A Diagram-Based Interactive Interface Design for Art Exhibitions

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Abstract

This paper presents design phases of a Diagram-Based Interactive Interface Design (DBIID) for art exhibitions. To develop DBIID, the information visualization model presented by Card, Mackinlay and Schneiderman in 1999 was foundational. In the design process of DBIID, first data is collected from various sources and then transformed to be interpreted in the *Processing* coding environment. Before visualizing each data type in the interface, visual structures are designed. Diagrams are created by different arrangements of visual structures. Last, the interface is interactively experienced by the users and new features are added to the interface based on user feedback. In this study, the DBIID is developed for the "Artist in Their Time" exhibition of İstanbul Modern. Initial findings of the experiments show that DBIID can be used to visualize both abstract and concrete data of an artwork or exhibition by using diagrams. Also, these diagrams can help exhibition visitors to gain a deeper understanding of the artworks and exhibition.

1. Introduction

In the present day, with increasing amounts of data, technology has undertaken a significant role in refining and transforming data to make it more understandable for the user. In this context, many research disciplines use various data visualization techniques. The data visualization process includes a series of operations such as: collecting data, transforming it into visual structures, and presenting them through an interface. Data visualization is widely used in the education field. Visualizations as a graphical display of data can be used to reveal or teach ideas, concepts, and relationships between phenomena. Through the visualizations, learners are expected to synthesize information and construct their knowledge related to the presented content.

Another education-related field is museology. Since the 18th century, museums as institutions have undertaken the mission of educating societies. Until today, museums have developed different formal, informal and interactive learning models for transforming the data into a more useful format (information). Specifically, museums concerned with history, nature, and space, information are presented to the visitors with systematic interactive displays (maps, timelines, holograms etc.). The interaction between exhibitions and visitors are experiential. However, art museums do not adopt this kind of approach. Visitors in art museums are generally passive observers without any digital or physical interaction. In art museums, exhibited artworks are also presented to the visitors through labels, audio guides, and QR codes that provide written information limited to well-known features of the artworks. Besides these, art museums have developed their own mobile applications. However, these applications do not convey more information to the visitor than was obtained during the museum visit (Figure 1).

Figure 1. *(a) Mobile Application of Guggenheim Museum [1]; (b) Mobile Application of MOMA [2]*

In addition, visitors visit the art museum in a limited time within the scenario developed and route defined by the curator. However, this situation makes it difficult for visitors to gain in-depth understanding about the exhibitions and artworks and to perceive the embedded patterns such as transitions from one theme to another, distribution of artworks by time periods, grouping of artworks etc.

Based on these problems, in the scope of this study, a diagram based interactive interface was designed that invites the visitor of art museums to learn actively by doing visualizations based on various data belonging to artworks. The main purpose of this study is to enable the visitor of the art museum to seek new information and construct their knowledge about exhibition and artworks through interactively created diagrams. Another purpose is to give the visitor the chance to visit the exhibition without any temporal or spatial restrictions through the interface.

Within the scope of the study, the "Artists in Their Time" exhibition opened by the İstanbul Modern (art museum) in 2015 was selected as a case to design the interface. The interface has been designed in *Processing* coding environment and tested with a group of respondents consisting of people who have visited or not visited the museum. As an initial finding, it is observed that the respondents who used the interface are able to synthesize information, discover new relationships between the artworks that are not explicitly presented during the museum visit.

2. The Role of Interactive Systems in Museums

Data visualization tools have been designed to present and make inferences from the data. Concepts, techniques, and theories associated with the design of these data visualization tools are adopted from fields of psychology, computer science, statistics, graphical design, and

multimedia design [3]. Since the artworks in the museum have many features and each feature corresponds to a different data type, exhibition can be considered as a large data source. Through using different filtering techniques, visualizations support the human's cognitive skills to handle complexity and find patterns in this large data set [4].

