Using GIS and Open Web Resources to Reconstruct Great Tang Records of the Western Regions

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Abstract

This paper applies Geographic Information Systems (GIS) methods and Open Web resources to reconstruct Tang Dynasty Buddhist Pilgrim XuanZang's travel routes and 180+ city states, stupas and monasteries he had recorded in the *Great Tang Records on Western Regions (大唐西域記)*. Prior mapping efforts of XuanZang travel routes were selected for digitization, using reference points of the 80+ known locations XuanZang had mentioned in his biography, *A Biography of the Tripitaka Master of the Great Ci'en Monastery of the Great Tang Dynasty(大唐大慈恩寺三藏法師傳)*. The authors then applied a cost-distance analysis method to validate the digitized routes by calculating high to low cost grids using four layers of rasters, including land cover, slope, distance to cities, and distance to water bodies (primarily rivers). This spatial method allows us to map the XuanZang travel routes more precisely. In addition to retracing XuanZang travel routes, the authors compiled coordinates of the 180+ locations recorded in the Travelogue. We retrieved locations in Wikipedia place entries with reference of XuanZang, and through the use of open sources, such as "Mapping Buddhist Monasteries" project to consolidate places recorded by XuanZang or referenced to XuanZang. The historical place names in Central and West Asia, mentioned in XuanZang's recordings, have multiple Wikipedia entries in many languages. Extractions and compilation of these names can help to expand efforts of geographic thesauri of historical place names.

Keywords: Buddhist Pilgrimage, Spatial History, XuanZang, Tang Dynasty, Silk Route, Historical Place Names, Central and West Asia.

1 Introduction

Chinese Buddhist pilgrims from 400 to 700 A.D. played a key role in spreading Buddhism doctrines from India to China, triggering cross-cultural exchanges across Euro-Asia continents. Among hundreds of Chinese monks who traveled on foot to India the long, hazardous routes, Faxian, XuanZang, and Yijing were most influential and left detailed accounts of their journeys. (Sen, 2006). XuanZang's Great Tang Records on Western Regions (thereafter, the Travelogue) is considered as one of the primary sources of materials for research on Medieval West, Central Asia and India (J. Yu, 2016). The Travelogue contains 12 chapters with more than 120,000 Chinese characters describing the geography, climate, vegetation, products, people, language, mythology, religious practice, and customs in 110+ countries, regions and city-states from Xinjiang to Persia, Tajikistan, Uzbekistan, Pakistan, India, Bangladesh and Sri Lanka, among other regions.

A variety of cartographic efforts were undertaken to map XuanZang's routes and sites that he recorded in the Travelogue and his biography *A Biography of the Tripitaka Master of the Great Ci'en Monastery of the Great Tang Dynasty (thereafter, the Biography)*. Most of the efforts resulted in maps accompanying a monograph about XuanZang and his travel. Prominent examples include the 13 maps created by Philip Schwartzberg which are included in the book titled "The Silk Road Journey with XuanZang," by Sally Hovery Wriggins (Wriggins, 2003). Much of these efforts are done by experts or historians through manual identification based upon their research and interpretation of XuanZang's travel.

With the rise of open source publishing, public accessible digital archives and crowd-sourcing, more and more of the historical materials and archives can be retrieved, analyzed, extracted, and visualized online. Digital humanities have become part of historical research methods. Recent methods include text mining, geo-visualization and mapping using Geographic Information Systems (GIS) techniques. They can shed light on historical research, and most importantly, build research upon the collective efforts published on the Web (Gregory et al., 2015).

Least-cost analysis has been widely used in mapping historical places (Herzog, 2014). In this paper, we will utilize a linear weighted map algebra method to determine a more precise route that XuanZang travelled from China to India. The details of this method will be discussed below.

2 Mapping of the places recorded by XuanZang

This section will detail the mapping of the points manually compiled by authors from the Travelogue, and compare them with points harvested from Wiki entries as well as the open source project of Buddhist monasteries with XuanZang references.

