Interface Design of GIS System Based on Visual Complexity

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Abstract. This paper will take the GIS system as a typical interface, and analyze the main design elements such as information structure, interface layout and element com-position. Based on the combination coding characteristics of cognitive complexity, a visual representation method is established. Through the preliminary mapping of visual complexity factors and physiological indicators, the mapping relation-ship between digital interface visual information and cognitive brain mechanism of information weapon system is proposed. Finally, the design strategy of GIS interface optimization complexity is proposed, which provides innovative ideas for the study of interface visual complexity.

Keywords: Interface design · Visual complexity · GIS system

1 Introduction

Human-computer interaction of geographic information system (GIS) is getting more and more attention, and GIS human-computer interaction interface is constantly developing and changing, and it is developing in the direction of humanization and intelligence.

The Geographic Information System (GIS) was first proposed by Canadian surveyor Roger F. Tomlinson in 1963 and established the world's first GIS, the Canadian Geographic Information System (CGIS). Later, Harvard University's SYMAP and GRID systems appeared. In the 1980s, GIS gradually matured and was promoted worldwide. The application fields were expanded and combined with satellite remote sensing technology, and began to be applied to global issues such as global change and global desertification monitoring, Nino phenomenon, acid rain, nuclear proliferation and nuclear waste monitoring. At this time, a number of representative GIS software emerged on the market, such as ARC/INFO, GENAMAP, SPANS, MAPINFO, ERDAS, IGDS/MRS. With the rapid development of information technology, GIS systems are widely used in many fields, such as: urban planning, water conservancy and hydropower, network management, network security, land resources, environmental monitoring, traffic scheduling, etc. At the same time, users of GIS systems have also expanded from early professional users to the majority of ordinary users. For the user, the most important thing is that the GIS system can be easily used, easy to learn and respond quickly. The user does not need to spend energy to understand how the background of the system works. Just use the interface to interact with the human body

T. Ahram and C. Falcão (Eds.): AHFE 2019, AISC 972, pp. 713–722, 2020.
https://doi.org/10.1007/978-3-030-19135-1_70

to obtain the required information, and then can complete the task. Geospatial information in GIS systems is essential for location-related information services, especially in some special applications, such as effective decision making in the handling of emergencies. However, with the complexity of human-machine interface, the demand for manipulating complex information system display interfaces is expanding, and its application range is gradually increasing, which is a huge challenge for designers and operators. GIS complex geospatial interface information often increases user cognitive load and high error rate, resulting in a lot of wasted time. This kind of complicated and difficult to understand problems in the use of GIS has always been a problem that has been widely criticized by users, and it is also a problem that has not been overcome in related research. Therefore, the influence of interface complexity on system interaction efficiency is slowly attracting the attention of researchers.

Although most of the current electronic maps or GIS software tend to be the same in some aspects of human-computer interface design (such as file and view operations). However, the human-computer interaction interface of GIS software still has not formed a unified human-machine interface design standard. As a typical complex information system, the GIS system has a large amount of information, a complex information hierarchy, a complex information presentation mode, and a complicated interface layout. The existing design starting point mainly focuses on the realization of functions and not paying enough attention to the user experience. As a result, many systems are powerful, but the interface is not friendly, the information structure is chaotic, the interaction is complicated, and it is difficult to learn and master quickly. This leads to the difference in the human-computer interface of the software, which brings a lot of inconvenience to work and communication.

The application of visual complexity as complexity in the interface and image field was originally proposed in the field of cognitive psychology representation and has a close relationship with human cognitive efficiency. Through the study of visual complexity, qualitatively and quantitatively describing the visual complexity of its interface, it can better guide and grasp the processing and analysis of human-machine system, and it is also of great significance to all fields of ergonomics.

