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Ancient Migration Algorithm: A Behavioral Path Model Study of the Lowest-cost Goal from an Anthropological Perspective

Ziyang Weng
School of Information *Management*
Wuhan University
Wuhan, China
weng_ziyang@whu.edu.cn

Yidan Hu
School of Information Management
Wuhan University
Wuhan, China
Hydan1109@whu.edu.cn

Hui Li
Altay City Culture of Sports of Radiot of Television and Tourism Burea
Altay, China
altslyj@163.com

Xiaoyu Tang
School of Remote Sensing and Information Engineering
Wuhan University
Wuhan, China
00200260@whu.edu.cn

Zhimo Weng
China-Korea Institute of New Media
Zhongnan University of Economics and Law
Wuhan, China
202121250239@stu.zuel.edu.cn

Abstract—**Based on the construction of the geographic data elevation model in the GIS environment, combined with the long-term paleoclimate data, this work realizes mountain snow accumulation, water level cutting and restoration, vegetation ecological simulation, restores the paleo-ecological geological structure, and restricts the migration algorithm. It is extended to the behavioral deduction of ancient human migration, and the path models with the lowest cost of human migration in harsh natural environments are established taking into account the geological diversity, namely the Forest-Water Model and the Snow Line Model. Through the deduction, the effective support of the original Altay population for the route to the north was obtained, the northward migration of the ethnic branch was completed by crossing the snow-capped mountain area.**

Keywords—swarm intelligence algorithm; routes of ancient human activity; ancient geographical environment; Altay Region

I. Introduction

The oldest cave painting showing humans using snowboards has been unearthed in Altay, Xinjiang, China, which is the earliest indirect evidence that the earliest modern humans invented and used ice and snow transportation tools in the world's icy forest region [1]. The migration accessibility of the ancient human snowline forest survival area can be deduced from the geological diversity hotspot test and exploration path behavior in the Altay Tongtian Cave area.

Since the mountains in the north and west of Altay are still difficult to cross easily, it is necessary to successfully cross the forest and snow line at the bottom of the mountain several times to complete the large-scale migration of ancient people, furthermore, the correlation between biogeographic regions and population dynamics needs to be explored.

The Tongtian Cave site in Jimunai County, Xinjiang is suspected to be a major discovery of Paleolithic archaeology in China in 2017, filling the blank of prehistoric cave archaeology in Xinjiang. The top of the cave has a bat-shaped open Tongtian cave. A beam of light shines into the cave, making the whole cave appear bright and transparent. The cultural accumulation layer from top to bottom is nearly 3 meters deep, showing the cultural accumulation layer from the present to the early Iron Age, Bronze Age, and Paleolithic Age, which can be inferred to 40,000 to 50,000 years ago. In the Paleolithic cultural layer, a large number of artificial stone tools and animal bones such as deer, rabbits, sheep, donkeys, rhinos, brown bears, rodents and other relics, as well as relics such as pottery pieces and bronzes, have been unearthed. There were also obvious fire pond relics, which archaeologists described as "the earliest fire ignited by humans in Xinjiang". The microlithic assemblage composed of edge scrapers, flint cores, stone flakes, and stone leaves is a typical characteristic of the Mousterian, which is very important to discuss and study the migration, communication and diffusion of ancient human populations on the Eurasian steppe [2].

Archaeological records from Xinjiang, China, provide the earliest indirect evidence of early modern human tribes exploring and traversing the snow-capped mountains, because the region has a long history and human activity as early as the Neolithic period. Historically, it once belonged to the westward extension of the Mobei grassland, located between the eastern and central grasslands of Asia, and has long been a relatively integrated political and geographical unit together with the western Mongolian Plateau, the upper reaches of the Yenisei River, the upper reaches of the Ob River, and the northern foothills of Mount Talba Khatai [3][4]. It was also a passage and a place of living and competition for the nomadic tribes in northern China to move from west to east. The ancient human archaeological sites are distributed in the southern foothills of the Altai Mountains and the northern margin of the Junggar Basin. Today's Altay region is adjacent to Burqin County in the northwest, bordering Jimunai County in the southwest, and bordering Mongolia in the northeast. Hongshanzui, Takshken, Jimunai and Ahei Tubaike are four foreign ports around it. Most of its geological structure is located in the middle section of the Altai trough fold system, and only the southwest corner crosses the northern margin of the Junggar trough fold system. The two fold systems are separated by the Irtysh Great Fault Column, which has a typical piedmont landform. From north to south, there is an obvious vertical distribution, and from top to bottom, it can be divided into three natural landform units: northern mountainous area, southern hilly area, and inter-mountain alluvial plain area [5][6][7].

