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Conquering Sorting: A Study of the Distributional Characteristics of Information Entropy-Preserving Evolutionary Groups

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Abstract—In this paper, we take into account the objective evolutionary goals of different countries and regions in the course of history, combine complex military conquest with deep survival space requirements, and propose a distributional characterization algorithm for information entropy preserving evolutionary groups. We believe that firstly, we need to describe the complex evolutionary goals of individuals in the population with distributional depth; to avoid the algorithm from maturing prematurely and falling into local optimal solutions, we introduce a spatial distribution mechanism to facilitate regional development; secondly, we propose a group goal discrimination mechanism based on the population; finally, we verify the effectiveness of the algorithm using research cases. The experimental results show that the fast sorting is beneficial to the evolution of individual goals in the process of military conquest, and more beneficial to the co-evolution of regional individuals. This paper can better represent the complex network of relationships between multiple intelligent nodes and provide a reference for intelligent decision making of complex systems.

Keywords- multi-objective optimization; geometry; implicit data; growth mechanism

1. INTRODUCTION

Macroscopically, the entropy of the evolutionary population or the average information entropy of the population can better portray the diversity and distribution of individuals in the population [1,2], but this method lacks the portrayal of the relationship between individuals within the population, so it is not convenient for regulating the diversity and distribution of the population in the evolutionary process. Another method to portray population diversity is the aggregation density or aggregation distance of individuals in a population, if the aggregation distance between individuals is relatively large, it indicates that the aggregation density of individuals is relatively small. This method has higher computational complexity than the previous method, and it can portray the diversity and distribution of the population from a macroscopic point of view, but also better portray the intrinsic relationship between individuals, which can be used for the regulation of the population during the evolutionary process [3,4].

Three types of methods are usually used, The first category is to calculate the aggregation density of single individuals by directly calculating the similarity between individuals; the second category is to calculate the aggregation density of individuals by calculating the influence factor between individuals; the third category is to calculate the aggregation density between individuals by calculating the aggregation distance between individuals.

2. THEORETICAL BACKGROUND

2.1. The Military Conflict-Based Event Dynamics

Location data in the Historical Processes of Military Conflict dataset possess some extrapolation value, allowing for the measurement of the location of conflict areas relative to other factors of interest, such as capitals or neighboring countries. We include one such indicator in our analysis: conflict-rights distance.

The relative location of a conflict may affect the length of the conflict for at least two reasons: (1) First, the further the conflict is from the rights center, the more difficult it is for the military conflict leader to effectively project pressure on opposition forces. (2) Second, rights centers may perceive remote events as less urgent than proximate ones and therefore devote fewer resources to resolving them, while interfering with the use of power by local military conflict leaders.

2.2. The Military Conquest-Based Demand Goals

Underlying the military conflict is the nature of trade, the ultimate maximization of conquest routes, military costs, trade (plunder) gains, and population geo-territories through the regime's conquest goals. Information on geographic geo-territories under the conquest goal focuses on group goals such as road network accessibility and trade feasibility.

Explained in terms of revenue objectives, for example, the most commonly used metric to measure geo-geographic resource dependability is the ratio of primary commodity costs to the value of sales at the location of the arrival trading node. Similarly, indicators of rugged terrain are based on national statistics. This composite measure is only really meaningful if we can assume that the trade interaction area is a representative sample of countries with low conflict frequency for all explanatory factors and in cases where trade crosses the overall trading network endpoints. However, this assumption is rarely valid; after all, relying exclusively on country-level regressions, we cannot explain these differences between conflict and trade (in terms of trade type, trade dependence, trade duration, or economy). We believe that this is the high ground where type accounting and multi-objective optimization algorithms excel in a large sample setting.

2.3. The Geographical Information-Based Scenario Ecology

The GIS format provides a number of geographic variables that are often seen as affecting the propensity to war. The

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World Conservation Monitoring Centre of the United Nations Environment Program resently has published a gridded mountain dataset with global coverage (UNEP, 2002). In this dataset, the earth's surface is divided into grid cells of approximately 10 x 10 km, each assigned a value of 1 (mountains) or 0 (no mountains). Clearly, rugged terrain is not evenly distributed across the area covered in the case. The proportion of rugged terrain in high conflict areas is significantly lower than average, and the proportion of rugged terrain at the end of conflict behavior and the edges of military-controlled areas is distinctly higher than average, so the use of national-level statistics will result in biased estimates of the impact of rugged terrain.

