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Salt Craft Visual Analytics System

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Abstract: The traditional well salt production process in Sichuan is an important component of Chinese culinary culture, and its in-depth exploration contributes to the inheritance and promotion of intangible cultural heritage. To systematically analyze the production techniques of well salt and uncover its health value, this study proposes a multidimensional visual analytics system. First, novel visualization designs such as the "Bamboo Diagram" process metaphor and the "Fuxi River" spatiotemporal flow view are introduced to help users analyze the characteristics of traditional salt-making techniques from multiple dimensions. Second, through cluster analysis of the mineral composition of four types of salt (well salt, sea salt, etc.), a three-dimensional "composition-efficacy-population" correlation model is constructed, enabling users to explore the health benefits of different salts from various perspectives. Finally, a comprehensive well salt data visual analytics system is built with multi-view linkage, supporting users in exploring and comparing the salt-making process and health value at multiple levels. Through compositional analysis and efficacy validation, a scientific evaluation of the data confirms that well salt is rich in minerals such as potassium and calcium, highlighting its health benefits for hypertensive populations. The effectiveness of the visualization views and the practicality of the system are also demonstrated.

Keywords: Sichuan Well Salt; Salt Production Process; Component Analysis; Multidimensional Visualization; Visual Analytics.

1. Introduction

Sichuan well salt culture, a gem of China's traditional handicraft civilization, boasts a history of over two thousand years, bearing witness to the wisdom and technological achievements of ancient laborers. As a unique salt variety in the Sichuan-Yunnan region, Sichuan well salt is renowned for its highest output and superior quality [1]. Drilling technologies such as the Zhuotong Well and Shenhai Well in Zigong, the "Millennium Salt Capital," are hailed as the "Fifth Great Invention of Ancient China" [2], showcasing the ingenuity of ancient working people. However, with the advancement of modernization, traditional salt-making techniques face the risk of being lost, and the differences in mineral content among various types of salt and their health impacts on specific populations have yet to be systematically popularized, further marginalizing traditional well salt culture.

Against this backdrop, this study developed the "Salt Craftsmanship Visualization Analysis System," aiming to achieve dual objectives: first, to digitally preserve and pass down the cultural heritage of well salt through digital technology; second, to provide the public with scientific decision-making support for salt selection. Innovatively integrating visualization technology with well salt culture research, this system comprehensively reconstructs traditional salt-making processes and systematically analyzes the compositional characteristics of various salts and their correlations with suitable populations.

2. Related Work

This study integrates traditional salt-making processes, salt classification, and visualization techniques. The data involved primarily consists of textual information while also exhibiting multidimensional characteristics. Therefore, relevant research is reviewed from two perspectives: text visualization and multidimensional data visualization.

(1) Text Visualization

As an important branch of data visualization, text visualization employs graphical methods to intuitively reveal the internal structure and relational patterns within textual data, providing an effective approach for understanding complex content [3]. In cultural studies, Chen et al[4]. constructed a semantic network relationship graph of Yuan Dynasty clothing, systematically analyzing the clustering characteristics and associative patterns of apparel artifacts to uncover their cultural significance. In the era of information explosion, Liu Honghong[5] proposed a text visualization model that significantly improves information processing efficiency, helping users quickly identify hidden relationships in text through graphical representations. Additionally, to address the visualization needs of temporal text data, Jiang Tingting et al. innovatively employed Sankey diagrams and designed corresponding visualization algorithms, effectively mining and presenting implicit knowledge in time-series textual data.

This study applies text visualization techniques to systematically process unstructured textual data in traditional salt-making. Natural language processing (NLP) is used to extract key entities—such as tool names, labor categories, and operational steps—from salt-making process documents, constructing a semantic relationship network. A temporal sequence diagram is established to display the procedural information of traditional salt-making, addressing the inefficiencies and obscured relationships in conventional literature reading. This approach helps users identify core elements and implicit knowledge from vast texts, offering a novel research method for the digital preservation of salt-making cultural heritage.

