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Algorithm for Cartography: Adding Out-domain Knowledge to the Level of Complexity Can Improve the Evolutionary Nature of Multilevel Genotype GIS

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***Abstract*— By calculating the ecological efficacy in genotype-phenotype GIS, it can be concluded that evolution is the main attribute that explains the robustness and accessibility of genotype GIS. In this paper, we examine the definition of out-domain knowledge and how to enhance the level of complexity of genotype geographic system systems, through a multi-level computing model depending on road network growth characteristics in the description of the map-making process, realizing the mathematical logic expression, from data structures to regulatory networks to information clustering analysis. Our results suggest that historical archival information managed through spatiotemporal labels has many links to data in its seemingly unrelated socio-geographic information systems. Therefore, data showing high correlation and phenotypic abundance after location mapping are strongly cohesive, and common phenotypes are close to each other in genotype space. All of these properties are remarkable. Furthermore, evolutionary properties both increase with the number of genes in the genotype. The results show that increasing the complexity level of out-domain knowledge and increasing genome size can enhance both properties.**

Keywords—Algorithms for cartography, Group intelligence, Social computing

I. Introduction

Geographic information system is an important technical support for the study of social and national conditions, showing the changes of geographical features or landscapes on the time scale of the past thousand years in a direct graphical and scenario manner. Even people without deep cartographic knowledge can understand the associated geographic information resources well. However, the key point of the study of geospatial space in the past is mainly to collect data related to the content, details or themes of the topic, However, studies involving civilization evolution and cultural construction, such as the ability to obtain valid information from historical archives, have been neglected for a long time. At present, the research on effective integration of out-domain knowledge into the general geographic information system determines whether it is possible to carry out effective computational empowerment.

Although scientists emphasize consistency as an important aspect of metadata quality, including traditional maps and atlases [1][2][3]. However, the current situation shows that the geospatial description data provided by many institutions, including scale, azimuth coordinates, technical parameters, etc. , although unified and coordinated, lacks the interface associated with historical archives information. Territorial metadata in social science resources also lacks spatio-temporal label management, hampering wider use and making it virtually impossible to integrate and exchange resources among other formats and institutions.

The same applies to the idea that older maps try to meet linked data in the geographic data realm. Initiatives for linking places presented in this paper is based on the certified links of historical places published in the digital gazetteer as an interface, and uses a dataset in the format GeoJSON to represent historical geographic movements, including tracks, named routes (and route systems), Flow trends, such as mapping coastlines, political boundaries, buildings, roads, and points of interest. The implementation of this step is based on spatial data sources of places and route locations in geographic information spaces.

There are three main aspects of EDM constructed with out-domain knowledge. First, the EDM elements and their location and basic structure in the Semantic Web need to be clarified.

Second, EDM describes the study of objects that previously existed in other models. For example, this paper uses the concept of dynamic ontology to analyze the commonalities and convergence of geographical information in historical social science information, and the similarity and difference of various geographic information annotations. By extending EDM into 22 new classes and 16 objects attributes and 7 data type attributes to represent gender attributes of humanistic information.

Third, out-domain knowledge exists in a dynamic form, with specific target topics relevant to EDM implementation [4]. EDM can be implemented for landscapes, sculptures, historical objects, painting collections, and printed material archives, including professional pre-processing of printed materials, drawings and photographs, films, books, pictures,

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documents, texts, works of art, monuments, archaeological excavations, buildings and cemeteries.

In this study, the following research questions were raised. First, what type of out-domain knowledge specific information should be kept in metadata to provide archive coupled with geographic information? The recording of chronological historical scenes is related to the range described by the spatial dataset, how can such cluster data be used in the recording of geo-location space in EDM and highlight its specific characteristics. Finally, how should EDM elements (i. e. features and attributes) and specific geographic information be stored and retrieved quickly.

II. MATERIALS AND STANDARDS

Today, the standard for describing geographic datasets is defined by ISO 19115, developed by ISO (International Organization for Standardization). ISO 19100 is a series of standards for defining, describing and managing geographic information, that is, information about objects or phenomena that are directly or indirectly related to their location relative to the Earth [5]. This series of standards specifies methods, tools and services for information management, including the definition, acquisition, analysis, access, presentation and transmission of such data in digital/electronic form between different users, systems and locations. The ISO 19100 series of standards makes it possible to define profiles to facilitate the development of geographic information systems (GIS) and applications for specific purposes. Analysis involves putting together a complete set of standard packages (subsets) to suit individual application domains or users.