3. BEHAVIOR ABSTRACTIION

During conflict, some extraterritorial geopolitical resources are more easily accessible to the invading party than others. For example, larger economic trade points often established at road network intersection nodes, which are easily captured and plundered. Therefore, it can be considered as plunderable. The geopolitical resources of these cities are potential sources of information for the invading side and guides for the next wave of military actions. Other resources, such as irrigation and water information, can be considered unavailable until the invading party has a long-term governance goal. Through the study, the aim is to analyze map products to map the location of selected types of natural resources. The resulting database will contain information about the location and type as well as the time of discovery and initial extraction. In the following analysis, we use a preliminary version of the database to obtain data on four types of plunderable geo-resources: roads, rivers, cities, and natural villages. Based on these records, we generate two sets of simulations: a set of national-level variables indicating the presence of a given data in the country at the time of the conflict (coded as "1" if present and "0" if not present), and a set of conflict-specific variables indicating the availability of data within the conflict zone during the data availability within the conflict zone during the conflict.

The figure shows the distribution of geo-complexity and conflict zones. It is clear that the distribution of cities and natural villages overlap. Therefore, we can assume that the Lee Conquest Army has access to this very valuable geo-referenced data.

Even less data are available on other aspects of human geography. As far as we know, the spatial distribution of ethnicity, religion and culture has not been mapped to a satisfactory degree of detail, which is a great challenge even for the contemporary world. Development indicators such as disaster epidemics, economic growth, birth rates and economic statistics are other aspects that should be measured at the sub-national level and are generally not applicable to military conflict zones. One possible solution is to identify and use appropriate instrumental variables, such as rainfall variability as an instrumental variable for food income fluctuations. Also only for regions where changes in rainfall have a strong impact on agricultural growth and thus indirectly affect conflict. However, in other more developed regions, rainfall is a poor indicator of growth and therefore it cannot be used as a valid indicator for economic analysis.

There are several findings worth noting:

(1) The weak significant effect of rivers found in the first model is significantly larger and stronger when measured at the conflict level. Clearly, trade flows are significant in areas with rivers, and concurrent wars are more difficult to end.

(2) Another high geo-value city has a significant impact in the expected direction of geo-access. However, we must be cautious about making overly general statements from this finding, as the sample in this instance spans regions that have been the core of the Silk Road since ancient times, with cities that have a significant distribution status and are coded with a network structure that highly matches the road network nodes.

(3) The positive and statistically significant estimates of the mountain variables in the national-level model are misleading; there is no link between the extent of conflict in the mountains and their expected duration. However, unintended impacts from forests are very clearly present, limiting the range of human activity and possessing more difficult availability than in mountainous areas.

(4) The most influential factor in the geo-information acquisition specific model is the relative location. The information reinforcement that occurred between the metropolis (the capital of the Mongolian regime) - the presumed regional center of power (Ilkhanate) - and a more distant place (Egypt) did not evolve into a protracted existence, and with religious, ethnic, and military rivalries, information isolation was soon restored, and the old forms of power organization quickly closed off the growth of geo-numerical chains, making the coupling of global geographical information at this time a moot point. The inclusion of conflict-rights distance further removes much of the explanatory power of territorial conflict and GIS simulation calculations, while country size has a significant positive effect. Estimates for the remaining variables do not differ substantially from the country-level model.

In summary, the choice of multi-objective evolutionary-driven measures affects not only the standard errors and significance levels, but even the substantive impact of some regression coefficients. In particular, the changing behavior of the distribution of urban villages and towns, rivers and road networks implies that the use of supra-national level geo-data