(2) Multidimensional Data Visualization

Currently, multidimensional data visualization techniques are widely used for intelligent analysis and decision support across various fields. Chen Bo et al. conducted a multi-perspective analysis of epics, integrating data on character themes, regions, and clan themes to visualize multidimensional keyword correlations, enabling direct observation of inter-thematic relationships. In visualization research, time-based multidimensional data visualization is a critical direction. Zhang Yuwei proposed a multidimensional visual analysis method for Tang and Song poetry, designing novel charts and interactive views to present temporal changes and attribute correlations, aiding in understanding poetic patterns. Similarly, Li et al. developed a semantic spatiotemporal cube that simultaneously displays time-series trends, geographic distributions, and semantic evolution through multi-view linkages.

To address the need for analyzing heterogeneous data in traditional salt-making, this study implements multi-dimensional dynamic visualization and designs innovative views. Interactive methods dynamically present hierarchical relationships among labor roles, tools, and operational steps in the salt-making process. Additionally, it analyzes the correspondence between salt composition, content differences, and suitable consumer groups. By leveraging multidimensional visualization, complex data becomes more intuitive and comprehensible, providing robust support for related research and applications.

3. Data and Tasks

(1) Requirements Analysis

The traditional salt-making process is highly complex, with extensive textual information recorded in historical literature. Taking the well-drilling stage as an example, it consists of numerous detailed steps, each closely associated with various tools. These intricate and interconnected details make it difficult for general users to quickly extract key information or construct a comprehensive mental framework of the traditional salt-making process, hindering a clear and holistic understanding. Meanwhile, the current market offers a dazzling variety of salt types, leading to confusion among consumers. Since individuals with different physical conditions and dietary needs require different types of salt, people often struggle to choose the most suitable product. Based on these challenges, this system proposes the following analytical tasks:

N1.Text Visualization of Traditional Salt-Making Processes:

Utilize text visualization techniques to mine, extract, and categorize textual information from each stage of the traditional salt-making process, including well drilling. Present detailed procedural steps, related tools, and logical relationships between stages in clear visual charts, helping users quickly navigate complex information and establish a structured understanding of the entire process.

N2. Comparative Analysis of Salt Types:

Collect data on the composition, benefits, and applications of the four major salt types (sea salt, well salt, lake salt, and rock salt). Compare their trace and major elemental compositions, analyze their suitability for different human physiques based on elemental health benefits, and assist users in making informed and efficient choices.

(2) Design Objectives

Based on the above requirements, the objectives of the visual analysis system are summarized as follows:

T1. Visualization of Traditional Salt-Making Process Information

Divide the salt-making process into four main stages—well drilling, brine extraction, brine transportation, and salt production—and design an intuitive visualization. Support interactive exploration of the relationships between processes, worker roles, and associated tools/facilities.

T2. Visualization of Salt Classification and Differences

Conduct a systematic exploration and visual presentation of the four major salt types, including their compositional content, suitable consumer groups, and geographical distribution. Provide clear reference guidelines for users with different needs, aiding the public in making scientifically informed salt selection decisions.

(3) Data Sources

Based on task analysis, the data used in this study includes information related to the traditional salt-making process of Sichuan well salt, as well as data on the distribution of production areas and the compositional content of well salt, sea salt, lake salt, and rock salt, along with the health benefits of their constituent elements.

The data on the salt-making process, salt worker roles, and tools were collected from Sichuan Salt Administration Records and The History of Chinese Well Salt Science and Technology. After processing, four main procedural steps—well drilling, brine extraction, etc.—were identified, and the categories of salt workers and tools were classified and summarized.

Information on salt classification was sourced from the China Salt Group official website and the national standard GB/T 5461—2016. Based on the origins of the salt, four major types—well salt, sea salt, lake salt, and rock salt—were collected, including data on elemental composition and production area distribution.

