the feasibility and standard application of digital interaction to the Maritime Silk Road.

By taking an innovative approach to the granularity retrieval featured at being dynamic, visual, interactive and intelligent, it has effectively expanded the room for artistic expression devoted to the Maritime Silk Road. Instead of being confined to the word-based and picture-based research into the history, economy, culture and religion, it has made the new innovative breakthrough in the fields of computer data visualization, interaction design and art, thus improving the research system for the Maritime Silk Road.

ACKNOWLEDGEMENTS

This research has been funded by the PRC Ministry of Education Humanities and Social Sciences Research on “Interactive Narrative Network of Maritime Silk Road by Digital Platform” project (Grant NO.:16YJC760037, PI:Liu Danyun (GDUT, School of Art and Design).

The project has applied for both Utility patent (The Methodology of Dynamic Maritime Silk Road Historical GIS by Interactive hand space, Patent No: 201510136265.9) and Design patent (Dynamic Maritime Silk Road Historical GIS by Interactive Hand Space, Patent No: 201520175277.8) in China since 2015.

REFERENCES

[1] Lu, Yun(陆芸). Research Review on China's Maritime Silk Road in Recent 30 Years（近 30 年来中国海上丝绸之路研究综述）.The Silk Road, China, 2013(2).

[2] https://www.csis.org/analysis/building-china%E2%80%99s-%E2%80%9Cone-belt-one-road%E2%80%9D

[3] Song, Ping(宋平). On the Exhibition of Cultural Relics and Historical Sites of the Maritime Silk Road of Guangzhou（广州海上丝绸之路文物与文化史迹展示的现状与思考）, Urban Insight, China, 2014(4)

[4] Source:http://m.dayoo.com/136734/http://m.dayoo.com/136734/

[5] Keim, D. A., et al. (2008). Visual Analytics: Definition, Process, & Challenges. Information Visualization: Human-Centered Issues and Perspectives, pp. 154-175. Berlin, Heidelberg: Springer-Verlag.

[6] Pike, W. A., et al. (2009), the science of interaction. Information Visualization, 8(4), pp. 263–274.

[7] Kenderdine, S. (2010), 'Immersive visualization architectures and situated embodiments of culture and heritage' Proceedings of IV10 - 14th International Conference on Information Visualisation, London, July 2010, IEEE, pp. 408-414

[8] Source: http://dsr.nii.ac.jp/about.html.en

[9] Source: http://idp.bl.uk/idp.a4d

[10] Chan Fung Lin, Digital Dunhuang: The Use of New Technology for Off-site Interpretation of a Fragile Heritage Site, A dissertation submitted in partial fulfilment of the requirements for the Degree of Master of Science in Conservation at the University of Hong Kong, Aug 2012.

[11] Source: http://public.dha.ac.cn/content.aspx?id=695320789493

[12] Source:http://202.194.48.102/englishonline/culture/ChinaCulture/China Culture/en_madeinchina/2005-06/22/content_69910.htm

[13] Albrecht, Jochen. Dynamic GIS, CUNY Academic Works, 2007.Source: http://academicworks.cuny.edu/hc_pubs/18

[14] Kemp, K 1997. Fields as a framework for integrating GIS and environmental process models. Part 1: Representing spatial continuity. Transactions in GIS 1(3): 232.

[15] Xiang Da(向达), Zhenghe's voyage map（郑和航海图）, Zhonghua Book Company, 1961.Source:http://afe.easia.columbia.edu/special/china_1000ce_mingvoyages.htm

[16] Ma Huan(马欢), Wanming, the Overall Survey of the Ocean Shores（瀛涯胜览）China Ocean Press, 2005

[17] Tan Qixiang（谭其骧）, the Atlas of Chinese Historical Map（简明中国历史地图集）, China Cartographic Publishing House，1991.

[18] Tan Qixiang（谭其骧）, Han Geography Selection（汉书地理志选择）, Selected Readings of Ancient Chinese Geographical Famous Works, Science Press, 1959.

[19] Gong, Yingyan(龚缨晏). Selected Papers on Maritime Silk Road in 20th Century China (20 世纪中国"海上丝绸之路"研究集萃), Zhejiang University Press, 2011.

[20] Gong,Yingyan(龚缨晏).Maritime Silk Road studies in 20th Century China (中国"海上丝绸之路"研究百年回顾), Zhejiang University Press, 2011.

[21] Source:https://en.wikipedia.org/wiki/Jianzhen

[22] Peuquet, D 1994. It's about time: a conceptual framework for the representation of temporal dynamics in geographical information systems. Annals of the Association of American Geographers, 84(3): 441-461.

[23] Kemp, K 1997. Fields as a framework for integrating GIS and environmental process models. Part 1: Representing spatial continuity. Transactions in GIS 1(3): 232.

[24] John E. Ashbrook, Using Geographic Information Systems (GIS) as an analytical tool in the analysis of politics in Eastern Europe: Istria in the 1990s, Journal of the American Association for History and Computing, vol. 9, no. 2, Oct. 2006

[25] Luo guilin, Research on Silk Road Historical Geographic Information System Based on Spatial Information Technology, Central South University ,2013

[26] Bi Jiantao,Wang Xingxing,Application and research progress of spatial information technology in the history changes of the Silk Road, Arid Land Geography,vol 30(6), Nov.2007

[27] Xiang Hongmei, Li Yue, The development and research of the city multimedia geographic information inquiry system, Geomatics & Spatial Information Technology, 2004(3)

[28] Dequan Wang, et al. Multiple Granularity Descriptors for Fine-grained Categorization, 2015 IEEE International Conference on Computer Vision (ICCV), 2015

[29] Zadeh.L A, Fuzzy sets and information granularity, Advances in Fuzzy Set Theory and Applications, M. Gupta, R. Ragade and R. Yager (eds.), 3-18. Amsterdam: North-Holland Publishing Co., 1979. 3-18

[30] S. Gutman, Uncertain dynamical systems--A Lyapunov min-max approach, IEEE Transactions on Automatic Control, Volume: 24, Issue: 3, Jun 1979

[31] F. Schlaepfer, Continuous-time state estimation under disturbances bounded by convex sets, IEEE Transactions on Automatic Control, Volume: 17, Issue: 2, Apr 1972

[32] Regina, Saskatchewan, Granular Computing, Computer Science, Vol. 31, pp. 1-5, 2004

[33] Zhang Xia（张霞）, Application of Granularity Computing in Data Mining（粒度计算在数据挖掘中的应用研究）, China Fortune Publishing House,2011

[34] Goodchild, M.F. Combining space and time: New potential for temporal GIS. In Knowles, A. K. (Ed.). Placing history: How maps, spatial data, and GIS are changing historical scholarship. Redlands, CA: ESRI Press, pp. 179-197." (2008).

[35] Skupin A, Fabrikant S. (2003). Spatialization methods: a cartographic research agenda for nongeographic information visualization. Cartography and Geographic Information Science, 30(2):99–119.