The learning experience in the museum is often supported by interactivity and this experience is enhanced by the use of various data visualization tools. Adams and Moussouri [5] classified museums as interactive and traditional, and then asked adult and child visitors to express their thoughts on museums in their own words. Statements describing the interactive museums are listed as: exciting, enjoyable, colorful, participatory, memorable, and insightful. Statements describing the non-interactive museums are listed as: boring, passive, adult-centered and physically and behaviorally constraining.

In the art museums, data of the artworks is not explicitly presented. However, by reading related text from exhibition catalogues and other sources provided by the artist or the museum, visitors may gain a better understanding of the artwork. The main reason why visitors further investigate artworks (even artworks previously seen in the exhibition) is because the artwork contains some abstract (implicit) data.

Diagram as a type of visualization and representation aims to make abstract (implicit) data visible (explicit) and investigate their embedded relationships. According to Allen [6], diagrams describe possible relationships between elements, rather than being a "thing" itself. Diagrams as schematic representations also help to reduce complexity, enhance the cognitive limits, and question the relationships [7,8]. Diagram is an expression of an abstracted entity, concept, or event. However, this abstraction should not mean a reduction of phenomenon. Beyond supporting the representation of a production process in mind, diagrams play an important role in the externalization of abstract concepts such as design ideas through visuals [6,9,10]. Diagrams also undertake many tasks such as establishing relationships of abstracted concepts, ideas, and raw data, presenting their relationships, synthesizing information from these relationships, and transferring the synthesized information [9].

In this study, an interface has been designed to visualize a comprehensive exhibition and a large number of artworks of an art museum by considering visible (explicit) and invisible (implicit) information belonging to them. In this context, to visualize both concrete and abstract data together, the interactive visualization interface was decided to be diagram-based. In Section 3, the general framework of interface design and its design phases are explained in detail.

3. Framework of the Interface Design

İstanbul Modern was founded in 2004 as Turkey's first private modern and contemporary art museum. In its first permanent space (Antrepo #4, a former customs warehouse in Karaköy), İstanbul Modern continued its activities for 14 years. Due to the new "Galata Port" master plan, Antrepo #4 was demolished and İstanbul Modern moved to its temporary space in Beyoğlu, as of 2018.

In this study, the exhibition titled as “Artists in Their Time” which took place as a temporary and themed exhibition in İstanbul Modern between August 2015 and June 2017, was selected as a case. This exhibition includes 183 artworks belonging to 109 artists. Figure 2 shows interior space of the İstanbul Modern at Antrepo #4 before moving and different types of artworks including painting, sculpture, video, and installation exhibited in “Artists in Their Time” exhibition [11].

Figure 2. *Photos from İstanbul Modern at Antrepo #4, “Artists in Their Time” Exhibition, 2017 (Photos by Author)*

The reasons for choosing this exhibition for the interface design are as follows:

- The exhibition's content in terms of type of art works, number of artists and variety of themes.
- The exhibition has been visited by the vast majority of people living in İstanbul and is likely to be revisited before or after using the designed interface; the popularity of İstanbul Modern provides this study an opportunity to collect feedback.

While designing the Diagram Based Interactive Interface Design (DBIID), *Processing* coding environment was used for visualizing and externalizing the links between different kinds of data of the artwork. As a foundation to DBIID, the information visualization model presented by Card, Mackinlay and Schneiderman [12] was taken.

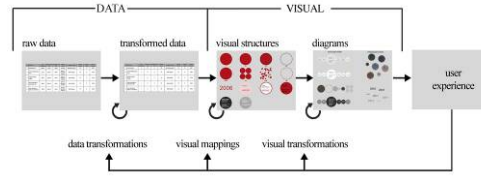

Figure 3. *Flowchart of the DBIID developed based on Card, Mackinlay and Schneiderman’s [12] model*

The phases of the design process of DBIID can be listed as: the collecting raw data obtained from the sources, the transformation of raw data to be used in the computer environment, the creation of visual structures for each data type, the diagrams created by the visual structures, and the experiencing the interface by the users (Figure 3). In the following subsections, design phases of the DBIID are explained in detail.