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The passage through the northern part of Altay seems to be the only option because the distance between the mountains is shorter, but according to the older archaeological sites in the area, go west, bypass the main body of the mountain, and migrate northeast along the snow line water system, It may be the choice of ancient humans after continuous trial and error. At the same time, one of the most likely differences is that after the archaeological discovery of the earliest known human activity sites in Altay, there is no evidence to find that the subsequent groups continued to provide supplies to ensure the long-term survival of the area - this is because of geological changes or the extinction of ethnic groups in the natural environment, the answer is still uncertain. However, according to the regional distribution characteristics of human activities in the northern Xinjiang region of China [8][9][10], even if we consider the huge time interval in which the ethnic groups exist, it is still unavoidable that the primitive human ethnic group as a whole has completed migration over an ultra-long time span and an ultra-long spatial distance, and It has left traces in human DNA, and how to try to deduce the lowest cost migration route of primitive groups from the perspective of anthropology has become a problem that needs to be solved in spatial computing and algorithm description [11][12].

As shown in Fig 1., where A and A-1 are the remote sensing image analysis and basic water source analysis of the Altai region - Aljinshan vein, and B and B-1 are the excavation areas of human activity sites in ancient times, it can be seen that the river channel in A has diverged and collapsed many times, to near the city of Altai for the recent river confluence branch, it is worth paying attention to the fact that the river channel does not lead to the east direction, but converges to the east to west confluence after the snow melt After entering the mountainous cut-off area, it flows westward to the Eurasian continent. The river course in this region is an important reference to influence the choice of migration direction of ancient human groups. a-1 intensively marks the snow line and river trace features. It can be seen that the lake storage area and the infiltration area in the B map, the large water-bearing area under the iteration of planting species and the popularization of new agricultural cultivation techniques, as well as the formation of a large cultivation area, while comparing with B-1, the area should be the area of serious soil loss and accumulation changes in the historical changes, with more than 3 meters of sediment layer left in the site, it is known that the area appeared 10,000 years ago, the particles of charcoal-burned millet. It is known that wild cereal species existed in the area and were harvested and processed for consumption by the original community. Combined with the animal bones excavated and the processing and decomposition characteristics during human consumption, the soil and water features and natural species diversity in the area are consistent with the design premise of this paper and have the ability to supply and meet the necessary conditions for the survival of the original community.

The distribution visibility of ancient Altay archaeological sites and the possibility of supporting various routes based on GIS data models. This paper first defines two different forms of mutual invisibility, relative visibility to indicate huge mountains visible from land, and absolute visibility. estimate to indicate the visibility of action along the valley. Then, the key advantages of whether the mountain environment of the whole region can provide survival supply are determined, and these advantages are used to measure the visibility to deduce the upper limit of population reproduction. The data of early survey and mapping show that the ancient land can be seen farther from the Altun Mountains, so that the visibility of the unreached area is directly related to the migration direction and the relative visibility of the route, while there is no clear visibility between the Gobi, sand dunes, plains and forests. Early pathfinders could determine the intended direction of the migration seen from the top of the mountain and determine the direction before setting off. However, in today's understanding, unless advanced navigation capabilities are known or can be combined with relative invisibility, known directionality prior to departure has little advantage as it means the explorer needs to maintain a visual reference at all times . In any case, the survivability and supply capacity along the northward crossing route in the Altay region is quite different from that along the westward crossing route. To make up for the greater connectivity between them, more optimized transportation methods must be realized, such as the use of sleds to complete the shortest distance and lowest cost fast passage along the frozen river in winter, thereby increasing the probability of the northward migration successfully reaching the migration target point (the mountaintop observation area).