4. Data Processing

The visual analysis workflow is shown in Figure 1. During data collection, based on demand analysis, relevant classical texts and website data on the four types of salt were manually gathered and web-scraped, covering six aspects: the traditional well salt-making process, salt worker roles, salt-making tools, salt classification and production areas, compositional content, and health benefits. In the data preprocessing stage, the collected raw data were cleaned, filtered, and segmented. Using the processed textual and multidimensional data as a foundation, mining and analysis of information such as salt types, elemental content, and suitable consumer groups were achieved through category classification and correlation analysis. For visualization design, the Vue front-end framework was employed to build the webpage, while the D3.js and Echarts libraries were utilized to implement two visualization modules: the salt-making process and salt classification.

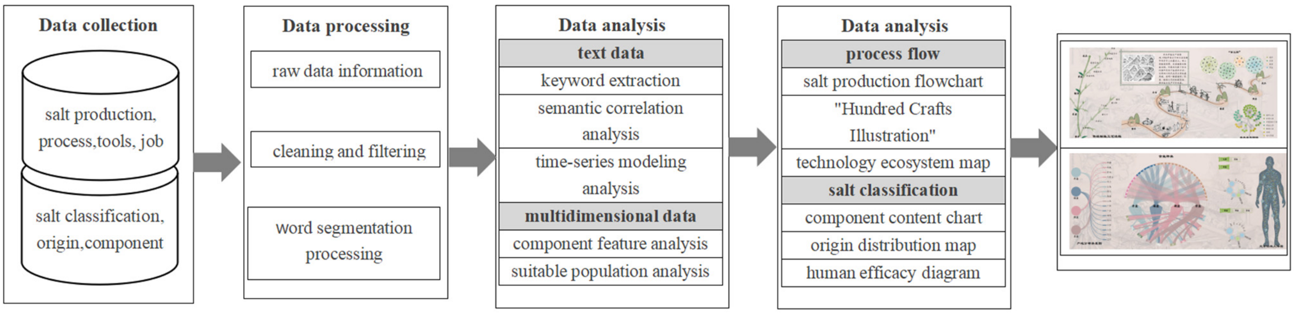

Figure 1. Data Processing and System Design

5. System Design

To achieve the defined objectives, this study proposes and implements a visualization system for traditional salt-making processes and salt classification. The system includes a flowchart of traditional salt production, a bubble chart of salt worker occupations, diagrams of tools and facilities related to the process, as well as visualizations of salt composition, suitable consumer groups, and geographical distribution of salt production sites. The visual analysis begins with salt classification, allowing users to select different salt types, compare their compositional content, explore suitable salt varieties for specific demographics, and examine the distribution of production regions.