3.1 Collecting and Refining Data

In the scope of this study, the data of the exhibition is obtained from written sources such as boards and labels in the exhibition space, exhibition catalogues prepared by the museum and information from the museum’s official website (Figure 4).

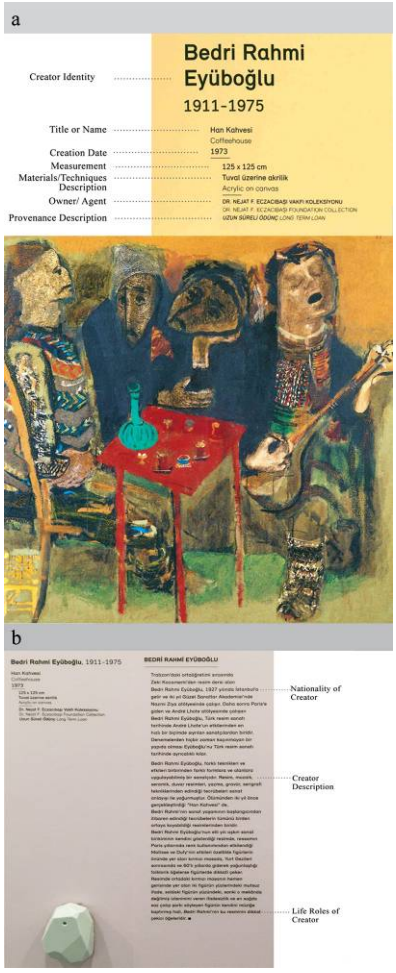

Figure 4. *(a) Data from Exhibition Catalogue [11]; (b) Data from Labels (Photo by Author)*

To refine the obtained data, the main categories of the CDWA (Categories for the Description of Works of Art) classification system developed by the Getty Center is used [13]. In the scope of this study, the categories (storage number, cataloging style, etc.) of the CDWA that are essential only for museum experts are not included in the classification.

First, the dataset consisting of 183 pieces of artwork from the exhibition were classified as textual and numerical. Some of the textual data has been converted to numerical data to ease the interpretation of data by the computer. Figure 5 illustrates the textual (T) and numerical (N) data types, also transformation of data types from T to N. For example, while “1” in the data table represents installations, “2” represents photographs, “5” represents painting. Alternatively, in another dataset, including 14 different countries; while artworks created in Germany are represented with “1”, Netherlands with “8” and “Turkey" with "13”. In this step, all data related to the artworks are stored in the Excel sheets. These Excel sheets then imported to *Processing* to create diagrams.

ID	Title	Catalog Level	Object/Work Type	Classification Level	Creator Description
1	cehennemim	item	painting	painting	painter
N	T	T	T	T	T
N	T	N	N	N	T

Creator Identity	Nationality of Creator	Creator Role	Creation Date	Size 1	Size 2
fahrelnissa zeid	turkiye	painter	1951	205	528
T	T	T	N	N	N
T	N	N	N	N	N

Size 3	Duration	Dimension Description	Color Code (R)	Color Code (G)	Color Code (B)	Materials/Techniques Description
0	0	2 dimension	119	95	61	oil on canvas
N	N	T	N	N	N	T
N	N	N	N	N	N	T

Theme	Owner/ Agent	Provenance Description	Collection Status
personal issues	Istanbul museum of modern art collection	unknown	Sirin devrim and prince Raad donation
T	T	T	T
N	N	N	N

Figure 5. *22 Data Types and their transformations*

3.2 Transforming Data into Visual Structures

The refined data of artworks are transformed to two-dimensional visual structures so that the data belongs to artworks can be easily understood by visitors. While transforming the raw data of artworks into visual structures, basic design elements such as point, line, plane, and color are used.