On the contrary, if the untargeted migration drift is also constructed into a path model to analyze the route behavior, finding a compromise position in the visibility measurement of one step of exploration and one step of migration will make it impossible to design an attainable target due to the small amount of information recorded in the life of the ancient human population, and it also cannot prove that migration along this path can successfully move in that direction.

The goal of this study is to use geographic information system (GIS) and Altay's most inclusive bathymetric data to digitally reconstruct the mountain model and investigate the routes that ancient humans most likely used to migrate, creating a "mountain crossing cost surface", representing the difficulty of ancient human migration among the Altun Mountains. The model results visually summarize the effects of these variables on early population migration and provide a computational reference for future archaeological surveys and excavations.

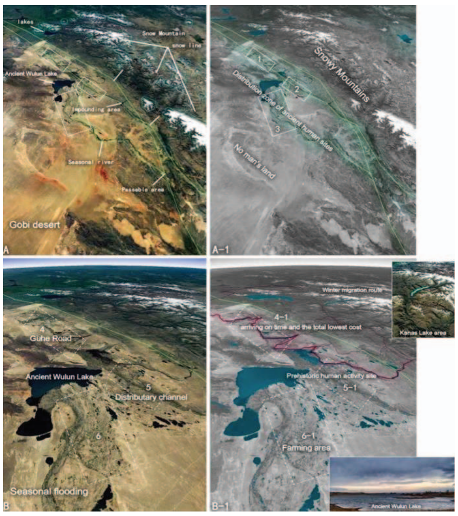

Fig. 1. Geographical evidence-based comparison of regional eco-environmental characteristics

A. Altay geological diversity and remote sensing archaeological sampling

Archaeological sampling throughout the Altay is relatively limited, especially considering that most areas of the entire mountainous region are still inaccessible and covered with snow and ice, with a complete lack of geographic data. In addition, archaeological data are mostly small-area data with very small granularity, and behavior path analysis cannot be limited to the regional level, but also includes snow lines, vegetation, hydrology, etc. Most of the archaeological sites that have been surveyed have only one or two excavation sites, which is nowhere near the amount of basic data required for computation. So far, after most of the excavation of the human activity sites in Altay, it is unlikely to replicate any relevant spatial scenes due to the complexity of the cave subsidence history. Soil sampling and composite stratigraphy of the entire site can provide partial support for site use, and the lack of archaeological records for the entire region (and colder regions more generally) due to insufficient biomaterial data. However, some ecological data can be recovered by using geological exploration data and paleo-meteorological data. Therefore, the current archaeological record of Altay is almost certainly incomplete at the site level, while at the level of mountain valleys or water system cut areas, data validity can be guaranteed when considering the proportion of model results and the degree of ancient environmental evolution.

B. Designation and migration trend of ancient human activity sites

There is some controversy about the age of Altay and its nearby archaeological sites. Apart from the very limited sample size of the Altay, the earliest dates for the identification of ancient skeletons spanned tens of thousands of years, due to the latest radiocarbon calibration curves dating back to 50kA. As this point gets closer, accurate dating and calibration of radiocarbon samples become increasingly difficult. The discrepancy between the identification dates of the remains of Altay hominins and those of neighboring hominins may reflect the product of different dating techniques, or the absence of necessary ethnic commonality among them. Regardless of whether the date can be determined, affected by dating artifacts, or started from the wrong date, the designation and migration trends of ancient human activities throughout the Altay region will require further deduction using various calculations to resolve these issues. Assume, and confidently determine the reachability of the migration.

II. MATERIALS AND METHODS

In interdisciplinary research, "data-algorithm-computing power" is playing an increasingly important role. The traditional natural genetic algorithm needs iterative evolution to solve the complexity of human behavior in social computing. It is a basic work to abstract typical events, processes, objective data and information of objects in specific social evolution into mathematical descriptions.

A. Learning area and learning cycle

The focus of this work is that the human activity scenes and migration paths in the Altay region are of great significance as the biogeographical regions of ancient humans: these regions are located in the core of Eurasia, and are also important for the birth, enlightenment, reproduction and migration of ancient humans. point. This work ignores the anthropological and sociological consensus of modern countries and nations, and only follows the legal definition of today's national boundaries. By superimposing the research on the migration distribution of human groups, and taking the mountain spanning curve as the benchmark, it studies the forest water model and the snow line model, and tries to Explain the change in geographic constraints between the two options.