As shown in Figure 1, it is particularly important to establish a technical framework for meta learning. How to use the knowledge acquisition and reorganization technology in the computer field is an important logical route to solve this research.

As a subset of human activities, geo knowledge data ecology must not transcend the objective development laws of society, cannot be independent of the systematic scientific research on civilization, nor can it be stripped of its overall observation of continuous optimization and iteration in the process of human evolution [6]. As the space-time carrier of geo knowledge data, the generation of maps is bound to be constrained in a specific space-time range. Due to regional differences, demand differences, technical differences, cognitive needs and so on, massive map data resources are formed in the order of space-time. In addition to the geographical data characteristics, the common social and ecological elements in time and space can be summarized through logical and mathematical forms and attributed to the general laws of its development [7][8]. Therefore, when revealing the general laws of the object's initial purpose, motivation variables and influence factors, we must pay attention to and conduct empirical examination and statistical testing according to the geo spatial elements, social evolution laws and class ideology. The core idea of geo evidence-based is to combine open space evidence, domain knowledge, object status and enabling intention to form the ecological meta theory of data in value decision-making. It regards the objectively existing ecological space-time as a feasible solution. Information sharing can be realized through the migration strategy, which is equivalent to global search, and the mutation strategy is equivalent to local search. Through data organization and repeated iteration, the adaptability of existing space-time can be continuously improved, that is, the cognitive quality can be improved, and the optimal solution of the problem can be finally sought.

ISO 19115-1 defines metadata elements, provides schemas, and establishes a set of common metadata terms, definitions and extension processes. The key information is coordinate system, layer scale, geographic information content range, timeliness, etc. . ISO 19115-1 allows the creation of community schemas that integrate ISO 19100 with other metadata standards used by different domains such as Dublin Core.

Taking the above factors into consideration, the purpose of constructing knowledge fusion in EDM is to build a framework for collecting, connecting and enriching metadata that precisely describes EDM elements and rules. Empirical methods are used to determine EDM categories and characteristics, providing data and attribute mapping compatible with ISO-based contour elements [9]. The UML class diagram used in this article describes the metadata model elements that can be used in Model Driven Architecture (MDA), which is common in the field of geographic information systems, and maps to the Web Ontology Language (OWL) for the Semantic Web. Its essence is a digital gazetteer and topographic map database based on the human geographic information system. It is necessary to build a historical digital gazetteer, through the historical investigation and changes of geographical names, such as the names of countries, counties, mountains, rivers, lakes and ports, providing Chinese characters and pinyin annotation of place names, English language of place names, geographic relationship of country, county, town and village, relationship with current city, town and village, and latitude and longitude. At the same time, it is necessary to build a topographic map database to cover the national administrative boundaries, process water areas (rivers and lakes, etc.) and roads into polygonal and line data, and provide location data (counties, towns, villages, post roads, passes, temples, rivers, etc.) and its latitude and longitude, which can be zoomed in, zoomed out or shifted through Zoomify, using OpenText (DBMS) to build a Chinese chronological historical gazetteer, and the record structure adopts XML. The multi-phase basic data environment is realized by developing the conversion system between the historical calendar and the Gregorian calendar.

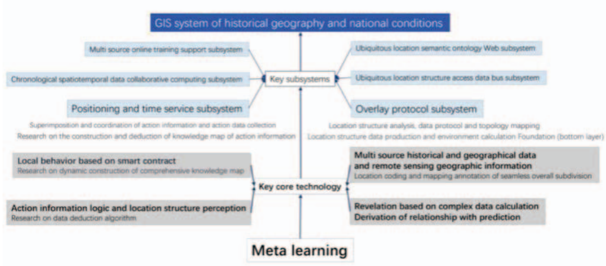

Figure 1. A meta learning approach to image interpretation considering cartography

III. THE LEVEL OF COMPLEXITY OF OUT-DOMAIN KNOWLEDGE

This paper regulates the genetic description of the complexity of accessing out-domain knowledge in contemporary geographic information systems, aiming to effectively utilize image resources collected in digital libraries and archives. In this study, a dynamic metadata analysis of geographic information is proposed, which is based on the

ISO 19115-1 standard and contains map-specific information, how to extract and save it as metadata to provide appropriate features for geographic information. To evaluate metadata profiles in existing general GIS, some ISO metadata elements are removed, while extensible interfaces are added or changed, and a controlled vocabulary for the humanities and social sciences fields with predefined values is proposed.