In the first stage, each artwork is represented with a point (Figure 6a). Points are selected because of their characteristics such as not defining any direction (x,y,z) and possibility to form clusters. In the DBIID the size of the points is dependent on the size of the artwork in the physical environment. The sizes of the artworks are obtained from exhibition catalogues and labels located next to artworks. Since size vastly differs between artworks, the sizes of the artworks are remapped between minimum and maximum radius defined by the designer. Moreover, the colors of the points are derived from the average color of the artwork calculated in the *Processing* environment based on actual photos of the artwork. Therefore, representation of each artwork differs in terms of size and color (Figure 6b).

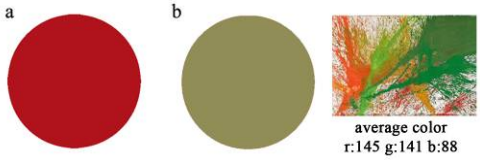

Figure 6. *(a) Representation of an artwork with a point; (b) Calculating the average color of an artwork*

Another parameter used in the DBID is the dimensions (2D, 3D, 4D) of the artworks. In DBIID classification and representation is done as follow:

- Paintings and gravures are considered as 2-dimensional artworks and represented with simple circles filled with color (Figure 7a).
- Sculptures are considered as 3-dimensional artworks and represented with circles filled with color with a thicker contour line (Figure 7b).
- Videos and installations are considered as 4-dimensional artworks and represented only with contour without any color fill (Figure 7c).

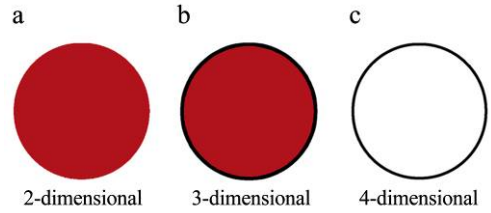

Figure 7. *Representation of (a) 2-dimensional (b) 3-dimensional (c) 4-dimensional artworks*

Another important feature considered to create visual structures is the “category of the artworks”. According to CDWA artwork can be classified as item (a single artwork), set of artworks, group of artworks, and series of artworks. These features are assigned to each artwork and illustrated as shown in Figure 8.

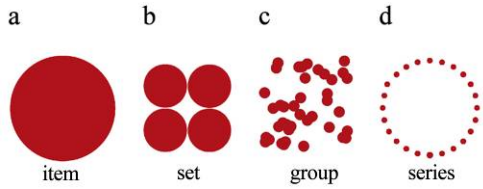

Figure 8. *Representation of categories of artworks (a) item (b) set (c) group (d) series*

In addition to transformation of certain data into visual structures by using basic design elements, data such as the title of the artwork, the creator of the artwork, the role of the creator, the technique of the artwork, the owner (name) of the artwork, and the status (owned/borrowed) of artwork for is presented in text format by superimposing with the previous created visual structures (Figure 9a). As an exception, the creation date of the artwork is presented directly as a 4-digit date (year) without any transformation (Figure 9b).

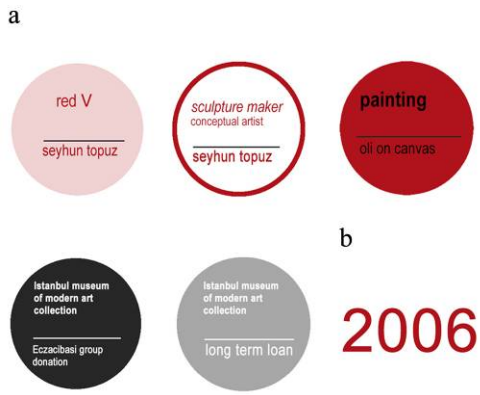

Figure 9. *(a) Superimposition of textual data on points; (b) Representation of creation dates*

3.3 Creating Diagrams

The interactive visualization techniques can be used to reconstruct and visually review large quantities of data. Burkhard [8] listed the main characteristics of the visualization-based applications as: being interactive, being dynamic and containing embedded details. To design DBIID for the "Artists in Their Time" exhibition, the *Processing* coding environment, which provides flexibility in establishing the relational networks of complex data and allows interactive inputs by mouse and keyboards, was used. The designed interface is compatible with both Windows and macOS operating systems. Due to the interactive characteristic of the applications, changes can be made by using filtering buttons in the interface and diagrams are produced. The dynamic feature of the interface allows the changes in the visuals to be shown to the user instantly. To reach the embedded details, the expected details can be highlighted by zooming in and clicking on the visual structures.