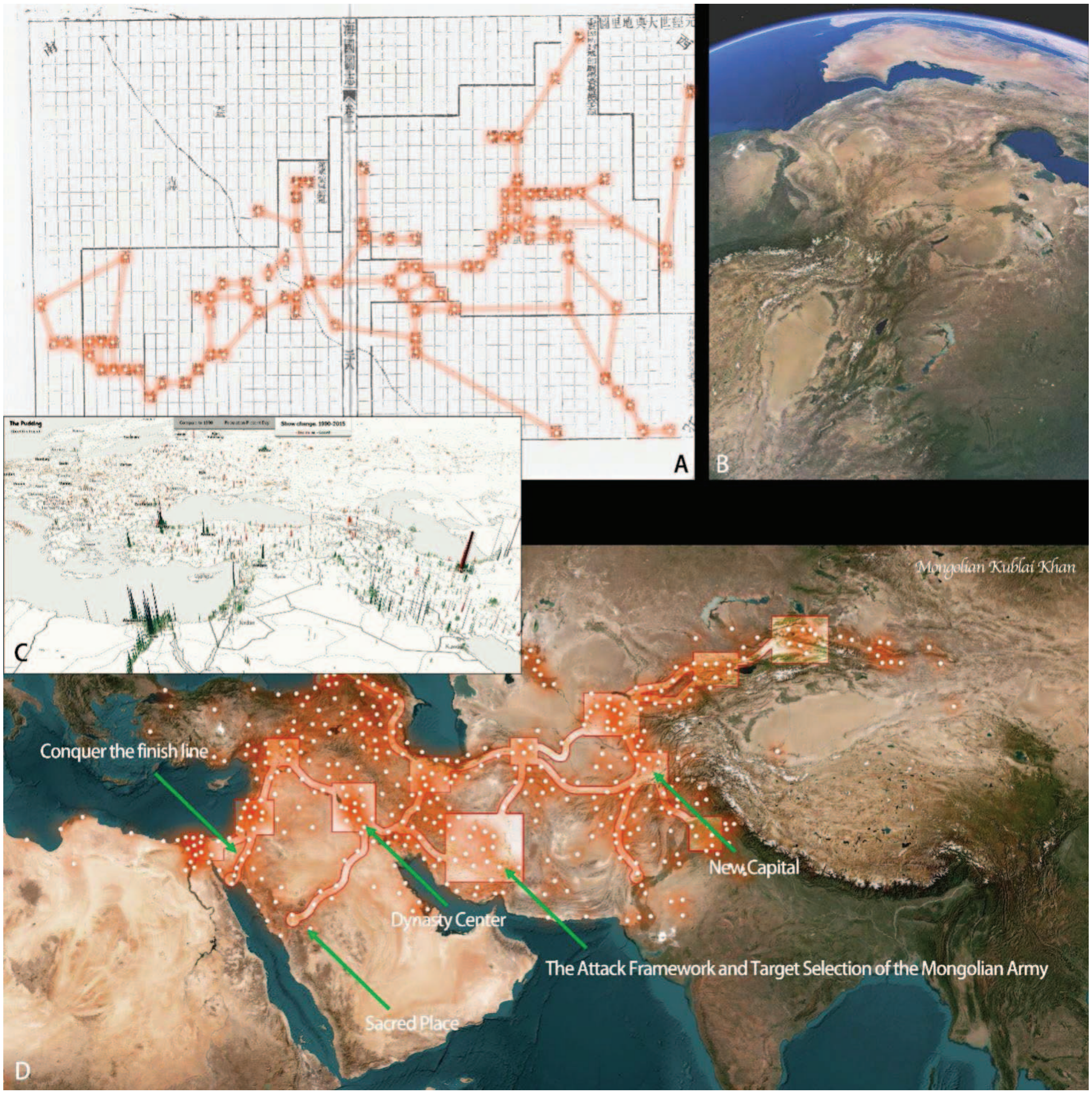

Figure 1. Optimal Sorting under Space Supply Constraints: (A) The Road Network Structure and Hub of China's Yuan Dynasty Historical Data to Egypt; (B) Geologic characteristics under the superposition of Eurasian plate and Indian Plate; (C) Distribution of population growth data in geographical regions over the past thirty years; (D) Presentation of Sorting Selection in the Conquering Process in GIS Data Environment.

aggregates as a proxy for geographic characteristics is indeed an inferential process. The analysis also reveals the importance of controlling the relative location of rights, with the growth of geo-number chains influenced not only by the expected duration of the conflict, but also by the estimates of other variables. Geographic data generated by a single GIS for each local area-undoubtedly more accurate and representative than supranational statistics-can be easily incorporated into statistical models of conventional validity.

4. Mathematical description of the algorithm

Whether not examining the risk of conflict itself helps explore patterns of conflict occurrence without explicitly including invalid cases in the model. For example, by using the center of mass of a conflict polygon or the location of a political, trade, or military core region as a unit, it is possible to measure the distance from any behavior to nearby behaviors and assess whether the spatial distribution of behaviors is significantly different from a random distribution. Ideally, the analysis should also include a temporal dimension, as behaviors in a region may also cluster in time. First, the underlying causes of multi-objective behaviors tend to be spatially and temporally concentrated.