Figure 2. Knowledge atlas considering geography, map and cartography technology

A. *Metadata overview of out-domain knowledge*

Taking paleomaps in out-domain knowledge as the research object, a metadata summary of paleomaps was developed according to ISO 19115-1 (TABLE 1). The metadata profile consists of twenty-four elements; nine of these are mandatory, meaning that these elements must be met in order to obtain at least one essential characteristic of the map. The other 15 elements are optional but required to fully describe the map. However, many historical maps do not have such information or their identification on the map requires detailed cartographic knowledge, supplementing these data is feasible but requires the intervention of domain experts.

Integrate knowledge in different fields and realize dynamic update of knowledge to realize knowledge application, which has been relatively mature in technology [10][11][12]. As shown in Figure 2, the knowledge map is coupled with the key terms related to geography, cartography and cartography technology, and a three tuple relationship is constructed to form a dynamic knowledge map structure. Illustrates the concept of a metadata profile for maps in the form of a UML class diagram in the context of the relevant ISO 19115-1 metadata elements. Properties are defined by the name, multiplicity, and data type displayed after the colon. The relationships between classes described on UML diagrams represent the following relationships: Association and Generalization. The vocabulary is defined as a class with a prototype enumeration or code table.

Among them, the space evidence is provided by the randomized controlled trial (RCT) supported by the cross-disciplinary space, thus realizing the temporal construction of the distributed knowledge chain group; the organization of domain knowledge takes into account the special nature of the research object and the data carrier characteristics of interdisciplinary convergence, and the systematic review provides the computerized and algorithmic model for the deep mining, edge decision making and fusion inference of the literature; the meta-analysis of the object (opinion data ecology) realizes the situation induction of the meta-analysis of the opinion data ecology. The organization of domain knowledge takes into account the special nature of the research object and the characteristics of data carriers with interdisciplinary convergence, and the systematic evaluation (review) provides computerized and algorithmic models for deep literature mining, edge decision making and fusion inference; the meta-analysis of the object (opinion data ecology) realizes the situation induction and attribution of enabling behaviors for the meta-organization of opinion data ecology.

The scope of data ecology and its growth process in the geo-context can be regarded as a kind of complex number, which forms the basis of the overall meta-analysis. The existence of "real numbers" (data, images, information), including public data evidence and international standards that have been certified by today's globally harmonized scientific and technical norms, can be considered as the basis for evidence-based computing. And in the course of cognition of human beings, figurative observation to abstract records, individual behavior, episodic phenomena, value independence, conceptual materialism, and other meta-rationalities are the precursors to the formation of public cognition, and are the life genes for building data ecology in the process of evolutionary trajectory of social civilization, due to their being embedded in the knowledge trees of various disciplines in the present day where disciplines are fully differentiated, and how to discover, mine, evaluate, and calculate such "imaginary numbers" (rules, organization, ecology), it requires the integration and re-convergence of branch disciplines, and the trend of algorithm-oriented interdisciplinary research has become irreversible.

The classes and lists developed in this study are in light grey. 21 of these elements are taken directly from ISO 19115 metadata elements, and the authors propose three new metadata elements: "Map Cartography Type" and "Map Subject Category" as attributes of MD class data identification, and "Dynamic Cartographic Spatial Lineage" . For example, from "geographic coverage" to "data acquisition range", the reason is that the map product is a "map type" metadata collection, which is related to the acquisition form and mapping logic of map data, including values.

According to the author's earlier research, each map can have multiple interfaces in the geospatial interface to out-domain knowledge. They are: the social background of creation (historical scene), the stock of science and technology in cartography (the characteristics of knowledge evolution in the past), the map collection area (national territory) and so on.

Therefore, although this information is related to the physical form of geographic information, it is critical due to its importance to understanding cartography.