On the main screen of the interface, there is a sidebar (Figure 10a) to display or associate the select data types and a number slider (Figure 10b) to define the number of artworks that will be included in the diagram.

Figure 10. *Opening Screen of the Interface (a) Sidebar (b) Number Slider*

The buttons of the sidebar are grouped under 3 menus. The top and the middle group buttons are used to make

visualizations with “main categories” of data. The buttons on the top group create "clustered" diagrams based on the following data types: random, nations, theme, collection, classification (Figure 11a) The buttons on the middle group create “sequential” diagrams to visualize the artworks according to order of artworks in the catalogue, order of artworks in the exhibition space, and chronological order of the artworks (Figure 11b). The lower group of buttons is used to superimpose a data type from “main categories” and another data from “sub categories”. Superimposition enables the overlap of two or more visual structures in a single view. In such visualizations, all visual structures can be visible by using the transparency of a visual structure [14,15]. Subcategories of the data types are listed as: size of the artwork, category of the artwork, name of the artwork and its creator, artist and their proficiencies, creation date of the artwork, material & technique, and owner and status (Figure 11c).

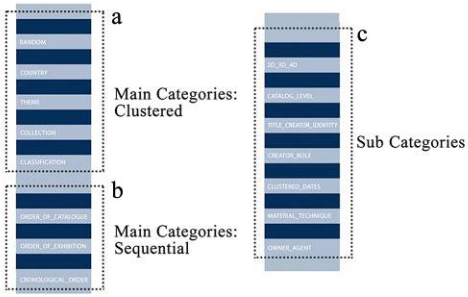

Figure 11. *Buttons (a) Clustered Categories (b) Sequential Categories (c) Sub Categories*

The bar at the bottom of the screen is designed as a "number slider". The range of this number slider is from 0 to 183. These numbers refer to the index numbers (order) of the 183 works in the exhibition catalog. In this case, the artworks up to the index number determined by the number slider are included in the diagrams (Figure 12).

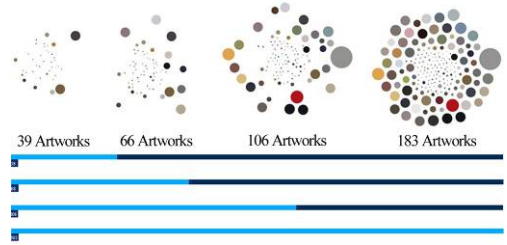

Figure 12. *Determining the number of artworks in the interface by the number slider*

Briefly, the created diagrams are grouped as clustered diagrams and sequential diagrams. The basic principle of “clustered diagrams” is that the artworks come together to form a cluster around a center point without touching each other. For example, when the main category of "nation of origin" is activated from the interface, the points representing the works of artists from the same nation merge to form clusters. The data under the “main category” of “nation of origin” creates a diagram that all artworks are clustered around 14 center points as "Germany", "USA", "Argentina", "Austria", "Bulgaria", "Denmark", "South Africa", "Netherlands", "England", "Italy", "Northern Cyprus", "Puerto Rico", "Turkey" and "Samoa". Produced from this diagram, where the majority of the works are from Turkey while other countries reached a maximum of 4 works except the United States of America (Figure 13).

