Data Visualization Model Based on the User Experience

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Abstract. The data characterization is effectively explored based on the human cognitive features of data visualization conforming to the characteristics and habits of human beings. It analyzes the principle and characteristics of human cognition, and interprets the advantage of the graphic symbols and visual thinking in cognitive process. Furthermore, a model of the big data visualization is proposed based on the human cognitive law, which includes four main parts: strategic level, scope layer, structural layer and data presentation layer. It gives an example to expatiate that the current visualization of the cognitive model can be applied to the related data visualization, and realize the mapping between the visual cognitive thinking and data visualization.

Keywords: User Experience, Data Visualization, Model

With the advent and development of the big data era, traditional charts are increasingly unsuitable for the flexible presentation of large amounts of data. In today's era of information explosion, how to make users quickly obtain information with their own cognitive ability in an all-round way and achieve the purpose of perceiving information more quickly needs to be closely integrated with human cognitive characteristics, quickly optimize the cognitive environment, and make decisions and deal with problems in an environment that is easy to be perceived and compared in order to effectively improve cognitive efficiency. Among the main unsolved problems of data visualization, Chen [1] mentions the problem of comprehension. For decision making and processing problems, solving the comprehension problem is the key. How to provide better service for data visualization through the design of perceptual level graphics, text and other visual elements is one of the key issues that data visualization urgently needs to solve [2].

1. Defining the Scope of the Study
The comprehension problem will involve factors from both the subject data and the object user. Clarifying the relationship between the two will help in solving the comprehension problem and provide a very good basis for data visualization models [3].

1.1. Data Visualization and User Experience
In order to communicate information effectively, data visualization uses perceptual visual elements to process complex datasets or database information [4], i.e., insights into subject data, and provides conditions for the object user to understand and recognize the data and the relationships between them.
in a collaborative human-computer environment, so in data visualization, it is critical for the user to receive information as an object. And it is from the user's point of view that UX proposes solutions centered on the user's perception. Since the 1990s, user experience was proposed by Donald Norman, and with the rapid development of computer and graphics technology, it has been expanded with a richer range of concepts. User experience is the cognitive impression and response of usefulness, ease of use and friendliness that a user gets during human-computer interaction in order to achieve the purpose of behavior in a certain situation. In the process of data visualization, optimizing solutions from the perspective of user experience will be an effective way to promote user understanding [5]. The Scottish engineer William Playfair's graphical drawing of statistical data has well integrated the features of human cognitive graphics in the user experience, such as his earliest design of the bar chart, which has long been one of the most widely used types of charts up to now. Later, Jacques Bertin, a French expert in cartography and semiotics, repeatedly compared the influences of visual variables in human cognitive processes. In his work on the theory of visual variables, he pointed out that for the quantitative variables that are frequently encountered in visualization, the more effective ways of presenting them are position and length, and that human perceptual estimates are more sensitive to changes in position and length than to changes in other ways. The variables of human cognitive visualization are shown in Figure 1.Jesse James Garrett proposed a model of the elements of user experience based on the design of web platforms. It provides a detailed analysis and process decomposition of user perception and experience from the perspective of research methodology. The model is based on the characteristics of website experience design with complex layers and numerous veins, and is applied in coordination with each of the five levels in the model, which has a great impact. From the point of view of user experience, the adjustment and establishment of data structure in data visualization also need to be built on the basis of user experience, from the user's point of view to organize and filter data, choose more matching visualization elements to represent, make it more reasonable.

![Variables of visual image](image)

**Fig 1.** Variables of visual image

1.2. User Perception and User Experience

User perception refers to the cognitive process through the visual perception of graphic symbols, tactile perception of interaction behavior and auditory perception of auditory impressions to present the relationship and meaning of the data presented. For most people, the left hemisphere deals with the operation of linguistic information, that is, logical thinking; the right hemisphere is in charge of spatial perception and is more dominant than the left hemisphere in non-verbal visual perception, auditory perception and tactile perception, that is, image thinking. Although there is a functional division of labor between the two hemispheres of the brain, the brain is always working as a whole. Data visualization is like full cooperation between the two hemispheres of the brain, and the establishment of data structure in data visualization cooperates with the perception of the user's cognitive process to better promote understanding [6].
2. Data Visualization Based on User Experience

2.1. Strategic Level
The strategic layer is a process of goal setting through understanding the user needs and acquiring data, and in the process of setting goals, it tries to answer what the user wants to know through data visualization. The solution to this question helps to clarify the way in which the user's needs should be met. In answering this question, user research is carried out through research and testing of users, and even the typical characteristics of users can be outlined using user cards. The data collected by understanding the user's needs will be more relevant to the questions and objectives. The results are applied to every detail of the hierarchy, so that clear strategic objectives are essential for data visualization.