The dominance relationship between individuals in an evolving population is denoted as "$\succ$" [5]. If the individuals are not dominated by each other, the two individuals are not relevant. On this basis, this section will define a new class of relations "$\succ_d$", if $x \succ y$ or x is not relevant to y, then $x \succ_d y$. And it will prove that the relevant properties of the relation "$\succ_d$". It is argued that the fast sorting method can be used to construct the non-dominated of the evolutionary population.

4.1. Relationship Between Individuals

An evolutionary group is composed of several individuals, and there are one or another relationships among them, such as the relationship between dominant and dominated, the aggregation relationship within the same small habitat, in addition to the relationship between non-dominated individuals, the relationship between dominated individuals, etc. The nature of the group is determined by the relationship between the individuals.

(1) If x is not relevant to y, and $y \succ z$, then either $x \succ z$, or x and z are not relevant.

With r subgoals, if x and y are not relevant, then $x_{.\alpha} \succ y_{.\alpha}$, and $y_{.\beta} \succ x_{.\beta}$, α and β are two different sets of subgoals, and $\alpha \cap \beta = \emptyset, \alpha \cup \beta = \Omega, |\alpha| + |\beta| = r$.

When $y \succ z$, we have $y_{.\Omega} \succ z_{.\Omega}$, i.e., we have $y_{.\alpha} \succ z_{.\alpha}$ and $y_{.\beta} \succ z_{.\beta}$. It follows that $x_{.\alpha} \succ z_{.\alpha}$. $x_{.\beta}$ and $z_{.\beta}$ have an indeterminate magnitude relationship.

Let $\beta = \gamma \cup \delta$, and $\delta \cap \gamma = \emptyset$, such that $x_{.\gamma} \succ z_{.\gamma}$ and $z_{.\delta} \succ x_{.\delta}$. This gives: $x_{.\alpha\cup\gamma} \succ z_{.\alpha\cup\gamma}$, and $z_{.\delta} \succ x_{.\delta}$, i.e., $x \succ_d z$. When $\delta = \emptyset$, we have $x \succ z$.

Correctness can be proved in the same way.

(2) If $x \succ y$, y and z are not relevant, then either $x \succ z$, or x and z are not relevant.

For the convenience of the problem, it is assumed in the following discussion that there are no identical individuals in the Pop. Different individuals in the nondominated set are uncorrelated with each other.

Let $\{y_1, y_2, \cdots, y_k\}$ be the non-dominated set, $\forall y_i, y_j \in \{y_1, y_2, \cdots, y_k\}, i \neq j$, both y_i and y_j are non-dominated, and assume that y_i and y_j are correlated:

① $y_i = y_j$, indicating that y_i and y_j are the same individual.

② $y_i \succ y_j$, indicating that y_i dominates y_j, or $y_j \succ y_i$ indicates that y_j dominates y_i; thus, y_i and y_j must have one dominated individual, resulting in a contradiction.

Therefore, y_i and y_j are not relevant.

It can be seen that since the non-dominated individuals are not related to each other, the existing sorting method cannot be applied to sort the evolved individuals by the relationship "$\succ$". For this reason, a new relationship between evolved individuals needs to be defined.

(3) $\forall x, y \in Pop \quad x \succ_d y$ iff $x \succ y$ or x and y are not relevant. The relation "$\succ_d$" does not have transferability.

$\forall x, y, z \in Pop$, let $x \succ_d y, y \succ_d z$. By the definition of the relation "$\succ_d$", there are four cases as follows:

① $x \succ y$, y is not relevant to z. It is known that $x \succ_d z$.

② x is not relevant to y, $y \succ z$. It is known that $x \succ_d z$.

③ x is not relevant to y, y is not relevant to z.

With r subgoals, we have $x_{.\alpha} \succ y_{.\alpha}$, $y_{.\beta} \succ x_{.\beta}$, and $\alpha \neq \emptyset, \beta \neq \emptyset, \alpha \cap \beta = \emptyset, \alpha \cup \beta = \Omega, |\alpha| + |\beta| = |\Omega| = r$; also we have $y_{.\gamma} \succ z_{.\gamma}$, $z_{.\delta} \succ y_{.\delta}$, and $\gamma \neq \emptyset, \delta \neq \emptyset, \gamma \cap \delta = \emptyset, \gamma \cup \delta = \Omega, |\gamma| + |\delta| = |\Omega| = r$. Then we have $x_{.\alpha\cap\gamma} \succ z_{.\alpha\cap\gamma}$, $z_{.\beta\cap\delta} \succ x_{.\beta\cap\delta}$, $x_{.\Omega-(\alpha\cap\gamma)-(\beta\cap\delta)}$ and $z_{.\Omega-(\alpha\cap\gamma)-(\beta\cap\delta)}$ have an indeterminate dominance relation.