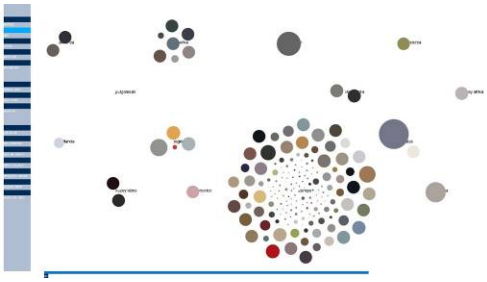

Figure 13. *Clustered diagram created with the activation of the "Country" button*

If a subcategory is activated along with a clustered main category, diagrams that consist of more information are created. For example, when Theme and Dimension (2D, 3D, 4D) buttons are turned on, two different data are superimposed. For example, it has been determined that the works in the theme of "artworks for women" are mostly 4-dimensional and pieces in the "Cinema" theme are 2-dimensional instead of 4-dimensional as expected (Figure 14).

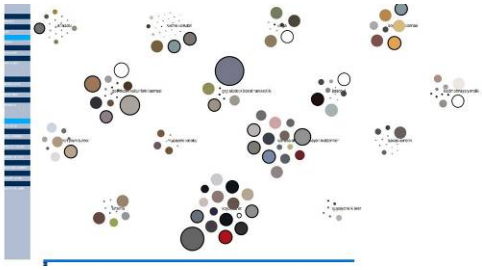

Figure 14. *Clustered diagram created with the activation of the "Theme" and "2D, 3D, 4D" buttons*

Juxtaposition is a flexible and easy-to-apply technique that is useful for bringing a huge number of visual structures in a single view. The principle to form a sequential diagram is the juxtaposition of the artworks on the interface (display). Since the visual structures that represent artworks are arranged side-by-side in the sequential diagrams, the diagrams are formed as three rows to fit all artworks to the interface (Figure 15).

The user of the interface can create the strings of artworks gradually by increasing and decreasing the number of artworks by using the cursor to manipulate the number slider. Sequenced diagrams deal with three different types of exhibition data: order of artworks in the catalogue, order of artworks in the exhibition space, and chronological order of the artworks. Through these diagrams, it was observed that the artworks were not arranged in the exhibition space as in the catalogue or chronologically in the exhibition space. In addition, it is obvious that small works are side by side, while there is no certain rhythm in the arrangement of large and small works in the diagram expressing the exhibition sequence. On the other hand, it is seen that the colors of the work are homogeneously distributed throughout the exhibition and there is no zoning in the exhibition in relation to the color of artworks (Figure 15).

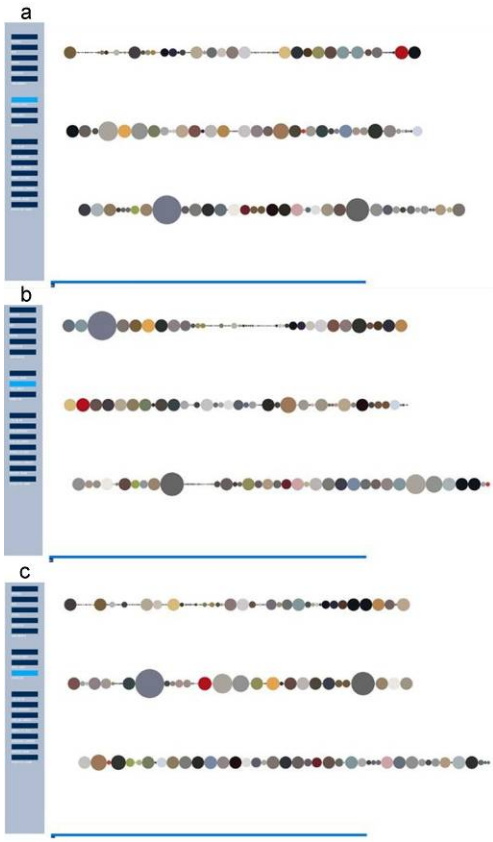

Figure 15. *Sequential diagrams (a) Catalog Order (b) Exhibition Sequence (c) Chronological Order*

When the “Exhibition Order” and the “Date of Creation” of the artwork are superimposed, it is observed that there is no chronological order while arranging the artworks in the exhibition space (Figure 16).