(1) Traditional Salt-making Technological Process

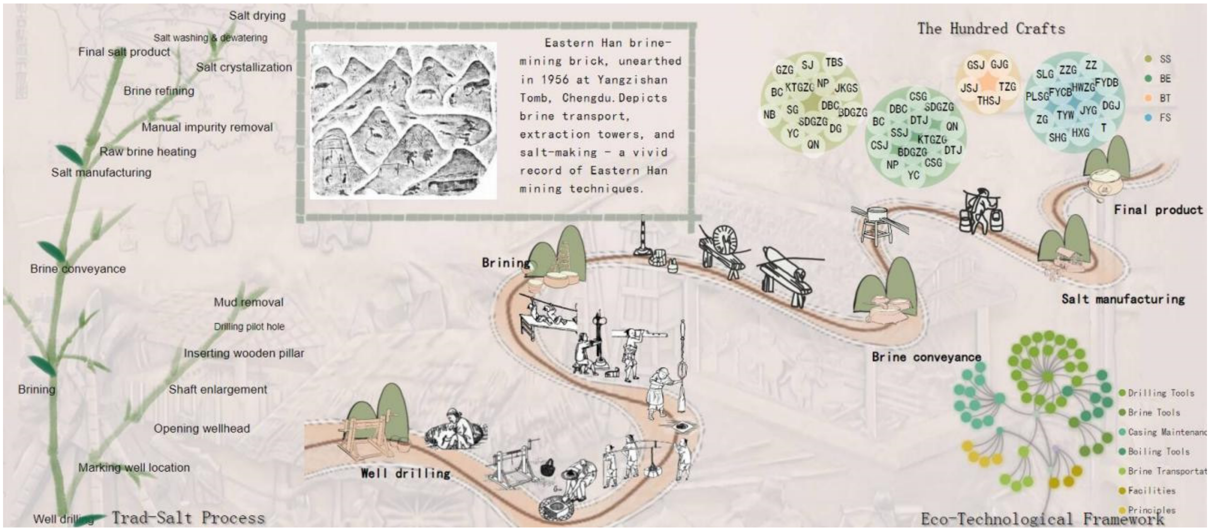

Figure 2. Process Flow

Based on the design goal T1, in Visual Diagram 1, an innovative visualization method is adopted to present the multi-dimensional information of the traditional salt-making technological process. Among them, Fig. 2 (A) "Bamboo Diagram" uses the natural growth form of bamboo to metaphorize the technological process. The main trunk presents the four core stages of "well-drilling, brine extraction, brine transportation, and salt frying", and the branch structure elaborates the sub-steps of each stage (for example, "well-drilling" includes 6 sub-steps such as well location determination and wellhead opening), realizing the hierarchical expression of the technological process. Fig. 2 (C) "Fuxi River Diagram" draws on the morphology of salt transportation rivers to design a time-sequence flow chart, gradually unfolding the details of each link in the form of river evolution. Fig. 2 (D) "Hundred Workers Diagram" uses nested bubble charts to classify salt workers' occupations in a process-oriented manner. Fig. 2 (E) "Technical Ecology Map" displays the categories of tools and facilities in the shape of a dandelion. Fig. 2 (D) and (E) establish a dynamic association mechanism with the main flow chart, intuitively presenting the mapping relationship between occupation division, tools/facilities, and the technological process. This multi-view collaborative visualization scheme, through metaphorical design, hierarchical decomposition, and associative interaction, enables users to grasp the overall architecture of the process and delve into local details, thus achieving multi-dimensional cognition and immersive experience of the traditional salt-making technology.

(2) Salt Classification

Centered around the design objective T2, this paper constructs a visual classification of salt types as illustrated in Figure 3. The core visualization, the "Salt Types" diagram (Figure 3(B)), employs a circular Sankey chart design to intuitively display the composition, proportional content, and target demographic characteristics of the four major salt categories: well salt, sea salt, rock salt, and lake salt. It supports interactive queries for detailed information. Figure 3(A), the "Production Distribution Map," showcases the geographic distribution of these four salt types, ranging from western regions to eastern coastal areas. The "Element-Usage" chord diagrams (Figures 3(C) and (D)) present the chemical composition of each salt type and their corresponding health benefits. Figure 3(E), the "Element Function Human Body Diagram," uses element bubbles to illustrate the physiological effects of salt components.

