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Study on road rehabilitation of the map on the Xuanfu zone of the great wall defense system in the ming dynasty

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ABSTRACT

On the basis of books and maps about the military fortresses of the Great Wall in the Ming Dynasty, GIS-based cost-surface and the best path are calculated and the road map of the military settlement of Xuanfu town is drawn to restore the space layout, traffic network and communication station of military settlement. Restoring ancient roads with GIS is proved to be feasible. This paper analyzes the defense mechanisms of the Xuanfu town according to the road map.

Key words: GIS; books and maps about the Great Wall frontier in the Ming Dynasty; road rehabilitation; cost-surface; Xuanfu town

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INTRODUCTION

The northern frontier of the Ming Dynasty was war-torn. Ming people complied vast amount of boarder defense drawings to act against invasion. On the Nine Frontiers with Map (Jiubian tushuo) [1] and Three Towns of Xuanda and Shanxi with Map [2] (also known as Three Towns with Map) are two of the prominent works, enlightening the study of the defense system of the Great Wall. However, these maps are involved with traditional figurative drawings [3], the way of which is hardly in line with drawing standards [4]. Due to topological deformation, these maps have brought difficulties to the quantitative study of traditional settlements.

Based on ancient border defense maps, surface costing of GIS and best route calculation, this paper completes the drawing of a road map of the Great Wall settlement in the Ming Dynasty to restore the space layout and traffic network. It provides an accurate map and a database for the dynamic and quantitative research on the military defense system of the Great Wall. The defense area of Xuanfu Town is located in the north of today's Hebei Province. In the Ming Dynasty, this area sat east to the central Jiubian of the Great Wall with Ji town to its east, Datong town to its west, Chang town to its south. Historical records noted that wars were frequently in this area. Proud of the fortress and the defense system, the defense area of Xuanfu Town has always been a strategic hub.

On the Nine Frontiers with Map (Jiubian tushuo) and Three Towns of Xuanda and Shanxi with Map are sources of map drawing. Both adopted figurative way of drawing. On the Nine Frontiers with Map was compiled by the Ministry of War of the Ming Dynasty. It detailed the layout of military defense. Pictures were accompanied by some captions. There were both panorama view and detailed view of fortresses. But the latter does not follow the same proportion. Four directions were lacking. Three Towns of Xuanda and Shanxi with Map introduced the surroundings of Xuanfu town, Datong town and Shanxi town. Maps of fortresses were shown in details. Though there were no roads, four directions were clear.

1. DATA AND METHOD FOR CALCULATION

2.1 SOURCE OF DATA

DEM (Digital Elevation Model) is used in this paper, an ASTER GDEM data product developed by Global Academy of Sciences Computer Network Information Center. The horizontal accuracy is 30m and the vertical accuracy is 20m. The scale is 1:400. Rivers (grade one to five), administrative division (from provincial to county), urban settlements and other data are derived from China National Geographical Center.

2.2 CALCULATION PRINCIPLE AND PROCESS

Access cost has always been a concern of people in choosing roads, which consists of physical access costs and time costs. Access cost is mainly decided by natural geographical conditions such as rivers, mountains, undulating slope and surface roughness as these conditions lay impact on people's physical strength and time to pass through.

Based on surface cost modeling [5] and the minimum cost path analysis, combined with the actual situation of Datong town (compared with daily commute, troop movements between military defense settlements take time as the primary cost. As troop movements have low requirements on roughness, the impact of roughness on the surface costs is overlooked), there summarize relevant costs: as the Great Wall is the defensive boundary and almost impassable, it has the maximum cost (cost_Wall,); rivers have relatively high costs (cost_river) and costs vary from each other in terms of different grades of rivers; slope and waviness have an interacted impact on costs and are noted as cost_slope and cost_ QFD respectively.

The total cost is expressed as the following:
COST=cost_river+cost_Wall+(cost_slope×0.6+cost_QFD×0.4)

Draw the road recovery map (Fig.1). As the frontier defense map is the kind of recognition map [6] that has low accuracy and there is no automatic adjustment to real situation, it is necessary to revise the calculation result according to environment recognition theory.