On this basis, the unconstrained function optimization problem is considered as:

$$\begin{aligned} &max f(x) \\ &s.t. x \in S \end{aligned} \tag{1}$$

Where, $f: S \rightarrow \mathrm{R}^1$is a real-valued mapping; $x \in R^n$； $S = \prod_{i=1}^{n}[a_i，b_i]$ is the search space, and $a_i < b_i$. The false form (1) always has a global optimal ssolutionolution$f(x^*)$, and the set M of global optimal points is nonempty. The function global optimization is to find the optimal solution in the search space, and the migration of ancient ethnic groups is to find the convenient living area in the regional space. TABLE I. shows the analogy between the two elements.

The migration of ancient ethnic groups is a very complicated process, and it is countless explorations in the primitive stage of ancient knowledge and technology. It does not completely correspond to the global optimization of functions. Therefore, the principle of establishing a global optimization search algorithm by simulating the migration mechanism is to extract useful elements in the migration process of ancient ethnic groups, rather than copy them completely.

The exploratory flow of ancient ethnic groups is carried out in the space within the prescribed residence area on the surface of the earth. In this paper, the research field focuses on the Altay area, and in the process of analyzing the area, it is expanded into the prescribed space. During the simulation, if the division is directly divided by the administrative area or the latitude and longitude, the problem of dimensionality disaster will appear as the dimension of the optimization problem increases. Therefore, N points $x^1, x^2, \cdots, x^N$, are randomly generated in the search space S. For each point x^i and the predetermined $\delta^i(\delta^i x^i, \in R^n; \delta^i > 0; i = 1，2，\cdots，N; j = 1，2，\cdots，n)$, and get a region:

$$\prod_{j=1}^{n}\left[x_j^i - \delta_j^i, \; x_j^i + \delta_j^i\right] \tag{2}$$

Considering that the migration exploration of ancient ethnic groups is a process of evolution from aimless behavior to purposeful behavior, which has no obvious regularity, in order to equalize the search opportunities in the area, the target location and destination direction are treated as uniform and random changes. During simulation, a number of points can be randomly generated in each area and then these points can be randomly changed. It can also be handled in a simpler equivalent way: using multiple random changes of one point to be equivalent to one random change of multiple points. In this way, there is only one random change point in each area to make uniform random changes for a predetermined number of times.

Convenience areas attract ethnic groups from other areas. For simplicity, the migration process is simplified so that everyone moves to the convenience area during the migration.

During simulation, the point of N is randomly generated in the convenient area, and points in other areas are replaced. The preferential area is redrawn centered on the point where the current largest $f(x)$ value is located. In the algorithm, the current maximum $f(x)$ value is used to measure the attractiveness of the preferential area, and each $f(x)$ value is used to represent the population income of each point.

As shown in Fig. 2, A and B are the geomorphic texture of the ancient human activity site area at different scale angles, the human activity area is selected from the middle and upper part of the medium-sized mountain location, with the south-facing grottoes (closed structure) with shelter from wind and snow as the winter storage activity area, and the sun-facing slopes with stone walls to shelter from the hot sun (semi-open structure) are selected as the summer living area. C is the accumulated soil layer of the winter grottoes analyzed by archaeologists Study, it can be seen that during the last ten thousand years, there are several traces of river impact layer, which is due to excessive water volume, resulting in nearly a hundred years of inundation cover, during which the soil vegetation environment was restored several times, until the last few thousand years, the overall climate and hydrology is more stable, and the soil properties of the accumulation layer are approximate.

D is dependent on the existing human activity road network after the extraction of the main behavior of the route along the river, valley, due to the region under the description of today's international border regime, located at the junction of Xinjiang, Russia and Mongolia, China. The access to the road network in the cartographic part of the map indicates only the extrapolation of migration paths of distant populations.