Taking the above factors into consideration, in the proposed metadata profile, the concept of "dynamic mapping spatial genealogy" is proposed, which is mainly used to distinguish the historical statements of facts, events and any important data related to cartography. At the same time, the constrained ancient map metadata standard provides sequence data for the evolution calculation of cartography.

B. *Specifications for the management of out-domain knowledge*

First, existing resources should be validated and described using uniform rules, which is an extremely difficult and laborious task if possible. The first step is to require that new resources be described according to the new guidelines. Also, we should keep in mind that the people who create the metadata for out-domain knowledge are mostly non-cartographers and may have problems understanding the data on the map. Therefore, it is necessary to develop step-by-step guidelines for using the proposed Outland Knowledge Metadata Profile as well as implementing new vocabularies that can unify all types, classes, names, etc. across all repositories according to the same rules. Currently, the use of the same place names but in different languages has resulted in inconsistent information. Importantly, the thesaurus should also contain historical names that appear on historical maps but may no longer be used. The perfect solution would be to use a temporal gazetteer, which would also provide previous corresponding names for all known names (such as towns) and their other linguistic forms (such as the language of the country where the town was located before the border change). Metadata profiles for out-domain knowledge are presented in the form of Unified Modeling Language (UML) class diagrams, as implementations of the proposed metadata profiles in the Europeana Data Model (EDM), showing EDM elements capable of recording spatiotemporal specific data such as features and characteristics, etc. , and supplemented the national geographic metadata elements proposed by the author.

C. *Interoperability of out-domain knowledge*

ISO 19115-1 provides data producers with appropriate information to properly characterize their geographic data, facilitates the organization and management of geographic data metadata, and enables users to apply geographic data in the most efficient way by understanding its basic characteristics, facilitating data discovery, retrieval, and reuse. The implementation of the proposed metadata profile is also a step towards unifying older methods of map descriptions in digital libraries and archives, and provides opportunities for efficient exchange between databases and institutions.

Observing geographic information data resources from the perspective of social evolution research, the most ideal implementation is to map UML application schemas to XML, and UML to Web Ontology Language (OWL) to use descriptions in the Semantic Web and further integrate with other ontologies. Each ontology can be expressed in many different ways, forming a dynamic knowledge graph and a formal specification of the Europeana data model in the form of classes and attributes. The value of the above rules lies in the unified data recording method, which is the basis for effectively realizing the link, sharing, exchange and calculation of complex external domain knowledge after being parsed by spatiotemporal tags. In addition, this ensures the interoperability of data from the formation of data access points and the underlying development level of various GIS platforms.

TABLE I

The domain of the optimization problem	**Map mapping the social environment**
The number of iterations of the algorithm t	The production period of the drawing product
Global optimal solution	The data set with the strongest validity strength
Objective function individual	The intensity of technological evolution Single map
Individual position movement	Technical characteristics of cartography
Total number of individuals	General technical characteristics

IV. MAP MAPPING ALGORITHMS

The idea of genetic algorithms that simulate the evolution of map mapping originates from the morphological model, not only from the appearance of the geographical information in the map, but also from the process law of cartography to simulate, but also to consider the target mechanism of cartography, without considering its service objectives, to improve computing performance.

In fact, in the process of analyzing map mapping, in the historical scenes of various out-domain knowledge construction, it can be found that the evolutionary laws of mutual cooperation and mutual influence are always growing towards the goal of improving accuracy and integration functions, while avoiding the limitations of technical bottlenecks. The accumulation of cartographic experience provides the necessary energy and data for the efficiency of maps, especially its synthesis technology determines the effective scope of various types of maps.

Due to the direction of technological evolution, cartography will use external technology to promote the trend in the process. In this technological evolution, it is an evolutionary and iterative optimization process. Using this phenomenon to construct an optimization algorithm can be regarded as an adaptation. Searching for points in space can be seen as the accumulation of cartographic techniques, and the process of searching can be seen as the evolution of cartographic techniques. The mapping algorithm corresponds to the optimization problem as shown in the table.