Let $\Omega - (\alpha \cap \gamma) - (\beta \cap \delta) = \zeta \cup \eta$, and $\zeta \cap \eta = \emptyset$, such that $x_{.\zeta} \succ z_{.\zeta}$ and $z_{.\eta} \succ x_{.\eta}$. This leads to: $x_{.(\alpha\cap\gamma)\cup\zeta} \succ z_{.(\alpha\cap\gamma)\cup\zeta}$, and $z_{.(\beta\cap\delta)\cup\eta} \succ x_{.(\beta\cap\delta)\cup\eta}$, when $(\alpha \cap \gamma) \cup \zeta \neq \emptyset$, we have $x \succ_d z$; but when $(\alpha \cap \gamma) \cup \zeta = \emptyset$, we have $z \succ x$.

Therefore, in this case, the relation "$\succ_d$" is not transferable.

④ $x \succ y, y \succ z$. By the definition of the relation "$\succ$" it is clear that there is $x \succ z$.

In summary, the relation "$\succ_d$" is not transferable.

Any sorting method that requires transferability is not suitable for sorting individuals in the evolutionary population by the relation "$\succ_d$", such as subsumption sort, heap sort, tree selection sort, etc. Sorting methods that do not require transferability can sort the individuals in the evolutionary population by the relation "$\succ_d$", such as bubble sort, quick sort, etc.

4.2. Quicksort

Quick sorting [6] can be implemented to sort the non-dominated set from the population. Each time we find an individual x as the object of comparison (usually the first individual is chosen), we compare and judge according to the relation "$\succ_d$", and after one sorting, we divide the individuals in Pop into two parts. The part of the population that is "smaller" than x must be the dominated individuals, and this part of the population will not be considered in the next sorting round. If x is not dominated by all these individuals, then x is a non-dominated individual in the Pop, and x is merged into the non-dominated set, but as long as one of them is "greater than" x, then x is still the dominated individual. The next round of sorting is carried out until there is only one individual in the second part.

A Quicksort method is used to classify non-dominated individuals from the evolutionary population. The construction of the non-dominated set by the quick-pass method is shown below. $Quick-pass()$ performs a quick sort on table $Pop\,[s.tt]$, and stores the individuals dominating $Pop\,[s]$ or not related to $Pop\,[s]$ in $Pop\,[s \dots i-1]$, and stores the individuals dominated by $Pop\,[s]$ in $Pop[i+1 \dots t]$, $s \leqslant i \leqslant t$.

Table 1. Pseudo-code for Algorithm 1

```
Function calls: Quick-pass (Var Pop: Evolution-Population; s, t: integer; Var i: integer)
i = s; j = t; x =Pop[s];non-dominated-sign=,T.
while(i < j)do
{while(i < j)and((x > Pop [j])or(Pop [j] = x))do
    {j = j − 1;if(Pop[j] > x)thennon-dominated-sign=..};
    Pop [i] = Pop [j];
    while(i < j)and((Pop [i] >_d x)or(Pop [i] = x))do
      {i = i + 1; if (Pop [i] > x)thennon-dominated-sign=.F.}
    Pop [j] = Pop [i]; }
Pop [i] = x;
if(non-dominated-sign)thenNDSet= NDSe t U x
endforQuick-pass
```

The main procedure for constructing the non-dominated set with the fast sort method is shown in the algorithm for constructing the non-dominated set with the fast sort method.

Table 2. Pseudo-code for Algorithm 2

```
Function call: sort_only_for_nondominatedset (Var Pop: Evolution-Population; s, t : integer)
1: NDSet = ∅;
2: if (s < t)
3: then (quick-pass (Pop, s, t, k) :
4:     sort-only-for-non-dominated-set-4 (Pop, s, k − 1) )
5: return NDSet
```

After execution, the $NDSet$ is the desired one. The average time complexity is $O(rN\log N)$. The time required for comparison when r targets are not considered is $T(N)$, then $T(N) = T_{\text{quick-pass}}(N) + T(N-1)$. where $T_{\text{quick-pass}}(N)$ is the time required to sort a segment of N individuals in Pop, so $T_{\text{quick-pass}}(N) = O(N)$. Due to the randomness of the distribution of individuals, if the probability of taking k between 1 and N is the same in each trip, the average time complexity of the algorithm can be obtained as:

$$T_{\text{avg}}(N) = O(N) + \frac{1}{N}\sum_{k=1}^{N} T_{\text{avg}}(k-1) < O(N\log N) \quad (1)$$