E is the ancient ecological and hydrological features that have been attempted to be recovered using climatic data and hydrological data, and the red circles are the locations of archaeological finds that have unearthed ancient human living sites. The blue river channels are combined with the short period (in the study of ancient ecological change process, the time scale coordinates are in millennium) water system network caused by the melting of mountain snow, which shows the complexity and accessibility of its structure is very different from today's geographical and hydrological environment.

The ecology after the ethnic groups move into the convenient area may continue to migrate and flow, live and multiply, and the population expands or disappears. There are N points in the convenience area at this time. Every time these N points complete a random change, we must find the point with the highest survival supply, and re-define the area with it as the center. This is to simulate the shift of the survival center of the population with the center of survival supply. Also shrink the area to simulate an increase in population pressure (or density).

TABLE I. ELEMENT ANALOGY BETWEEN FUNCTION GLOBAL OPTIMIZATION AND MIGRATION BEHAVIOR

Function Global Optimization Elements	**The migration elements**
x	location
f(x)	Location of survival supply and other factors
S	Movable Surface Space (Data Infrastructure and Extrapolation of the Ancient Geographical Environment)
The most advantage	The highest or most attractive point in a food chain
The optimal value	Optimal reproduction possible or maximum security
Behavior reachable	Move to convenient areas (transportation evolution)
Detach from the local optimum	Living pressure leads to relocation away from convenient areas

When the convenient area shrinks to a certain extent, or when the pressure on the survival of ethnic groups increases to a certain level, ethnic diversion occurs again, and it spreads outward. During the simulation, the population of the population is uniformly and randomly diffused into the entire search space, and the point of N is randomly generated in the search space, and the area is re-divided.

The last is the simulation of the information transmission of the facilitation of regional survival supply. The archaeological information such as survival sites, animal and plant survival information, and living technical indicators are abstracted into the best record unit. In the algorithm, the optimal point recording unit records the current maximum value of $f(x)$ and the corresponding the point of xinthe whole process, which provides a basis for the determination of the convenient area. The above is the optimization principle of the global optimization search algorithm based on the ancient population migration mechanism for the unconstrained function optimization problem.

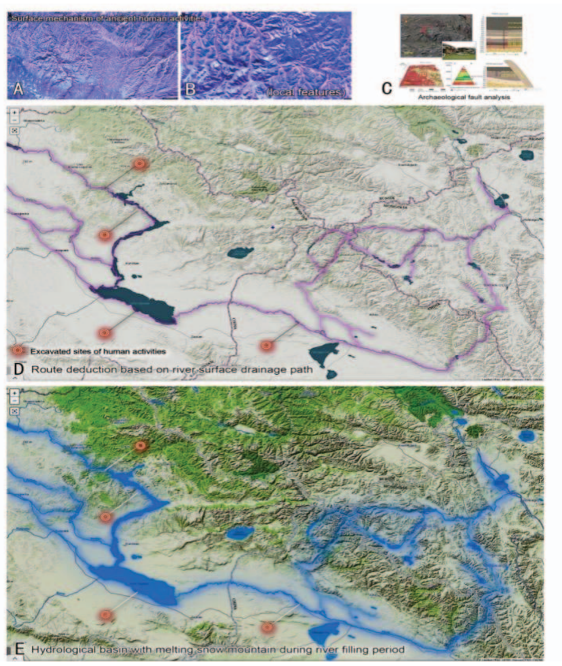

Fig. 2. The reappearance of archaeological evidence-based paleoecological geological environment

B. *Altay snow depth measurement*

Currently available snowfall data in Altay can be used for geographic context reconstruction, snowfall bathymetry profiles, mountain curves, and a combination of the average ascent rate of ice over all river systems, in the snowline model in this study. For the time coordinate interval of the ancient humid and hot period, the mountain curve is not limited by uncertainty. Within the scope of the models generated in this study, this degree of uncertainty has the least impact on the final results and will not be included in the model calculations.

Adjusting past mountain features for snowline lift rates is important for reconstructing past migration paths and existing elevations. This study acknowledges that changes in snowfall over specific periods of time will fluctuate widely, but, in general, there is a certain degree of stability. In addition, although the ice peaks and snow tops in the Altay region have melted, it is still important to make the average uplift rate of the snow line an uplift variable, considering the environment in which sleds are used. Therefore, until the Pleistocene variability, subsidence, and uplift rates of snowfall in all regions of Altay are better understood, this study considers the average snowline uplift rate to be an important variable for reconstructing the paleogeography of the region.