2.2. Scope Level
The scope layer under the strategic layer is useful to understand the boundaries of the tasks under the strategic objectives, and the boundaries in data visualization are actually the processing of the data layer. Analyzing the data structure, sorting out the storage and inter-organizational logical architecture between data; data denoising, effectively denoising the data will improve the efficiency of users to access data information. Mining feature data is helpful for discovering new data patterns, and analyzing the anomalies in the data flow to obtain implicit interconnections.

2.3. Structural Layer
The structure layer is perfected under the overall scope of the structure, data mapping maps data values, spatial information, relationships between data, etc. to different visual channels through points, lines, surfaces or colors to achieve the purpose of user perception; interaction design bears the design and creativity in the interaction behavior, reflecting the interactive operation of the user and the terminal, as well as the performance of the terminal in response to the user's operation, if the data The part of the visualization that has no user action will not achieve the purpose of user experience and user understanding and perception. Depending on the data and the user group, the design of the visual prototype can be interactive, rational and interesting [7].

2.4. Presentation Layer
Visual elements that are highly perceptible are studied from the perspective of visual perception in the visual channels at the structural level, such as position, length, light and dark, shape, color, etc., and are applied to the design for the target group. The visual interface is an integral part of perceptual design, and as long as there is operation and interaction between humans and machines, a graphical interface is necessarily involved. The interaction design of the structural layer and the visual elements in the visual channel are integrated in an orderly manner with visual perception, tactile perception, and auditory perception to make the interface meet the interaction requirements. In the hierarchy of strategy layer, scope layer, structure layer and performance layer, each layer exists on the basis of the previous platform, i.e., the scope layer develops user-oriented research based on the objectives of the strategy layer, the interaction and data mapping of the structure layer depends on the framework layout of the scope layer, and the perceptual design of the performance layer depends on the interaction mode and data mapping of the structure layer. Overall.

3. Case Study
In the case of a nationwide statistical survey, for example, strategic goals are set and confirmed by analyzing user needs from a strategic perspective, and the results of user research are used to create a user card to segment the population. In this example, we compare the differences in real-time data between different regions of the country in order to analyze users effectively for decision making. In the scope layer, by extracting the feature data of provinces, cities and municipalities in the database, the author replaces the coordinates or abstract place names with map-like graphic symbols in the
selection of perceptual elements in the presentation layer. The statistical analysis of the data is shown in Figure 2a, where the vertical bar graph on the 2D data visualization is used as a visually perceived graphic symbol, with shading to enhance the 3D effect. This oblique map-like graphical form of the vertical histogram presented on the graphical symbols facilitates the user to obtain preliminary judgments on variables by visual comparison. The hidden design is shown in Fig. 2b, and the ordinal variables of some comparison parameters are used in the interaction design session at the specific structural level with the hidden design to facilitate further precise analysis by the user [8]. Secondary interface design see Figure 2c, provincial and municipal areas are placed in the secondary page design, through the hierarchical framework interaction design, eliminating the excessive information on the primary page to cause confusion to the user's feelings. The interaction design is shown in Figure 2d, and the spatial geographic location in the corresponding structure layer is mapped by color mapping and height mapping, which improves comprehension from user experience and accelerates cognitive efficiency to achieve an intuitive and effective cognitive effect [9].

![Spark ML Workflow](image)

**Fig 2.** Design example

At the same time, the haptic sense of the interactive details reflected in the traditional mouse and terminal interaction process, such as the interaction with the geographic coordinates of the process, with the coordinates of the change shows a slight tilt, in order to reflect the immediate and exquisite feedback on the operation of the location; visual text and graphics of high perception of the design; auditory perception with dynamic sound effects. The result is a concise, intuitive, user-friendly experience that is also interactive and interesting.

In the presentation layer, the color channel also corresponds to the cognitive characteristics of the users in the strategic target. After understanding the target group in this example, the simple and intuitive design style was adopted to eliminate unnecessary interference. The effect is presented after the specification is set, such as the visualization interface design in Figure 2a, the color channel occupies a very important position for the overall data visualization interface, and the selection and control of the color tone gives people a rational and neat effect. The data visualization scheme derived from the cognitive model design of data visualization here presents good results in user experience, powerfully strengthens user understanding, and is significantly more effective than traditional visualization [10].

4. **Conclusion**

The study of data visualization based on the characteristics of human cognition, using the system model process decomposition method, proposed a model of data visualization based on user cognition. This model mainly contains four levels, namely, strategy, scope, structure and performance, each level is based on the previous platform, and the relationship between the levels is closely related to each
other to form a whole [11]. The core is to analyze and visualize the purpose of data through the hierarchical design of the data visualization model based on user experience, and to reveal the relationship between the visual channels and interaction methods such as graphics and text through friendly perceptual design, making these visualization components work together and influence each other [12]. Use data visualization for cognitive services, inspire logical thinking while providing cognitive shortcuts for visual thinking and to achieve cognitive purposes of data visualization that enhance comprehension and provide inspiration for user decision making.

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