2.1 XuanZang locations from the Travelogue

Samuel Beal translated XuanZang's DaTangXiYuJi, the Travelogue, and provided very thorough footnotes relating to locations of the places XuanZang described in the Travelogue. Based upon XuanZang's original work and Samuel's translation, footnotes, as well as Wikipedia entries, the authors

compiled a spreadsheet composed of 182 place names, including city states, well known geographic features, significant stupas, and monasteries. XuanZang used the Chinese distance measure of "li," which is equivalent of 500 meters, as well as rough directions (e.g. cardinal directions east, north, south, west, etc.) to describe the locations in relationship to each other. For instance, the description of Kesh was "going south-west 300 li from Sarmarkand." Based on these descriptions, Samuel Beal and others provided footnotes of the potential places in Romanized names. For instance, Beal noted on Rui-samangan: "In the upper valley of the Khulm river including the towns of Rui, Kuram, and Haibak, formerly called Samangan, and about 42 miles west of Baghlan." Using these detailed notes explorers such as Aurel Stein were able to discover and unearth many of the cultural historical sites in Central and West Asia, and India. XuanZang's Travelogue detailed the physical description of a location, populations, customs, products, vegetation, climate, religious practice, and sometimes, languages, monetary systems, as well as abundance of Buddhist mythologies and historical legends at the described sites. Using XuanZang's records and Beal's translation, the authors created a database of locations which contains the following attributes (fields):

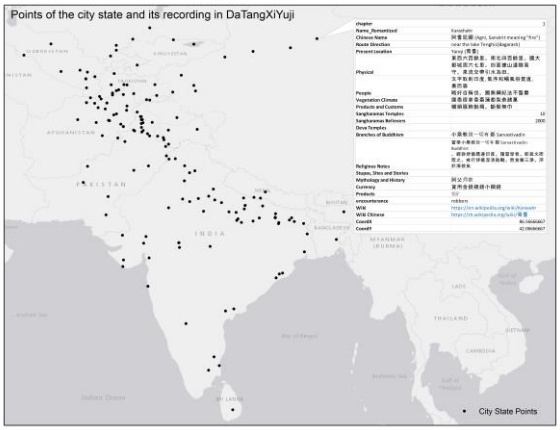
Table 1: Attributes of the Travelogue database.

Attribute	Properties
Place Name	Romanized (Samuel Beal, and notes)
Place Name 2	In Chinese characters
Present location	Today's place name; or related area
X East	Decimal Degrees
Y North	Decimal Degrees
Physical	Size of the area, topography, geography
People	Characteristics of the local people
Vegetation and Climate	Plants, weather conditions
# of temples	Number of Sangharama; Buddhist Temples
# of believers	Number of Buddhists dwellers in the temples
Religious notes	Branches of Buddhism; and other religious practices
Significant sites	Temples; Stupa; holy sites
Mythology	Stories about the kings; dragons; Buddha, and bodhisattvas; etc
Products	Local, agricultural products;
Currency; Custom	Money currency; cultural habits

Each entry of the database contains geographic coordinates with latitude and longitude, as well as descriptive data, e.g. the number of estimated Buddhist monks in a given city state, can then later on be visualized. Presenting the geo-coded content of the DaTangXiYuJi (the Travelogue) records presented in a web mapping format allows the user to pin point the city state XuanZang on a map and retrieve his original text as well as attributes reported in Table 1.

ESRI's ArcGIS mapping software and its on-line platform (ArcGIS Online) were used to visualize and publish the outcome of the manual compilation of the 182 places mentioned in the Travelogue. A point layer of the 182 records was extracted from the Records (see Figure 1). A preliminary on-line version of these locations was also made available. (http://maps.fiu.edu/xuanzang)

Figure 1: Points of the city states and its recording in DaTangXiYuji (the Travelogue).



2.2 Wikipedia entries extraction and filtering

Thousands of Wikipedia entries referenced XuanZang and his travel visits and many of them cite the Travelogue to describe the history of the place. As Wikipedia knowledge is a collective built from contributions of scholars and historians. We assume that if XuanZang is mentioned in a given Wikipedia entry and that entry has geographic coordinates, it is a place that XuanZang had either visited or recorded in his Travelogue or his Biography.

We used open source Wiki Parse, to first parse all Wikipedia entries with XuanZang and its multi-lingual variations of XuanZang (see Table 2) from the Wikipedia API where {language} represents one of the many languages (e.g. English, Chinese, etc.) supported by Wikipedia. Since the structured Wiki entry data is available in JSON format, we converted the JSON format data into a spreadsheet. Additionally, we used Google Apps Scripts and Google Spreadsheets that can access external resources on the web by fetching URL. In the custom Google sheets functions, there are eleven functions that are wrappers around the particular Wikipedia API calls. The functions tested and used are WikiExpand, WikiSearch, WikiGeocoordinates. The results from Google sheets functions were exported to a csv.