C. *Reconstruction of the paleo-ecological geography of Altay*

The reconstruction of paleo-ecological geography needs to confirm the plot ratio of biodiversity and wildlife. Before the trend of industrialization and commercial goals, the ecological harmony between ancient people and animals and plants lasted for thousands of years. This study uses ecological farming data for data extraction. First, the data model is reconstructed based on the past vegetation coverage and average mountain lift rate, and then based on the temperature Changes adjust the distribution of rebuilt forests, grass, lakes, and sand. Since biodiversity and supply have a significant impact on the choice of migratory destinations for ancient populations, it has a significant impact on the reconstruction of all paths and on measures of migratory connectivity.

Using forest water models and snowline model reconstructions to determine the extent of past quantification requires the intervention of paleo-river systems. For the reconstructed terrain, hydrological conditions must be performed on a Digital Elevation Model (DEM) to clearly determine the flow direction and remove small errors from the data. Based on existing reconstructions and conditional topography, areas of biological presence were determined using the Hydrology toolset in ArcGIS 10.5.1 (ESRI, 2017). It can be deduced that the amount of snow and rainfall directly affects the distribution of the water system and the ecology of vegetation, which has a significant impact on the connectivity of the road network, so the direction of the ancient ethnic groups may move throughout the region.

D. *The Value of the Least Cost Model*

A least-cost route model, focusing on slope and waterway variables, to calculate the most likely route from a migratory target. However, the initial simulations did not take into account the possibility of snow and ice covering the mountains in winter, forcing them to pause when the models reached the mountains. This study develops cost values for vehicle inventions in order to obtain the least cost path.

Three independent variables are combined in the winter migration of ancient populations, based on the following assumptions: as the difficulty of winter movement increases, the success rate decreases, and the survival guarantee rate is low. The second variable is mutual invisibility, which has three separate categories: absolute mutual invisibility and relative mutual invisibility. The assumption of computational invisibility is that migrations visible from another mountaintop may have been more successful and more attractive to prehistoric populations. However, it is slightly less attractive and may carry greater risks than the absolutely invisible area. However, the reachability of using a sled in winter is much more likely than an area that is completely invisible. Adjust the value related to the distance of the preset target, and you can expect the appearance of the variable. It is assumed that the early Altays could use the sled to a certain extent, without increasing the overall cost by a certain amount. While navigating the tools can be determined to be difficult, areas that "allow short-circuit segments", especially where there is a lack of available fresh water and specific equipment (and therefore technology) is required to ensure a successful migration.

Five different variables were used in the least cost path analysis: 1) slope; 2) major river; 3) riparian area; 4) Gobi; 5) snow line. First, the Altay region has known rivers that are sufficient to affect human activities; second, we do not believe that ancient groups could not pass through harsh natural environments (especially considering that the human sites found cannot prove to be native groups), so there is no "main barrier variable" ". But special explanations are needed, as the risk of migration increases exponentially when groups leave freshwater sources.

Therefore, the final cost surface includes the following five travel variables: slope energy cost, exponential distance cost to the river, invisibility level of mountain boating cost, distance to target cost, and survival supply cost, and then, using the cost in the spatial analysis Distance, Cost Backlink, and Cost Path tools to simulate the "path of least resistance" from the cost surface between the distances between points. Within the range of possible human activity, the least-cost models in Altay-adjusted paleogeographic reconstructions tend to reproduce very similar paths west of today's Altay, with the most notable differences between routes being slightly different choices for similar supply regions.

Biodiversity corridors facilitate successful migration of early populations in the region and reproductive constraints, such as biodistribution and supply across the region, may affect and linger populations. The lack of a sustainable supply environment will affect reproduction, which will further promote the continuous migration of ethnic groups, resulting in the dispersion of the population.