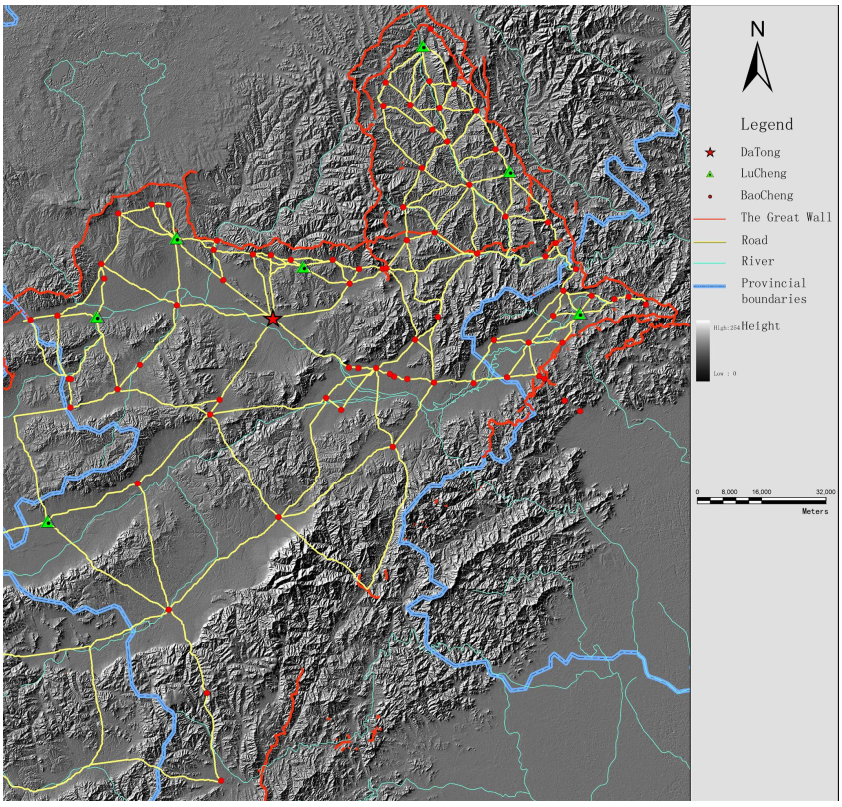

Fig.1 The road recovery map of the military settlement of Datong town

2. DATA ANALYSIS

Definitions:
Recorded value: distance from between fortresses in historical records
Calculated value: GIS-based calculation to obtain the surface distance between fortresses
True value: real distance between fortresses
Theoretical value: planned distance between fortresses

The horizontal axis in Fig.2 is an integer unit. Arranged in ascending order, it means the number of road between two fortresses and it is meaningless. The longitudinal axis refers to the calculated length of road. Any point in the horizontal axis corresponds to two points, red and black, referring to calculated value and recorded value respectively.

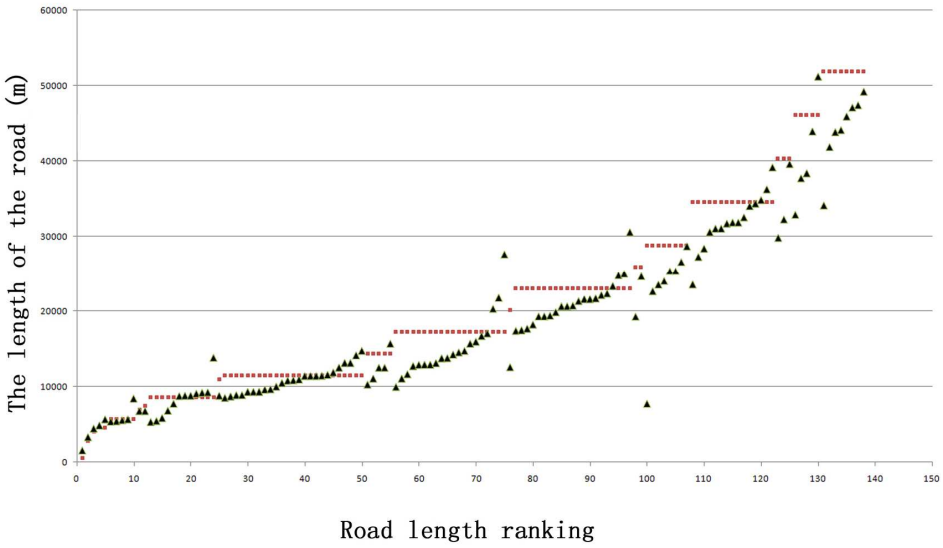

Fig.2 Calculated Data

3.1 BASIC INFORMATION OF DATA

The calculated value is almost increasing in a linear way and is subject to normal distribution. The recorded value remains the same in each section. The total length is between 20 and 30 Ming li (1Ming li≈572.4m) [7] and 30m is the center of normal distribution. According to principles of statistics and geography, the road length ranking of natural settlements in a region should be evenly distributed in a linear way or changing with sections. As the recorded value is constant in each section, it suggests that human planning and correction are part of the data. Human planning refers to that human sets distance for the defense system. The distance is mainly between fortresses of different grades classified according to their function and defense requirements [8]. Data correction is that ancient people made adjustment to the data according their perception of the map.

Ancient people were not as good at measuring the direction and the length of the road as modern people are. They usually used large scales, and direction or distance within a certain scope was recorded as one estimated value. This is eminent in this paper's case. In terms of direction, the atlas maps take the advantage of cognition and expression of polar coordinates. The recorded direction is usually 10 ° ~ 30 ° away from the real direction and some exceptions are more than 45 °. In terms of data, the real value is symmetrically distributed in a random way while changing along the theoretical value and there is almost no constant value in each section. Both the recorded value and the measured value have a range. In some occasions, the drawers might be influenced by the theoretical value and distorted the measured value by drawing a closer line between the recorded value and the theoretical value.

3.2 DATA COMPARISON

From Fig.2, it is clear that there is a significant correlation between two data. The trend of the calculated value corresponds to that of the recorded value. But the difference between the two increases along with the length of road. It is more meaningful to compare the difference between the recorded value and the calculated value than simply calculate the relative accuracy of two values. SPSS18.0 is used to test systematic variation. Both values are in pairs and normally distributed as they aim at the same object. Therefore, they fit for paired T-test [9].