2 Literature Review

The discussion and research on complexity in various fields has a long history. In addition to the fields of information science and computer science, it also extends to the fields of medicine and psychology, and its definitions vary from field to field. But there is no clear definition of it in the field of basic research or in applied research such as advertising and website design. Berlyne [1] roughly defined complexity as the number or diversity of element types in a thing. Geissler [2] summarized the complexity of the study of the relationship between the complexity of the website homepage and the effect of the website's communication, that is, the number of different elements determines the complexity of the other conditions; if the visual elements In the case of a constant number, the difference between elements feels the level of complexity; in a module composed of elements, the number of elements is inversely proportional to the complexity. That is to say, the complexity is determined by the number of elements, the differences between the elements, and the organization.

In the field of cognitive psychology, the study of complexity focuses on two aspects:

1. Complexity evaluation function

Machado et al. [3] found that the boundary detection features are highly consistent with human complexity; in addition, the compression error is also a good measure of complexity; the combination of multiple features can effectively obtain the complexity of human perception. Degree results. Oliva et al. [4] believe that the characteristics affecting human visual complexity mainly include three aspects: color richness, texture clutter and the number of target objects, while the influence of other factors on visual complexity is small. Four factors that affect visual complexity in more detail proposed by Stickel: the number of interactions, the functional elements of the web page (such as links, interface elements that can be active), the number of high-level structures (pictures, display elements, etc.) and RGB information entropy [5]. Huo et al. [6] proposed a mismatch ratio between photo image target object and actual salient object as a measure of complexity based on visual working memory, and proved image complexity, visual attention and visual working memory capacity. There is a relationship between them. Corchs et al. [7] proposed an image complexity perception assessment method based on three attributes: space, frequency and color. Based on neural network technology, the image complexity was initially divided into image texture, edge information and important regions [8].

2. The effect of complexity on cognition

Silva [9] analyzed a visual complexity estimation method based on image description task observation time human eye motion and different computational attention model. It is considered that the compression rate of the heat map or significant map is more consistent with the complexity of the image than that of the original image. Bonev [10] found that the interaction between image complexity and task requirements was the main influencing factor when scanning images of different complexity. At the same time, natural scene statistics play a mediating role in the process of human perception of image complexity. Tseng et al. [11] studied the relationship between visual complexity and web page credibility. Experiments show that users trust text-based high-complexity web pages, and trust levels decrease with increasing complexity. Wang et al. [12] studied the interaction effects of website complexity and task complexity. The user's cognitive behavior and complexity are inverted U-shaped. Task complexity can alleviate the impact of website complexity on users' attention.

In the field of computer, Rigau et al. [13] proposed an image complexity algorithm based on sub-regions, combined with information theory to segment images, and defined image complexity according to the distribution relevance of pixel points. Based on the fuzzy evaluation method, Mario et al. [14] divided the image complexity into three levels: small complexity, moderate complexity and high complex. The complexity of the edge ratio vector of the image and the cluster center is used to determine the complexity. Peters [15] defined the gray level consistency of the image to describe the gray space distribution of the image. The image similarity and distribution are calculated by calculating the contrast and edge intensity of each target similar area to determine the image complexity.

In the field of information science, one of the functions of image complexity is to measure the performance of target recognition algorithms. Rusu et al. [16] used the image complexity to compare and analyze the effects of automatic recognition and manual recognition of handwritten fonts. Li et al. [17] proposed an adaptive Chinese recognition method based on image complexity, which is characterized by automatically selecting appropriate algorithms from various edge detection algorithms according to the complexity of the image to compensate for the use of a single edge detection algorithm. Insufficient, improving the accuracy of Chinese recognition. Many information steganography algorithms also select the appropriate watermark embedding region or steganographic region by analyzing the image complexity. Because image complexity is characterized by differences in image content and is closely related to visual perception, hiding information in areas of different complexity, visual sensitivity and visual effects will be very different. Liu et al. [18] believed that in addition to using information-hidden ratios to measure the performance of analysis algorithms, image complexity is also considered. Carvajal-Gamez et al. [19] proposed a steganography algorithm based on color local complexity estimation (CLCES), which guarantees good visual quality while providing high embedding capacity, which is suitable for adaptive steganography.