III. Algorithm Description

The ancient migration algorithm proposed in this paper is a description of the evolution of swarm intelligence based on the simulation of competitive behavior. In the process of competition between human beings in ancient society and nature, the result of failure is the demise of the group. For each agent in the population, it will compete with the agent with the most energy in its neighborhood. When the energy of an agent is less than the maximum energy of the agents in its neighborhood, the agent cannot continue to survive, and its position is replaced by a new agent. Through the competition operator, the agents with lower energy in the population can be eliminated, and the total energy level of the population can be improved. The specific description is as follows.

Let an agent in the grid be $a = ((i,\ j)(a_1,\ a_2,\ \cdots,\ a_n),\ energy,\ neighbor),\ m = ((k,\ l)(m_1,\ m_2,\ \cdots,\ m_n),\ energy,\ neighbor)$, the agent with the highest energy in the neighborhood of agent a. If *a.ergy* < *m.ergy*, then a dies and a new agent *child*= $((i,\ j)(c_1,\ c_2,\ \cdots,\ c_n)$, energy, neighbor) generation is generated, then:

$$\mathrm{C_i = m_i + U(-1, +1) \times (m_i - a_i)} \tag{3}$$

Where, $U(\cdot)$ is a uniformly distributed random number, $i = 1, 2, \cdots, n$.

In order to reflect the law of the jungle and the principle of diversity at the same time, the occupation probability $poccupy$ is used to determine in what way the generated agent will replace the position of the original agent. If an agent of $rand$ is replaced. The main purpose of the competing operation is to purge the lower-energy agents in order to improve the overall energy of the entire agent system. Therefore, the value of poccupy should be larger.

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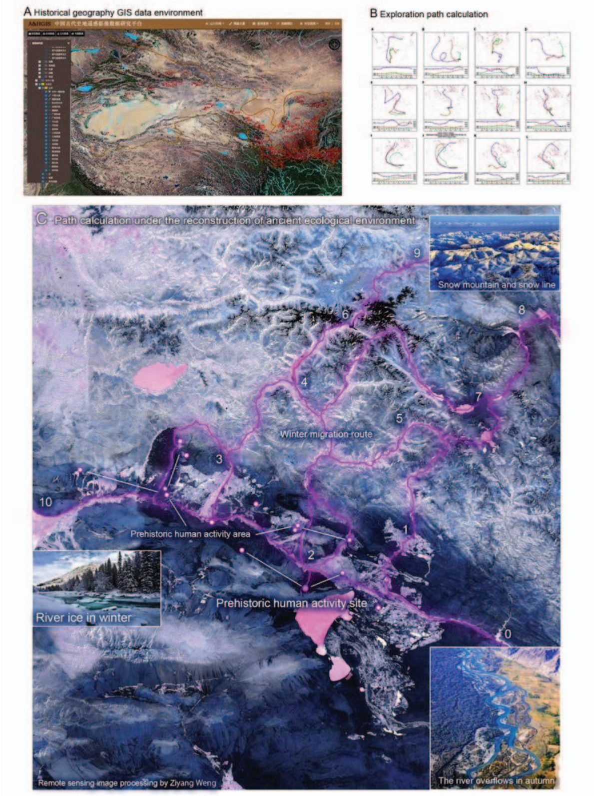

Fig. 3. Algorithm: crossing road network in winter with the lowest evidence-based cost

The cooperative behavior of the group is that for the agent living in the environment, it will cooperate with the agent in its local environment to improve its own energy. The agent will cooperate with all agents in its local environment with probability $pcross + trust \times 0.1$, which ensures that there will be more probability of cooperation between the agent and the agents it trusts. This fits well with the collaborative mechanisms in human society, reducing potentially ineffective operations, further speeding up searches. Let's say $(a',\ b') = cooperate(a,\ b)$, then determine the situation in which a and a' are dominant. If $a > a'$, the cooperation is considered to have failed, keep the original a unchanged, and let $trust(a,\ b) = trust(a,\ b) - 0.2$; If $a < a'$, then the cooperation is successful. Replace original a with a', and let $trust(a,\ b) = trust(a,\ b) + 0.1$; If $a \sim a'$, the reserved *agent* is selected according to its crowding degree. A failed collaboration has a greater impact on trust than a successful one. The orthogonal crossover operator is applied to the agents in *a.body* and its neighborhood to form the neighborhood orthogonal crossover operator and complete the cooperative behavior of agents.