From Wikipedia, we were able to parse 784 geo-tagged entries in 21 different languages, with reference to XuanZang. These entries were contributed by hundreds of authors about the places and their histories. We performed a query to retrieve all Wikipedia entries with reference to XuanZang and various spelling of the same name, or alternative names, and stored returned coordinates where available. The coordinates of these geo-tagged places will be mapped and compared to what the authors have manually researched and mapped based upon the Travelogue by XuanZang in a future paper following this.

The initial query returned over 5200 search results, out of which 784 had coordinates. After filtering entries that contain

Table 2: Number of languages of XuanZang references with more than one article (Wikipedia).

Language	Name	Records	Language	Name	Records	Language	Name	Records
Bielo Russian	Сюаньцзан	4	Hungarian	Hszüan-cang	17	Swedsh	Xuan Zang	10
Nepal	ह्वेन सांग	6	Italian	Xuánzàng	113	Tamil	சுவான்சாங்	69
Catalan	Xuan Zang	147	Japanese	玄奘三蔵	625	Thai	พระถังซัมจั๋ง	65
Czech	Süan-cang	33	Korean	현장	570	Turkish	Xuan Zang	41
German	Xuanzang	130	Norwegian	Xuanzang	51	Uzbec	Syuan Szan	15
Spanish	Xuanzang	79	Punjabi	ਹਿਊਨ ਸਾਂਗ	6	Vietnamise	Huyền Trang	5
Persian	شوانزانگ	4	Polish	Xuanzang	178	Chinese	玄奘	1200
Finnish	Xuanzang	23	Portuguese	Xuanzang	52	English	Xuanzang	1245
French	Xuanzang	227	Russian	Сюаньцзан	187	Gujarati	હ્યુ-એન-ત્સાંગ	2
Hindi	ह्वेन त्सांग	98	Albanian	Xuanzang	23	Telugu	యుఆన్ చ్వాంగ్	2

Table 3: Sample Wikipedia entries in different languages for the city name of Samarkand (Source: Wikipedia).

Language	Name	Language	Name	Language	Name
English	Samarkand	Hindi	समरक़न्द	Chinese	撒馬爾罕
Africaans	Samarkand	Armenian	Սամարղանդ	Vietnamese	Samarkand
Amharic	ሳማርቃንድ	Japonese	サマルカンド	Kurdish	Semerkand
Egyptian	سمرقند	Georgian	სამარყანდი	Kyrgyz	Самаркан
Bangla	সমরকন্দ	Korean	사마르칸트	Latin	Maracanda
Czech	Samarkand	Kurdish	Semerkand	Russian	Самарканд
German	Samarqand	Malayalam	സമർഖണ്ഡ്	Punjabi	ਸਮਰਕੰਦ
French	Samarcande	Malay	Samarkand	Portuguese	Samarcanda
Hebrew	סמרקנד	Chinese	撒马尔罕	Tamil	சமர்கந்து
Chinese	撒馬爾罕	Yiddish	סאמארקאנד	Turkish	Semerkant

the citation of XuanZang, we are left with 469 records of Wikipedia places where XuanZang might have visited or of locations where XuanZang had influence on. The entries with XuanZang references, comprise a total of 62 different languages entries. Many cities, for instance, Samarkand, were described in multiple languages. These entries in different languages are not of the same content, in another word not translated from one to another, and often times contributed by different authors from different linguistic background. Often times, they are individual contributions by authors from all different cultures. Samarkand is described in Wikipedia, e.g., in Chinese, Korean, Russian, German, Spanish, French, Italian, Vietnamese, and Yiddish. (See also Table 3) Not all entries about Samarkand in these different languages reference XuanZang. In our query, we only selected entries in those languages in which XuanZang was referenced. In the case of Samarkand, for instance, the English Wikipedia entry didn't mention XuanZang, while the Wikipedia entry in Chinese did.

Furthermore, relating to places names in Central and West Asia, the Chinese classics often has records about these ancient places dating as early as the Han dynasty (200 BC), detailing the name changes in different periods. For instance Samarkand had these Chinese names recorded in "Book of Wei"(《魏书》) named as "Xi wan jing" (悉万斤), in "Book of Sui – Records of the West Region" (《隋书·西域记》), named as "Country of Kang" (康国), … in "Book of New Tang Dynasty" (《新唐书》) named as "Country of Kang or Sha-Mo_Jiang" (康国、萨秣建), in "Records of West Journey" by Yelü Chucai (元耶律楚材《西游录》) named as "Xun-Si-Gang" (寻思干) in "History of Ming"(《明史》), named as Samarkand(「撒馬兒罕).