5. Case Study

5.1. Case Background Analysis

The case study is based on the example of a medieval Mongolian army waging a conflict to achieve its goal of conquering a vast area of land. Its main elements are as follows:

In the autumn of 1252, the vanguard of the Mongol army embarked on a western expedition, followed by the gathering of the army by Xulemu (the main general), who set out in the spring of 1253, with the military objective of the region west of Khorasan (eastern Iran) up to Egypt. The route went from the Mongolian steppe westwards over the Altai Mountains, crossing the Irtysh River, over the Tianshan Mountains, crossing the Ili Valley and reaching Samarkand, the middle region of the river in Central Asia, after replenishing supplies, and rejoining the supporting forces of the Golden Horde, Chaghatai Khanate and Voghodai Khanate.

At the beginning of 1256, the army reached the Erbhursh Mountains on the southern shore of the Caspian Sea (the area in the northwestern part of present-day Iran by the southern Caspian Sea) and prepared to attack the first target, the Kingdom of Murayi, which was destroyed after nearly a year's campaign, at the end of November 1256, after the elimination of nearly 300 forts in the enemy's territory. In the autumn of 1257, the army marched on Baghdad after sending an envoy to the Abbasid caliph Mustahedin to persuade him to surrender. Upon reaching Kermanshah, 200 km from Baghdad, the army was divided to combat Western reinforcements in the Caucasus region.

Subsequently, the army was divided into three directions to attack Baghdad: the left flank attacked the lower Tigris River to encircle Baghdad from the south; the right flank attacked the upper Tigris River to encircle Baghdad from the north; and the main force of the Commander-in-Chief's middle army was the center, with its front pointing directly at the city of Baghdad.

The three Mongolian armies divided and attacked, and in a few months' time completely cleared the resistance forces on the outskirts of Baghdad. By January 28, 1258 AD, the Mongolian army completely surrounded the entire city of Baghdad to start the general attack, and on February 9, the Abbasid dynasty surrendered.

In the process of ranking the targets for conquest, the commander-in-chief prioritized the selection of the Khanate capital, choosing Tabriz, the capital of East Azerbaijan province in northwestern Iran, which is close to the Caucasus Mountains to the north.

Synchronized military operations were kept active. At the beginning of 1259 A.D., the Mongol army and the allied forces of Georgia and Armenia began to attack Syria to the west, still in a three-way strategy of attacking the core hinterland of the Ayyubid dynasty in Syria. 18 January 1260, the army arrived at Aleppo, a major town in northern Syria, and after a month of bloody battles, the Mongols captured Aleppo and ordered the execution of all prisoners of war and the slavery of 100,000 inhabitants. The city was razed to the ground, and no one was allowed to stay in the city.

On March 1, 1260, the administration of Damascus was handed over to the Mongols by the Imam of Damascus, the deacons and the group of traders.

On March 21, 1260, the remaining resistance forces in Damascus were exterminated. The conquest sort changed to Kudus, the Mamluk king of Egypt, and in April 1260 Mongol Khan died in battle at the front line of the campaign against

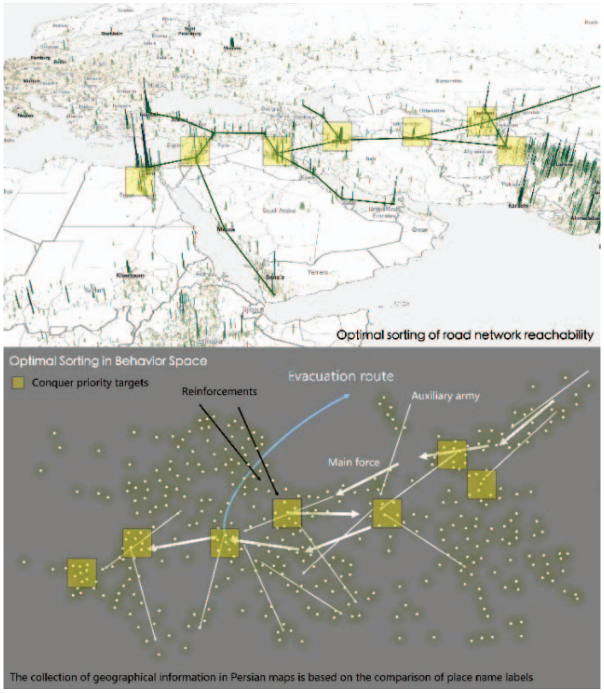

Figure 2. Optimal Sorting in Behavior Space: (a) The population growth is constrained by the geographical supply capacity, and the intuitive reachability optimal sequencing of the road network can be obtained; (b) The collection of geographical information in Persian maps is based on the comparison of place name labels