The self-evolution of human beings is the improvement of the active thinking acquisition of the environment according to the individual ability. In this behavior, the agent uses its own knowledge to improve its own energy to enhance its competitiveness. In order to reduce the amount of computation, this behavior only acts on the agent with the optimal energy in the current generation.

Assuming that the agent of the *Pareto* optimal solution in this generation is *CSAgent*, where $CSAgent.body = (v_1,\ v_2,\ \cdots,\ v_n)$, a new solution $(c_1,\ c_2,\ \cdots,\ c_n)$ is generated as:

$$\mathrm{c_i} = \begin{cases} \mathrm{v_i} & \mathrm{U(0,\ 1)} < \dfrac{1}{\mathrm{n}} \\ \mathrm{v_i} + \mathrm{G}\left(\dfrac{0{,}1}{\mathrm{t}}\right) & \text{else} \end{cases} \tag{4}$$

Where, $G(0,\ 1/t)$ represents a random number generator with gaussian distribution; t is the evolutionary algebra, $i = 1, 2, \cdots, n$. If the new solution dominates the original solution, the original solution is replaced as *CSAgent.body*. The function of this operator is to perform local hill climbing operation on the *Pareto* optimal solution.

IV. Conclusion

Based on the construction of the geographic data elevation model in the GIS environment, combined with the long-term paleoclimate data, this work realizes mountain snow accumulation, water level cutting and restoration, vegetation ecological simulation, restores the paleo-ecological geological structure, and restricts the migration algorithm. It is extended to the behavioral deduction of ancient human migration, and the path models with the lowest cost of human migration in harsh natural environments are established taking into account the geological diversity, namely t*he Forest-Water Model* and *the Snow Line Model*. Through the deduction, the effective support of the original Altay population for the route to the north was obtained, the northward migration of the ethnic branch was completed by crossing the snow-capped mountain area.

As shown in Fig. 3, A is the water system and habitat place of some regions in Xinjiang, it can be seen that the external traffic of the Altay region does not have the advantage, so far there are still a lot of deserts and Gobi in the east direction and south direction, and the area that can be expanded is the west direction. B is the behavioral calculation that the algorithm is involved in, in the coupled calculation of the ant colony algorithm and this algorithm, it can be concluded that 1) it is difficult for the early communities to stick to explore a specific direction, and in the absence of a specific target place will continuously circulate locally along the river; 2) in the process of circulation, it may try to use ancient cereals as food, but it is impossible to complete effective farming, and the main food still depends on capture. Thus, the main survival area is the combination of river and mountain areas, archaeological sites can also effectively prove this rule; 3) in the exploration of mountainous areas, the river is still the main path, relying on high observation, can be clearly found near the target site; 4) combined with the specific biodiversity and survival necessary, migration to a similar natural environment of the community has a higher chance of survival, contrary to this principle of the community is difficult to resist the complex 5) Combining with the geographical environment, including elevation data, winter snowfall, length of frozen rivers, temperature status and other factors, the winter environment of the region can be reproduced, and the main river canyons have completed abundant water accumulation in autumn and winter, creating a good natural environment for the accessibility of frozen rivers in winter. The geo-exploratory behavior of spreading outward from the area of ancient human activity can be obtained at this stage with the lowest cost of crossing the road network.

In contrast, during the spring and summer when food was abundant, it was difficult to create a desire for community migration even when the waterways were flooded.

The biggest difference with the migration of other ancient groups is the clear appearance of four-person sleds in the petroglyphs excavated in the region, which proves that the ancient groups in the region had a special skill point, namely, using birch wood and animal skins to make winter vehicles that could carry and transport people and goods using the characteristics of the frozen rivers to turn the flooded river channels in spring, summer and autumn into a fast-passing road network in winter. Although the water has cutting characteristics, the river does not fall steeply after a long period, and also for the formation of many cliffs, and has good accessibility after the freeze.

Based on available data, low-cost models can explore the most likely pathways for population migration. Future improvements to the model will require the development of more accurate Altay bathymetry, fine paleocurrent models of Altay, broader uplift records across the region, and sediment core analysis, which are critical to proposing different modeling pathways.

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