According to the research of image complexity in the above fields, the research on image complexity in foreign countries mainly focuses on three aspects:

1. Complexity can be used as an evaluation index to evaluate and improve the performance of an algorithm or measure the quality of an image.
2. Complexity can be used as an attribute of the image, reflecting the visual characteristics of the image, used for target recognition, image classification, information steganography.
3. Complexity can be combined with the basic concepts of the human visual system for the study of image cognition and computer aesthetics.

3 Analysis

As the application of complexity in the field of interface and image, the visual complexity of graphics is one of the indicators to measure the visual stimulus materials because it affects people's cognitive process of graphics. It was originally proposed in the field of cognitive psychological representation research. The visual complexity is closely related to the cognitive efficiency of human beings. The change of complexity is likely to cause the user's confusion in information cognition, which leads to problems such as increased user cognitive load and poor performance, and at the same time greatly affects. People's reading speed and cognitive efficiency. Snodgrass and Vanderwart define the visual complexity of a picture as the complexity of a graphical line in a picture in the study of visual stimuli. In applied research areas such as advertising design and industrial design, visual complexity includes the complexity of visual elements in an advertisement or product to explore the relationship between visual complexity and advertising effectiveness or product availability.

Therefore, GIS complexity research can be a good entry point. Through the study of visual complexity, qualitatively and quantitatively describing the visual complexity of its interface, it can better guide and grasp the processing and analysis of human-machine system, and it is also of great significance to all fields of ergonomics. Studying the complexity of human-machine interface is not only a description of the complexity of the intrinsic value information, but also the complexity of the presentation form and the amount of content. In the process of human-computer interaction, users' perception stratification of information is an important guiding stage of information decoding in the brain. Through the attribute stratification and association construction of visual complexity, users can effectively obtain visual information quickly and efficiently in the cognitive process, and accurately predict and judge. The study found that users' cognitive load on the display interface of complex information systems is much higher than that of ordinary operation interfaces. The functional structure, the effectiveness of information transmission, the convenience of interaction and the aesthetics of visual effects contained in the human-machine interface jointly determine the satisfaction of the user experience during the use of the system.

3.1 User Cognition

Brain information decoding includes four hierarchies of nervous system, sensory, brain decoding activities and memory categories. According to the different ways of information in the record, the nervous system is divided into three categories, namely, sensory organs and thalamus for sensory level recording, cerebral cortex for perceptual level memory, and hippocampus for thinking level memory. Interbrain, neocortex, reflex pathway, etc. The interface information enters the brain from left to right to decode the information, and each decoding activity is limited by the feeling, perception, thinking and reaction in the sensor. This limitation includes both the selection process control from the attention resource and the constraints from the memory extraction and storage capabilities in the information storage activity. Among them, attention resources not only have the choice of "gate" in the input stage of information, but also coordinate the effective allocation of cognitive resources by selecting, maintaining, supervising and regulating information during processing. The extraction and storage constraints of information mainly depend on the memory system: the information from the sensory memory enters the short-term memory or working memory, and then interacts with the schema in the long-term memory. When the brain is to lower cognitive activities, such as reading, recognition, etc.), part of the sensory memory information will be selected into short-term memory, through extracting relevant information from long-term memory processing of new information, finally stored in long-term memory, when the brain have higher cognitive activity (e.g., comprehension, calculation, etc.), the information in the sensory memory by attention to screening, into the working memory for storage and processing of two kinds of process, finally stored in long-term memory.