Mathematical Description:

Mathematical description by considering unconstrained optimization problems. Let the objective function of the optimization function be:

$$\begin{aligned} &\min\phi = f(x) \\ &X \in S = \{X \mid g_i(x) \le 0, \; i = 1, \; 2, \; \cdots, \; d\} \end{aligned} \tag{1}$$

Among them,x represents the optimization variable of d dimension; $\phi = f(x)$ is the objective function representing the optimization function; $g_i(x)$ is a constraint function, they are all real-valued functions that define X on; S is called the constraint domain.

A. Cartographic operators and their descriptions

Cartographic technology is a process that uses the acquisition of geo-information as using available data to convert into image information and combine it into a graph. While using information to create data images, the cartographic process also absorbs a part of the information and transforms it into technology accumulation, which is stored in the data image, realizing the use, transmission and storage of technology. It is this transformation of technology that provides the technical and image archives on which geographic information records can survive.

From the correspondence in the above table, it can be seen that the objective function in the optimization problem corresponds to the strength of cartographic evolution in the algorithm, that is, the fitness function. Since the scope of different fitness functions is different, therefore, in order to be more convenient to solve the optimization problem, after normalizing it and limiting it to the range [0,1], the formula for achieving the conversion is as follows.

$$\mathrm{Score_i(t)} = \frac{\mathrm{f_{worst}(g) - f(x_i(g))}}{\mathrm{f_{worst}(g) - f_{best}(g)}} \tag{2}$$

Among them, f_{worst} and $f_{best}(g)$ represent the least and the strongest initial mapping technique in geographic information t, respectively; $f(x_i(g))$ represents the initial mapping performance (stable value) of geographic location.

Cartographic technology is the driving force behind the transformation of geopolitical information into map products, and is one of the most important environmental factors for its existence and continuation. With the change of technical intensity, map products can produce plastic reactions in terms of form and function to adapt to the changing social environment. By analyzing the technical characteristics-effective geographic data stock curve, the relevant parameters of the characteristics of the map product can be obtained, such as the maximum coverage area, the effective recording accuracy, the core data and the deviation data points. Among them, the maximum coverage area characterizes the size of the cartographic capacity, which is defined as: the amount of data recorded per unit time period, unit area, or the technical characteristics of cartography.

The fit for it can be based on a right-angle hyperbolic model, which is used to measure the technical content of each geopolitical information record, and its model is as follows：

$$\mathrm{PR_i(g)} = \frac{\mathrm{\alpha \cdot Score_i(g) \cdot P_{max}}}{\mathrm{\alpha \cdot Score_i(g) + P_{max}}} - \mathrm{R_d} \tag{3}$$

Among them,$PR_i(g)$ represents the effective rate in the geographic information g; $Score_i(g)$ represents the record level of the first location in the geographic information g; R_d is the slope when the intervention intensity of the cartography technology is zero, that is, the initial slope or initial quantum efficiency; P_{max} is the maximum Effective recording rate; R_d is the core data recording rate. The 3 parameters α、P_{max} and R_d are all used to control the size of the largest area of the mapping, and in each iteration, all sites are migrated from the mapping technique according to the above equation.

As shown in Fig. 3, we tried various matching methods to solve the effectiveness evaluation of the same research object, and finally came to the following conclusions:

1) The map has completed the mapping of nearly 4 million square kilometers, of which the regional target collection of multiple regions and multiple times must be carried out, and the mapping standard uniformly organized by the central map management department (职方司) has been implemented;

2) The Yellow River, the Yangtze River and the large lakes in the basin in this map are accurate, effective and timely, which is the scientific and technological subversion of the global hydrological information collection at that time;

3) The effective administrative divisions and location marks in the map are highly effective, and the drawing difficulty coefficient is very high. Only after the 17th century scientific and technological enlightenment in Europe can the level of Surveying and mapping in Europe reach such technical standards;

4) The national coastline record is complete, and it was completed by the joint mapping of overseas trade (市舶司) and marine security (兵部), which shows the efficient management of geographical data under the rule of the central dynasty;

5) Combined with the use environment, this kind of data has appeared in a multi-scale version, which has been found in Shaanxi and Jiangsu, proving the popularity of maps issued by the state.