Through the repeated testing, within 25 Ming li (14310m), the Sig (2-tailed) in Table 1 is 0.071, greater than the significance level standard of 0.05. Thus, the presupposition that there are no significant differences between the

population mean of two sets of data is proved to be true. And the shorter the distance is, the smaller the difference between the two. The difference increases when the distance is over 25 Ming li. At 30 Ming li (17172m), the Sig (2-tailed) value is 0.030, less than 0.05 level of significance, but greater than 0.01 (this standard is commonly used to identify the approximation of two sets of data). This result indicates that the difference between two sets of data rises up between 25 and 30 Ming li, but it is still acceptable.

Table 1: The recorded value and the calculated value of paired sample test

	Differential pairs					t	df	Sig.
	Mean	Standard deviation	Standard error of the mean	The difference of the 95% confidence interval				
				Lower limit	Upper limit			
Recorded values Calculated values	449.85818	1811.75697	244.29726	-39.92834	939.64470	1.841	54	.071

The reason is that GIS are able to get the maximum value by adopting the overall calculation and cost comparison under various scales. Human perception for the distance is only available within a scope. The longer the distance is, the weaker the perception is. So at the time the only way is to segment the distance and estimate them one after another. The results are in line with the calculated value.

In summary, the approach based on surface costing of GIS to find the best path and restore ancient military defense road map of the Great Wall has higher accuracy within 25 Ming li. Between 25 and 30 Ming li, the error increases with the distance. This method has applicability. In actual use, long distance can be separated to sections and add up each section to get more accurate results.

3. ANALYSIS AND DEDUCTION OF THE DEFENSE SYSTEM OF XUANFU TOWN

The restored road map will give an intuitive spatial form of the military defense system in the Ming Dynasty. Based on geo-spatial dimension, we can further deduce the appropriate defense mechanism.

In terms of fortresses, the roads from higher level fortress to lower level fortress are radial distribution. This layout indicates the radial-like level management of the defense system of the Great Wall. In terms of the maturity of road networks, road networks among lower level fortresses and road castles are more mature than among higher level ones. These networks are stripping along the Great Wall in high density and can be accessible to anywhere. It is deduced that road castles and its fortresses distributed within are main bodies for defense and scheduling. In comparison, fortresses distributed in road networks of higher level (town castles) are more often used to meet special wars.

In terms of the cost of troop movement, we can find that the distance between neighboring fortresses is shorter than that between a lower level and a higher level road castle. But the distance between interval fortresses is longer than that between a lower level and a higher level road castle. Considering the population of a fortress (usually between 200 and 500 people) and that the defense section is long, it is deduced that daily defense is limited to a certain area that the fortress belongs to. When it needs troop movement, neighboring fortresses may gather the strength and send troops for the same mission. It is not possible to send troops from interval fortresses as the cost is high. Another reason is to prevent from being lured by the enemy from the base, which tactic was frequently used by the enemy in order to invade the Great Wall recorded by historical documents. And sending troops from neighboring road castles of the same level has less cost than from interval road castles. Given its maturity, road castle is the core institution of regular defense.

According to historical and geographical facts of Fortresses in Xuanfu town, the data derived from maps and calculated by GIS coincide with each other within a specific range, which is due to the same criteria selected by ancient people and modern people, namely, the surface cost. The study also shows that GIS is feasible in restoring ancient maps and deducing settlement connections.

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REFERENCES

[1] Ministry of war in the Ming Dynasty. On the Nine. Frontiers with Map" (Jiubian tushuo) [M]. Taiwan: Taibei Zhengzhong Publishing House. **1981**.
[2] (Ming Dynasty) Yang Shining. Three Towns of Xuanda and Shanxi with Map (Three volume) [M]. Taiwan: National Library of Taiwan, **1981**.
[3] Lu Liangzhi. Peixiu and the theory of "six types of drawings" [J]. *Land and Resources*, **2008**(02):54-57.
[4] Zhao Xianhai. Books about the Great Wall Written in the Jiajing and Longqing Period in the Ming Dynast [J]. *Journal of Inner Mongolia Normal University* (Philosophy & Social Science), Oct, **2010**, 26-38.
[5] Douglas, D.H. Least - cost Path in GIS Using an A accumulated Cost Surface and Slopelines [J] .*Cartographical*, **1994**, 31(3): 37-51.
[6] 若林芳樹. Spatial cognition と GIS [J]. *Geographical Review*, **2003**, 76(10):703-724.
[7] Zheng Tianting, Tan qixiang. Big dictionary of Chinese history [M]. Shanghai: Shanghai Lexicographical Publishing House, **2000**
[8] HE Jie. GIS-based Cultural Route Heritage Authenticity Analysis and Conservation Support in Cost-surface and Visibility Study Approaches [D]. The Chinese University of Hong Kong, October, **2008**.
[9] Li Hongcheng.data analysis and practice of SPSS18 [M]. Beijing: Publishing House of Electronics Industry, **2010**.