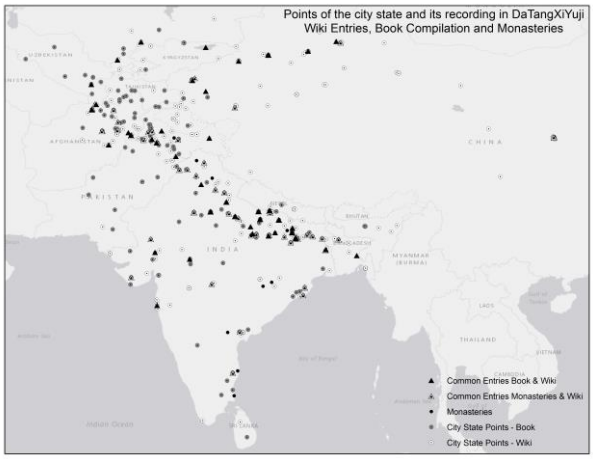
By Parsing these geographic names within the Wikipedia records in multiple languages, we can gain a more complete trail of names of these ancient places.

Comparing the different sources to collect these city states points, i.e. wiki entries and the compilation from the Travelogue, it was possible to see that the records complement each other. From the total of 182 points, compiled by the authors from the Travelogue book, which includes mostly city states and significant landmarks (for instance, the Iron Gate in the Pamir mountains), 45 were also found Wikipedia entries. (Figure 2).

Further research can be then conducted to determine the reasons for the additional Wiki records that do not overlap with the author's compilation and research based upon the Travelogue. Possible reasons include: 1) The author's compilation is incomplete or interpretations of the locations are different from Wikipedia authors; 2) the extracted Wikipedia entries contain places which XuanZang has not visited or recorded in his Biography or his Travelogue.

Similarly, when we add the mapping efforts of yet another significant crowd-sourcing project, e.g. Mapping Buddhist Monasteries 200-1200 CE Project (Gordon at all, 2009), we may gather a fuller picture of Buddhist temples or monasteries described in XuanZang's Travelogue and Biography. From the total of 84 monasteries extracted from the Monasteries Project database, that have any description related to the key word "XuanZang" or "monk XuanZang", there were 72 records in common with wiki entries (See Figure 2).

Figure 2: Comparison of the records compiled from the Travelogue, the points extracted from Monastery Project and Wikipedia entries.



Source: Authors' compilation from the Travelogue; Wikipedia; Mapping of Buddhist Monasteries Project, http://monastic-asia.wikidot.com).

Comparing the data from the Book compilation, Monasteries Project and Wiki entries, it was possible to see that all of them bring additional information of rebuild the history of XuanZang's travel. There are 195 records in Wikipedia that are unique (compared with the book compilation and the monastery project) (Figure 2). By this approach we expand the knowledge base about visited locations, therefore, give historians more materials to work with.

3 Mapping the routes

Earlier efforts of XuanZang travels routes, in general lack precision and are largely based on rough estimates of experts and historians. We attempt to use GIS methods to find a more likely route that XuanZang could have traveled by taking in consideration following:

- Cities that XuanZang recorded in the Biography; The reasons we chose cities from his Biography rather than the Travelogue, is that there are many cities mentioned in the Travelogue were well-known cities and states which he may not have visited, but gained knowledge about them from the locals; whereas his Biography detailed the journey and experiences of the places that he did visit.
- Slope derived from a global Digital Elevation Model based upon "Shuttle Radar Topography Mission (SRTM) datasets , we assume that the traveler would avoid steep slopes;
- Global Land cover classification generated by the university of Maryland, Department of Geography, we assume that the traveler would avoid harsher land cover types (e.g. deserts, glacier, steep slopes, etc.) and try to follow grassland, oasis, bushes, cities, etc.;
- Global Rivers or water body (ESRI world datasets), we assume that the traveler try to stay closer to water sources as much as possible.

Each one of these layers of information was converted into a Raster layer, where each cell contains a value that represents the cost of travel. For instance, in the river raster file, cells closer to the water body would be given a lower cost than cells further away. The same logic applies to gentler slopes, proximity to cities, distance to oasis or bushes, etc. The cost analysis conceptual diagram is shown in figure 3.