Human cognitive resources run through the entire brain information decoding process. In the process of cognitive processing, pay attention to the reasonable

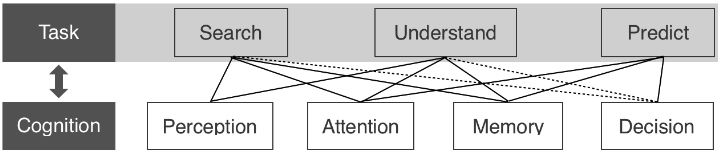

Fig. 1. Relationship between task activities and cognition

awakening of limited cognitive sources through regulation, so as to filter useless interest and select useful information; working memory is based on attention screening, and allocates limited cognitive resources (working memory resources). Processing information entered through selection. The cognitive resources possessed by attention and memory reflect the brain's ability to decode information, and also increase and limit the requirements and rules of design information coding. When people recognize information, whether the cognitive resources are in an efficient state, whether the resources used for information processing can meet the needs of interface information resources, or whether the difficulty of processing information processing is within the cognitive ability range. It is an important factor affecting the effectiveness of human-machine interface information coding and cognitive load. Therefore, whether cognitive resources can be effectively and even efficiently distributed is the key to solving the problem of cognitive load in human-machine interface. From the perspective of cognition, in the process of information processing, the dynamics of information acquired over time and the uncertainty of spatial structure connectivity cause the complexity of cognition. The cognitive phase of users includes perception-attention-memory-decision 4 stages, as shown in Fig. 1. Among them, perception-attention belongs to the user's shallow level of cognition of the image, and the memory-decision stage belongs to the user's deep acquisition stage of the interface information. Therefore, combined with the internal and external causes of the interface cognitive process, it can be assumed that the interface complexity is accompanied by the cognitive behavior of people at different stages of the cognitive process, which can be divided into external visual complexity and internal visual complexity. The external visual complexity mainly presents the basic information of the image, and the inherent visual complexity allows the user to understand and extract the intrinsic information of the image.

3.2 Complexity Analysis

The information processing system at the cognitive level generally contains four important components: perception-attention-memory-decision. At the perceptual level, Lin et al. and Harper et al. confirmed that the layout, structure and background color contrast of the image have an impact on the visual complexity of the image. At the memory level, the user's familiarity is also a factor that affects the complexity of the image at the cognitive level, that is, the correlation and degree of conformity between the image information and the user's memory information. Therefore, the visual complexity is further divided into presentation complexity (CP), semantic complexity (CS) and memory complexity (CM), as shown in Fig. 2.

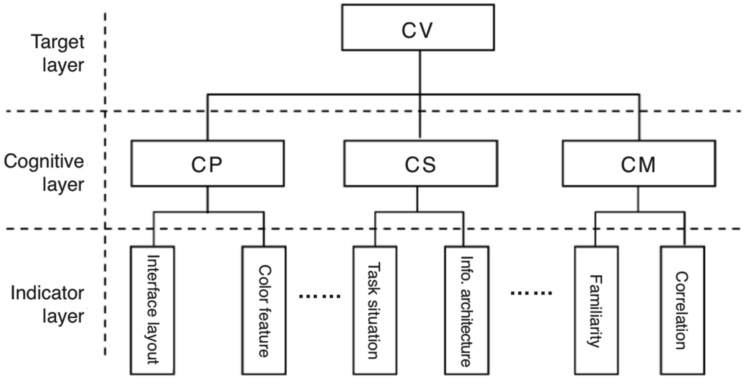

Fig. 2. Cognitive level interface complexity classification

From the perspective of cognitive law, CP mainly exists in the shallow cognitive stage of the user's image, which is an external factor affecting cognition, corresponding to the visual attributes in the interface information, namely visual information such as color, texture, shape and position; The semantic attribute of the corresponding interface refers to the information that the user needs to obtain through understanding, prediction and judgment, that is, the meaning of the topic, the information structure, the spatio-temporal relationship, etc.; the decoding attribute of the CM corresponding interface, and the user's own long-term memory and psychological resources. The tolerance is related to the time pressure. It is necessary to activate the memory to judge the familiarity, relevance and similarity of the internal and external information matching. The mapping model of visual complexity and GIS interface attributes is shown in Fig. 2.

4 Discussion

GIS (Geographic Information System, GIS) system is a computer system that processes, transmits and presents various information based on digital space. It is based on the spatial distribution of observation objects, through physical location, logical relationship, data statistics and alarm status. The aggregation of information forms a comprehensive situation, thus achieving the overall grasp and local monitoring of the observed objects. The integration of data visualization, information visualization and two-dimensional and three-dimensional virtual electronic map display technology makes the interface design of GIS system complex and diverse.