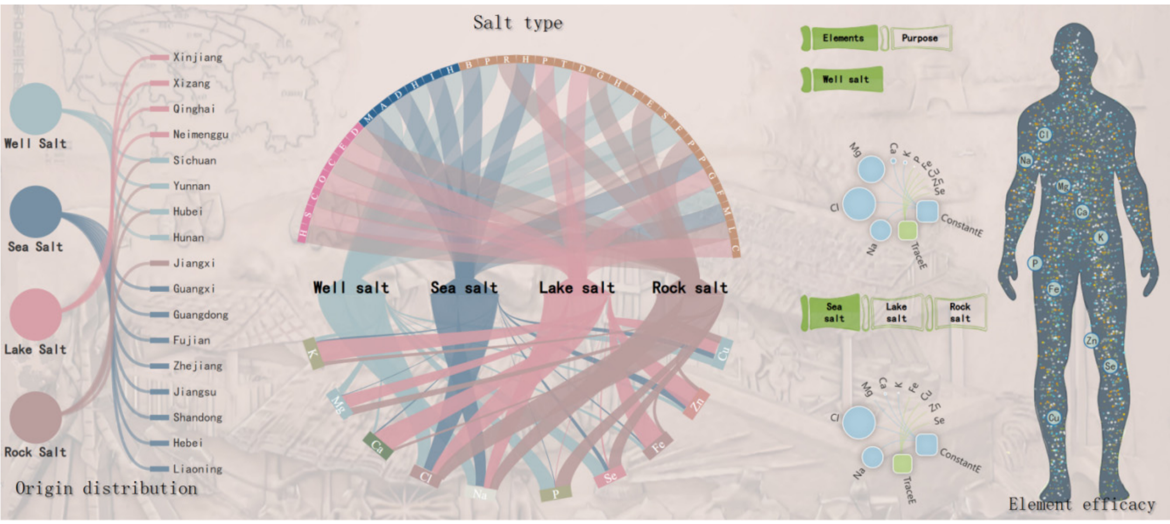

Figure 3. Classification of Table Salt

Based on the visualizations in Figure 3, the analysis proceeds as follows: Through Figure 3(B), the system systematically examines the differences in elemental content and target demographics between well salt and sea salt, lake salt, and rock salt. Further integrating the data correlations in Figures 3(C, D, E), a multidimensional mapping of "composition-benefits-demographics" is established to explore the suitability of different salt types for various populations. This provides more precise and comprehensive guidance for individuals when selecting salt.

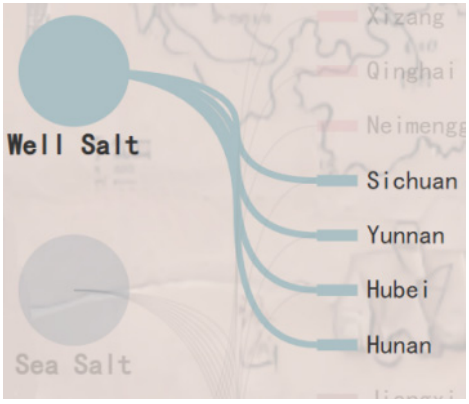

Figure 4. Production Map of Well Salt

6. Case Study

Mineral Composition-Population Suitability Analysis: Well Salt vs. Sea Salt:

China boasts a rich diversity of salt resources, primarily categorized into lake salt, well salt, rock salt, and sea salt, with production areas spanning from the western plateau to the eastern coastal regions. Due to differences in sources and extraction methods, various types of salt exhibit distinct mineral compositions and health benefits. This case study focuses on well salt and sea salt, conducting an in-depth analysis of their compositional differences and evaluating their suitability for individuals with hypertension.

(1) Salt Sources and Composition Comparison

Well salt is predominantly produced in inland regions such as Sichuan and Yunnan (Figure 4). Its brine is extracted from underground sources at depths of over a thousand meters. As illustrated in Figure 5, well salt is rich in minerals, containing not only sodium chloride (NaCl) as its primary component but also trace elements such as potassium (K), calcium, magnesium, and zinc. In contrast, sea salt is obtained through the evaporation of seawater, with production concentrated in coastal areas like Guangxi and Fujian (Figure 6). Although sea salt contains small amounts of potassium, calcium, and other minerals, its overall mineral content is relatively lower compared to well salt (Figure 7). Additionally, since well salt brine is sourced from deep underground inland, it is less exposed to pollution and maintains higher purity than sea salt.

(2) Key Mineral Content and Health Implications

As shown in Figure 8 and 9, a comparison of the mineral composition between well salt and sea salt reveals that well salt contains significantly higher levels of potassium and calcium than sea salt.