Using Map algebra the 4 values (Slope, Distance to Rivers, Distance to Cities, Landcover) are summed up for each cell location (Figure 3). This results in a final raster representing a cost surface (Figure 4). Dark blue cells have the least travel cost, and therefore represent areas that are more suitable for travel, whereas orange and red areas are less desirable for travel.

When we add the from and to cities points mentioned in XuanZang's biography, and use them to trace the cells which are with lowest travel cost, which is also the more likely cells, we were able to come up a more precise travelled route by XuanZang (Figure 4).

Figure 3: Cost distance workflow

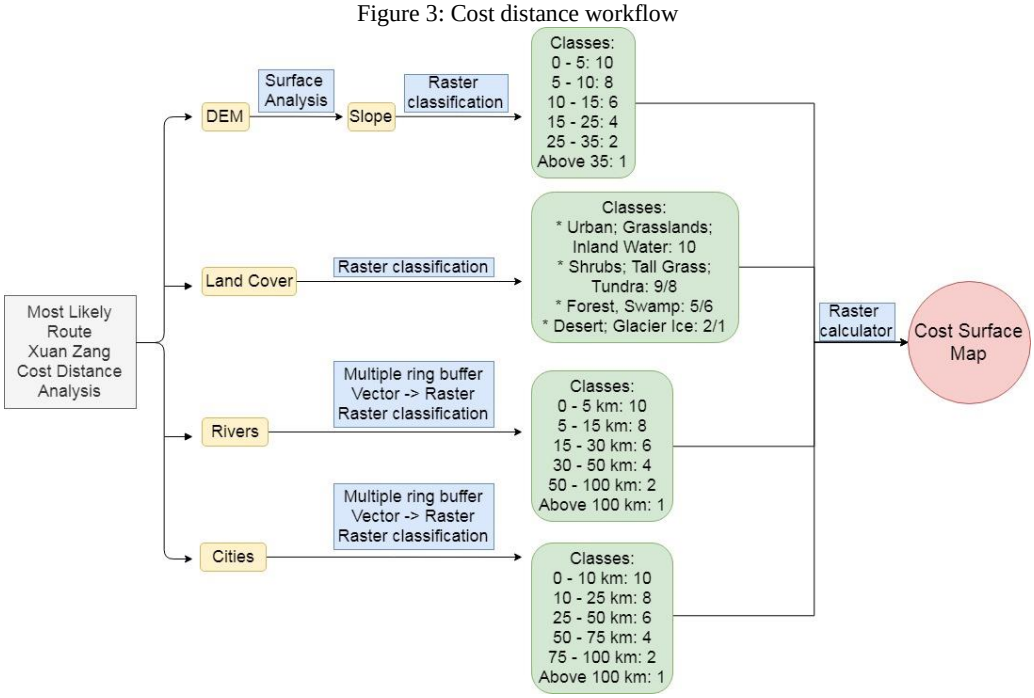
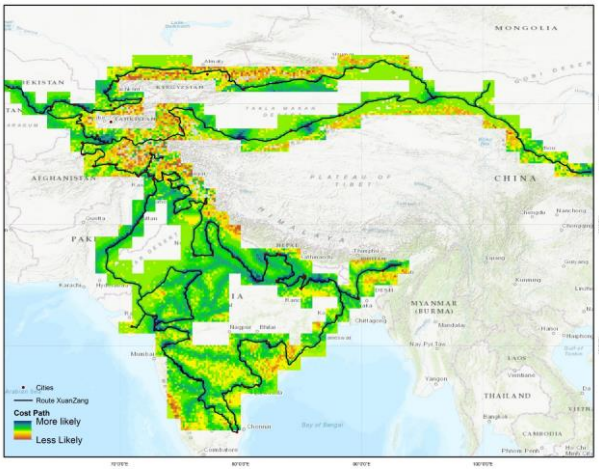


Figure 4: The cost path of most likely travelled routes by XuanZang.



4 Conclusions

Current spatial and digital methods can provide means to conduct research which was not available to prior historians. This paper applied geo-spatial methods in combination with data extraction from open crowd-sourcing platforms such as Wikipedia, as well as Buddhist Monasteries Project, in developing a more comprehensive mapping in both the city states and the routes traveled by XuanZang, Future directions of this research will include method of extracting historical places names from open crowd sourcing sites such as Wiki or Baidu to extend the historical place name thesauri such as the Getty's Thesaurus of Geographic Names.

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