the Southern Song Dynasty, under the Chinese city of Diaoyu in Hechuan, Chongqing. According to the custom of the Mongolian Empire, when the Khan died, the kings of the Mongolian Golden Family clans had to rush back to the Mongolian steppe to attend the Kulitai Conference to determine the next Khan of the Mongolian Empire. With the Lord Commander sorting priority decided to lead the army back to Tabriz to rest and then return east from Tabriz, leaving the remaining troops to continue to keep pressure on Egypt.

In July 1260, Egypt gathered a large army to march across the Sinai Peninsula to the Gaza Strip.

In mid-August 1260, the Egyptian army reached the vicinity of Nablus, about 100 km north of Jerusalem. The two armies encountered each other in the valley of Ayin Zarut, and a great battle between them was imminent. On September 3, 1260, the battle between the Mongols and the Egyptians began, and the Egyptian army won the battle and the Mongol army was wiped out. After the battle of Ayin Zarut, the Mongol army withdrew from the Syrian region and the southwestern frontier of the Mongol empire stopped here, after which the Ier Khanate exhausted all its strength and failed to let the Mongol horsemen step on Africa.

Expand with this case, large-scale military action could increase the risk of more conflict in the region by destabilizing the economy, causing population attrition, refugee movement, facilitating smuggling, and increasing supply demand. Therefore, a more rigorous point model model should be used. Either the potential variables should be included in the model or the distribution of conflict surfaces should be compared with the distribution of relevant conflict-promoting variables. For example, one could explore whether conflict follows the distribution of rugged terrain and, if so, whether there are any unexplained clusters of conflict once the terrain is controlled.

5.2. Experimental Analysis

Event descriptions based on map artifacts and literature composition, through the topology with spatial scenes[7], form a data distribution that can be used to verify conflicts. As this case tends to be examined in terms of cluster target ordering to obtain a more detailed analysis of multi-target behavioral clusters and to distinguish between two forces driving clusters: clusters of potential causes of multi-target evolution and spatial interactions between geo-numerical chain [8] growth.

Programming in Python3.11. Obtain the longitude and latitude coordinates of important cities in Central Asia, West Asia, Eastern Europe, Central Europe, North Africa and the Arabian Peninsula in areas occupied by the Mongol army in the 13th century. Obtain the longitude and latitude coordinates of Kodeguara (Mongolia), the starting point of the Mongolian army's western expedition. Obtain longitude and latitude coordinates of important Mongol military bases including Kabul (Afghanistan), Tashkent (Uzbekistan), Mashhad (Iran), Tehran (Iran), Iraq, Lebanon and Cairo (Egypt). Score the terrain environment attribute and attack value attribute of each location, assign high weight value to the important military stronghold, and. The more favorable the terrain is to combat, the larger the terrain environment attribute value is. The higher the level of economic development, the greater the attribute of attacking value. Use a quicksort algorithm to sort all candidate locations and get the non-dominant solution set of the target that the army was to attack. The experimental code and data have been uploaded to Github address: https://github.com/Science-Art-Demonstration-Research-Lab/2023.04-Conquering-Sorting.git. Some of the results are shown in Table 3.

However, civilizational interactions are by nature events that involve a considerable amount of area and are difficult to describe as points even on small-scale maps [9]. In addition, the terrain they cover varies from case to case. This raises some difficult methodological issues regarding how to generate data distributions for various out-location synergies and how to compare them with the study area distribution. Another methodological problem is that global perspective studies involve the overall land, sea and ocean. Thus, researchers must address how to deal with the non-contingent regions separated by the Great Lakes, oceans and seas.

The above analysis illustrates the problem of potential patterns of conquest goals versus population evolutionary goals.

More work is needed to fully measure the effects of various aspects, including the use of more advanced methods to account for spatial autocorrelation and interactions, such as spatial regression and multilevel analysis.