Figure 5. Composition Diagram of Well Salt

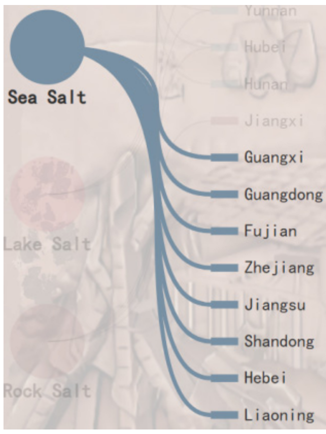

Figure 6. Production Map of Sea Salt

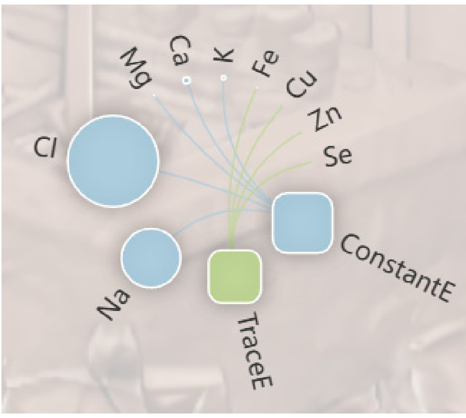

Figure 7. Composition Diagram of Sea Salt

Potassium plays a crucial role in human health by helping to balance sodium levels in the body, thereby effectively alleviating vascular pressure—a particularly important benefit for individuals with hypertension. Calcium, on the other hand, contributes to maintaining bone health and proper neuromuscular function. Although well salt and sea salt have similar sodium content, the presence of potassium, magnesium, and other minerals in well salt can partially counteract the blood pressure-raising effects of sodium, making well salt a milder option in terms of blood pressure impact. Considering these factors, well salt is more suitable for individuals with hypertension from a health perspective, as illustrated in Figure 10.

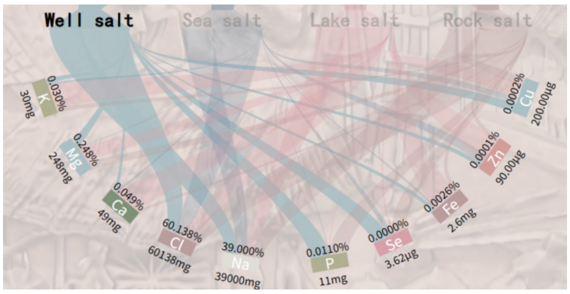

Figure 8. Composition Content Chart of Well Salt

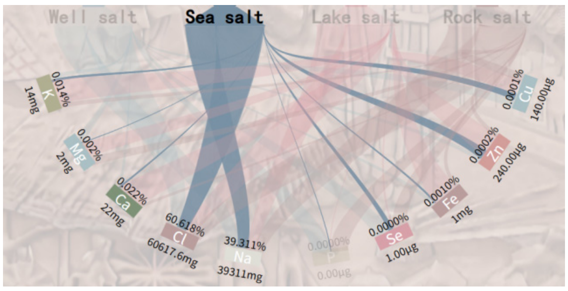

Figure 9. Composition Content Chart of Sea Salt

Figure 10. Chord Diagram of Suitable Populations for Well Salt

7. Conclusion

The "Salt Craft Visual Analytics System" innovatively integrates text visualization and multidimensional data analysis techniques, paving a new path for the preservation of well-salt culture and the dissemination of scientific knowledge on salt usage. It vividly presents traditional salt-making techniques, enhancing public understanding and appreciation of well-salt heritage. Through visualized charts, the system conducts correlation analyses between the compositional content of four major types of edible salt and their suitability for different demographic groups, providing users with valuable references for salt selection. However, this study has limitations: the scope of data collection could be further expanded, and the analytical dimensions of the relationship between salt and health require further enrichment. We anticipate that more scholars will contribute to this field in the future, continuously improving the system to better preserve well-salt culture and provide more precise health guidance for the public.

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