4.1 Model Construction

In order to effectively evaluate the complexity of human-computer interaction interface, and to understand the related factors such as influencing factors, specific performance, and category, the complex information interface is evaluated by means of vocal thinking. The selection of the user's operating experience has a high requirement for the military system interface as the research object, and invites the expert user to conduct the operation experience and interview. In the process of experience, the user needs to use the method of loud thinking, that is, to express and describe the complex features of the interface that he found during the operation. The collected interface description features are abstractly extracted to form interface complexity model elements. Finally, through the above analysis, six kinds of factors that can measure the interface complexity, namely color characteristics, interface layout, information architecture, task scenarios, familiarity and relevance, are extracted. On this basis, according to the user feedback and expert interview results collected in the previous research process and some use cases, the design strategies corresponding to the complexity factor are mined.

4.2 Design Strategy

Presentation complexity (CP) corresponds to two indicators, namely color features and interface layout. First of all, from the perspective of color features, the GIS system contains a large number of multi-dimensional display information, and the more color coding, the more easily the complexity of the entire interface.

It is recommended to use a basic color to determine the overall color, use the different brightness or purity of the same color to reflect the general information, use the adjacent color to reflect the auxiliary prompt information, and use the contrast color to reflect the important or key information.

Secondly, from the perspective of interface layout, it is characterized by more operating areas, dynamic planning of regional location and area, and automatic hiding of some operating areas. For the optimal design of the interface layout, you can refer to the following points: First, the presentation styles of the same type of interface elements in the system should be consistent, and the interaction mode and feedback mechanism of the same function should be consistent; Second, the effective communication of key information is more important than the accumulation of redundant data; Third, to pay attention to the visual balance of the distribution of interface elements, and the key information is placed in a prominent position; Fourth, construct a reasonable information level according to the task execution process or the importance of information; Fifth, it is possible to consider establishing a unified human-machine interface interaction design specification.

Semantic complexity (CS) corresponds to two indicators of information architecture and task scenarios. The information architecture is mainly reflected in the confusion of the information level hierarchy in the system. The complex information architecture increases the user's cognitive load and easily guides the user's wrong mental model. The task scenario is mainly reflected in the uncertainty of task operation and the degree of psychological load on the user caused by the complexity of the task. The higher the difficulty of executing the task, the more complex the task scenario, the design needs to consider that multiple task scenarios may appear at any time. Situation, test users' ability to respond to multi-source, multi-task information.

Memory complexity (CM) corresponds to two indicators of familiarity and relevance. Electronic map system or GIS has strong professionalism. Many people lack the ability to recognize space, that is, they don't have a special understanding of electronic map systems or GIS concepts. Professional concepts such as roaming often appear in software interfaces. The user is very difficult to understand. David Mark (1991) pointed out that user categories, computer level, software usage frequency, personal language, cultural differences and other factors are important aspects of researching GIS user interfaces. The electronic map is aimed at professionals with professionals and non-professionals, but more ordinary people. The professional background and computer level of the public are different. This requires that the electronic map should be user-oriented and people-oriented when designing the interface.

5 Conclusion

Based on the cognitive hierarchy, this paper proposes the classification of interface complexity based on GIS interface features and cognitive processes, divides the GIS interface visual complexity into presentation complexity, attention complexity and memory complexity, and establishes the mapping relationship between interface attributes and complexity. Based on the user's cognitive needs and actual evaluation, the preliminary exploration and research on the mapping relationship between visual perception cognitive mechanism-cognitive complexity factor-physiological index is carried out. Through the simple quantification of the mapping between complex factors and interface elements, the design strategy of optimization complexity is proposed, which helps to further guide the GIS interface complexity evaluation and design practice, and provides a basis for further research on the interface visual complexity.

Acknowledgments. This paper is supported by the National Natural Science Foundation of China (No. 71871056, 71471037).

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