Table 3. Top 20 Non-dominated Solutions

Rank	Location	Latitude (N)	Longitude (E)
1	Tebitz	35.6961	51.4231
2	Tehran	35.6892	51.389
3	Mashhad	36.2604	59.6168
4	Ashgabat	37.9601	58.3261
5	Baku	40.4093	49.8671
6	Yazd	31.8736	54.356
7	Kirkuk	35.4681	44.3922
8	Bukhara	39.7667	64.4167
9	Turkmenbashi	39.7167	64.5442
10	Baghdad	33.315	44.3668
11	Tikrit	34.5959	43.676
12	Erzurum	39.9075	44.0392
13	Khujand	29.6163	52.5311
14	Bamyan	34.8469	67.8272
15	Dushanbe	38.5411	68.7821
16	Kuwait City	29.3759	47.9774
17	Tashkent	41.2995	69.2401
18	Milnaya	39.0265	69.6796
19	Turka	37.4378	69.7763
20	Ghazni	33.5667	68.416

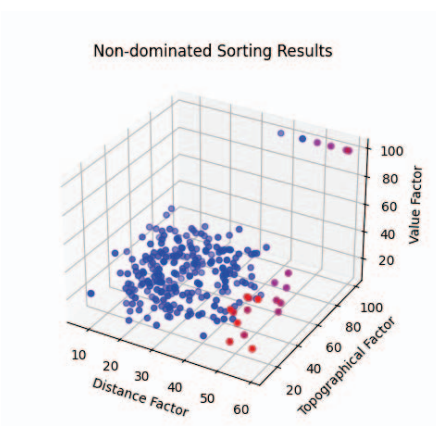

Figure 3. Distribution of solution sets

The spread of civilization and neighborhood effects can be studied at the right level by using data on regional locations. For example, tests of spillover effects in neighboring regions could be limited to a sample of nearby countries, or they could be weighted according to the opposite distance of neighboring regional political centers [10]. This allows for the exclusion or reduction of adjacent regions that are not relevant when exploring the impact on the surrounding area when geo-information is obtained, such as the case of the Voghodai Khanate, Chincha Khanate, and Chaghatai Khanate, which were separated from the central regime. When more data are available, such as war mortality and refugee flows, we will be able to analyze other aspects of conflict devastation rather than duration.

One of the challenges is the choice of observation units. Core regions can be used as the basic unit when we analyze geo-data to obtain duration, type, cause of termination, and specific location. However, risk analysis requires one or more city-specific units of observation, including invalid cases (conflict-free cases), which makes the setting of conflict-specific variables more effective. An alternative approach is to use research institutional data sources as a sample for data generation and analysis. Where data are available, this research design facilitates more accurate calculations of how, for example, conflict area geo-data generation is captured in inland areas with low population density and extremely rugged terrain and near national borders.

A second possible strategy is to define a geometric unit, such as a 100km x 100km grid, as the basis for the measurements and assign conflict values and explanatory variables to each pixel. This solves the problem of huge variations in unit size, while allowing to bridge with economic statistical methods for detailed analysis. Unfortunately, data on fiscal levels, population birth rates and other spatial variations are missing from the long history and must be reasonably extrapolated to be converted to the original grid format. Although this can be accomplished by calculating average weights based on the relative shares of administrative entities within each grid cell, we still have the problem of missing data.

6. CONCLUSION

A huge obstacle to the study of multi-objective evolutionary driven algorithms to explain the relationship between the growth of test geo-number chains lies in the inadequacy of available data. One of the most serious problems is the lack of relevant data at the sub-national level. This is true for the difficulties of data acquisition, processing, encryption, and interpretability. However, this paper shows that using relatively simple methods, researchers can generate richer and more accurate data for large-scale statistical analyses. Rather than variables growing in geo-number chains differing significantly between measurement scales, the analysis of the evolutionary validity of multiple targets further reveals that changes in geo-number chains between sub-national and supranational scales do demonstrate a clear effect of civilizational interactions, with the behavior of changes in four categories of variables being particularly striking. It is clear that geo-information acquisition under the domination of a single civilization is not a complete record of the region, and that geo-information acquisition under the perspective of converging civilizations is not only a data backup of relative locations, but also a data alignment and technological upgrade after synergistic evolution. The analysis also demonstrates the importance of the relationship between access location and distance to the center of power, and the behavioral-distance metric reflects the estimated impact of country size, civilization types of different ethnic groups, and economic approaches.

This paper demonstrates the data generation capabilities of GIS. The potential contribution of GIS to conflict research extends well beyond coverage and area calculations. By selecting appropriate units of analysis, GIS and spatial econometrics will provide better tools for assessing the true spatial relationship between geography and civil war.

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