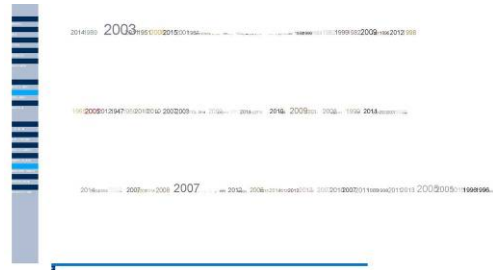

Figure 16. *Sequential diagram created with the activation of the “Exhibition Order” and “Date of Creation” buttons*

3.4 Improvements after User Experiments

Based on the feedback obtained as a result of the user experience, the interface has been developed by adding new features. In the design of interface where the abstraction feature of the diagrams is adopted, the visitors stated that the lack of actual images of the artworks has a negative effect in the retaining of memory of the exhibition. For this reason, the visuals of the works have been added to the interface so that they can be turned on and off depending on the user's request by right clicking on the representation of the artwork (basic design element) in the interface (Figure 17).

Figure 17. *Displaying the actual image of a clicked artwork on the interface*

Similarly, due to the use of the zoom in command that causes complexity and difficulties to perceive the text representation of data in the categories (work name, artist name, artist description and role) during the user's experience of the interface, with the left click of the mouse, an informative pop-up window containing the artworks title, artist name, year, collection name, material technique can be displayed on the interface (Figure 18).

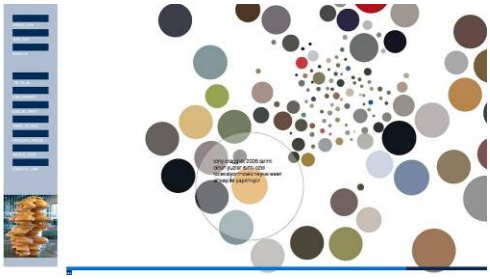

Figure 18. *Displaying the textual data of a clicked artwork on the interface*

4. Discussion

The interface is designed to enable visitors of museums to make a computer-aided, interactive visualization and gain a deeper understanding of the exhibition and the artworks in the museum space. The reason for the interface to reach the visitor through visualizations is that visuals support the cognitive system and reduce the cognitive load in the process of learning, producing and transferring the generated information. The visualization model developed in the study aims to transform the interface user into an active and participatory visitor by dynamically filtering the large amount of implicit and explicit data of the art exhibitions with interaction.

With DBIID diagrams were created using simple forms and elements such as point, line, plane, and color, based on the abstraction feature of the diagram, instead of directly presenting the data related to exhibitions and artworks. In other words, abstract diagrams were created from the abstract data of non-abstract (concrete) artworks.

As a result of the use of the interface, the positive features of the interface are listed as follows:

- Revealing invisible data networks and patterns with clustered and sequential diagrams
- Refining the complexity of relationships between data and visualizing them in an understandable way
- Enabling visitors to take an experiential role by encouraging them to ask new questions about exhibitions and artworks through discovered patterns
- Having a different perspective on exhibitions and artworks with the combination of the experience and knowledge gained from the interface in the digital environment and the museum visit
- Providing exhibition experience without temporal and spatial restrictions
- Presenting data that is not available in the exhibition space or the exhibition catalogue
- Providing the opportunity to experience the exhibition in different arrangements other than the order determined by the curator (catalog sequential, chronological)

Another important point to mention is that the "Artist in Their Time" exhibition and the Istanbul Modern exhibition space do not exist at the moment. In this context, the interface and the database behind it have a digital heritage feature.

The interface design provides some flexibility as stated. The CDWA standards, which were used in this study and developed with the purpose of creating a database of artworks, can be used to refine obtained data of any other art exhibition.

To use the same interface for different art exhibitions, visualizations can be made by changing the basic qualities such as shapes, colors, sizes representing the works of art, while the algorithm scheme and data conversion principles remain constant.

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