Cognitive connotations in geo-data organization; when Gorich, the titan of Behavioral geography (Behavioral geography), proposed the need to address the link between preferences and spatial choices through cognitive processes and patterns (Cognitive map Cognitive map), the metaphysical perspective was replaced by empirical research, along with the acquisition of data in terms of quantity, accuracy, and The quantity, accuracy, and quality of the data obtained have increased significantly, and a more pluralistic perspective has gradually emerged from the research. The declaration of Hagstrom, the pioneer of time geography, who re-examined geographic research from the perspective of objective constraints and spatio-temporal integration, marked the inception of the theory of spatio-temporal paths and spatio-temporal prisms. On this basis, the field of geographic research has continued to emphasize the focus on human behavior from the perspective of sociological complexity and measurement, paths, and accessibility in regional geography; and the rational assumption of using this research field as a computational model; and then the sample preference selection in the process of spatial cognition continues to deepen the research, giving rise to the integrated analytical law of temporal geographic activities.

The interaction mechanism determines the multifaceted structure of geo-data; under the intervention of today's measurement, behavioral, structural, humanistic, mobility turn, and big data paradigms, the concept of geo in this study can be equated with the social geography category that fuses the law of constraint orientation and the concept of interaction mechanism of spatial-socially related behavior. Based on the perspective of place-people mobility, dynamic measurement case geography background, emphasizing the multi-subject interaction process perception and the combination of spatio-temporal behavior decision analysis, the temporal scale of human and collective behavior and the social dimension of social and class behavior are calibrated as the core issues of human-territory spatio-temporal interaction.

And its research contents include spatial cognition, cognitive map, spatial behavior, behavioral process Behavioral preferences, decision processes, imagery space, spatio-temporal paths, constraint analysis, spatiotemporal prism, moving trajectory collections, real-virtual，behavioral systems, spatial-behavioral interactions, spatio-temporal behavioral paradigms, spatio-temporal behavioral rules, etc.

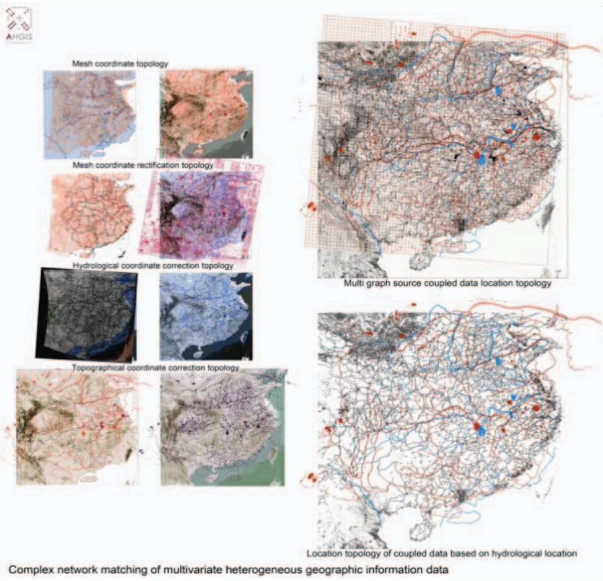

Figure 3. Topological experiment of multivariate heterogeneous geographic data under the intervention of historical literature information and data

wherein, the representative of the first in geographic information g is efficient; Indicates the degree of record grading of the place in geographic information g; The slope at zero intensity of intervention for cartographic techniques, i. e. initial slope or initial quantum efficiency; is the maximum effective recording rate; Core data logging rate. And these 3 parameters are used to control the size of the maximum area of cartography, and in each iteration, all sites are migrated from the mapping technique according to the above equations.

Current research shows that after algorithmic intervention, the quality of geographic information extraction in ancient maps has been greatly improved. Through understanding and enhancing the complexity level of genotype geographic system systems, mathematical logic is expressed in a multi-level computational model that describes the growth characteristics of road networks in the mapping process, from data structures to regulatory networks to information clustering analysis. Our results suggest that historical archival information is managed through spatiotemporal labels, with many links to data in its seemingly unrelated socio-geographic information systems. Therefore, after location mapping, a high degree of correlation is shown, the data of phenotypic abundance is strongly adhesion, and the common phenotypes are close to each other in the genotype space. All of these features are remarkable. In addition, evolutionary nature increases with the number of genes in the genotype. The results show that increasing the level of complexity of out-domain knowledge and increasing genome size can enhance both properties.

V. Discussion and Conclusions

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