The Hitchhiker's Guide To The World of Art: An Information Visualization Approach

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A project supervised by Gjorgji Strezoski.

Oscar Ligthart, Muriel Hol, Rohit Shaw, Nicole Ferreira Silverio, and Kjell Zijlemaker

Abstract. This research focuses on a new and innovative way of visualizing artworks as found in the Omniart dataset. The goal of this visualization was to show the temporal and spatial information buried within this data. Interaction and easily understandable views as shown in our visualization are meant to give users more insight into the data characteristics. We approach the creation and evaluation of our visualization by using theories and research from the fields of Interaction, Visual Analytics design, Story Telling and Visual Thinking design. For the interaction we followed the categories of Yi to try and make sure the user can obtain as much insight as possible while easily navigating through the visualization. For the visual analytics design the data and visualization part of the visual analytics model were emphasized, maximizing the insight generated by extensive data preprocessing and strong visual elements. In the story telling design, the most prominent insights gained by uo visualizationrwere given and shown in a clear and aesthetic way. In the visual thinking design it is elaborated how the design choices make sure that the working memory of the user is not overloaded, with the emphasis on pattern recognition which is widely used throughout the visualization.
A full overview of the visualisation interface is provided in the Appendix A. The code of the project is available at `https://github.com/murielhol/picasso`.

1 Motivation and Concept

The history of human creativity reaches far back, the first artwork was created around 500,000 years ago[1]. It is also diverse, as it knows a large variety in styles and materials [2]. Finding interesting patterns and causalities in the history of art is challenging, because of the sparseness of available information. This project is a research on designing an information visualization framework that can compress the history of art in a format that is both visual appealing and that provides insights in the data that are otherwise hard to deduce. To conduct this research, we needed a rich multivariate art corpus. We use the Omniart [3] dataset which is generously made public [6].

Fig. 1: Vincent van Gogh 1889: Madame Roulin Rocking the Cradle.

We were inspired by previous InfoVis projects with the Omniart dataset. Strezoski et al. [5] designed a multidimensional visualization that explores the color space of the dataset for different meta data properties such as year and genre. The visualization is highly responsive and interactive, and it allows the user to navigate trough all dimensions intuitively. Another project on the OmniArt dataset [4] visualized how the style of an artist changed over time by providing multiple views that allowed for intuitive exploration of the dataset from abstract to very detailed level.

Color space and artist style development are two interesting research dimensions that can be successfully explored trough the designed visualizations. In order to contribute to the exploration of the OmniArt dataset, we focus on another dimension that to our knowledge has not yet been visually explored, which is the geographical development of both style and materials in time. Each artwork

[1] Wikipedia: `https://en.wikipedia.org/wiki/Prehistoric_art`

[2] Wikipedia: `https://en.wikipedia.org/wiki/List_of_art_movements` `https://en.wikipedia.org/wiki/List_of_art_media`

[3] Omniart dataset: http://isis-data.science.uva.nl/strezoski/

[4] Omniart information visualizations: http://www.vistory-omniart.com

has multiple spatial-temporal dimensions such as the time of creation, the location of creation, the origin of the style of the artwork, the relevance of the used materials and the influence that the artwork may have on future artworks. The motivation to capture all dimensions in a timeline arises from a use case we had in mind when thinking of the design.

In the use case, art tourists are our target audience. Say you are an art tourist who wants to travel to locations that had high activity in art creation, the first thing you are interested in is the *number* of art creations. You would want to be able to filter out the styles that you are not interested in or emphasize on the ones that you are, and possibly see *variety* in artistic creations and not get bored by the same style of art during your visit. You are also interested in how far you would have to travel to each city and the area of the world you would have to travel. We aim for a visualization that allows the traveller to choose a target location with minimal effort.

We also consider the other side of the story: you visit Amsterdam and you see the painting by Vincent van Gogh, as in Fig. 1. You notice that the style is not very Dutch and you want to know from where this style *originates*. You open the same application as the one you used to book your art holiday and select the style: Japonisme. You can check the *migration* flows of this style, which shows where Japonisme was first created and to which places it has migrated. You click on the first Japonisme painting ever made and compare it with the one you see before you.

Even though our use case represents a pragmatic situation, the visualization could prove valuable for research purposes too. By compressing multidimensional art data into a small space while minimizing cognitive load, we aim for a visualization that allows for insights that are surprising even at expert level.

The four dimensions of our visualization patterns are quantity, diversity, origin, and migration. Effortlessness and multidimensionality are key such that the visualization is easy to access, but also insightful. How we approach this is elaborated on in this report, by using theories and research from the fields of Interaction, Visual Analytics, Story Telling, and Visual Thinking design.

1.1 Related Work and Contributions

To identify the work done by others and our own contributions, we use the Nested Block model [2]. Fig. 2 shows the Nested Block model for our project, which is decomposed into the following blocks:

Algorithm (purple block) : The tasks on algorithm level have been adopted from previous work. Our base visualization is a globe, as shown in Fig. 5a. The algorithms used to describe the behaviour of the globe such as rotation and plotting (i.e. points disappear when at the back of the globe) are build by the open source initiative *Planetaryjs* [5]. Other algorithms in this work are the clustering of the artworks by binning spatial coordinates, and the encoding of the visuals into new plots by filtering and computing histogram data, which are all done with existing algorithms build in the D3 library [6].

Technique (green block) : The *Planetaryjs* project also provides techniques for the 3D projection on the globe. The *D3-GEO*[7] provides the technique needed for the Mercator projection, which is displayed in Fig. 5b. A contribution of this project on technique level is the ability to show migration flows, which are created by drawing lines from the origin of each artwork to its descendants. We propose guidelines to switch between projections (2D to 3D and inverse), including re-encoding techniques of all plotted points and flows. Additionally we propose a heuristic for distributing color codes to the different classes, and a legend that uses these colors to create a selection and filter tool that handles large amounts of classes (Fig. 3).

Abstraction (yellow block): Our visualisation is based on different abstractions of the data. Event abstraction is introduced to form the clusters, that are interpreted as events. We abstract two different events: the creation of a piece of art and the invention of a new category. Secondly, migrations are abstracted from the data. Migration is a property that is not featured in the data itself, but it is pinpointed by combining abstraction and visualisation. The third abstraction is the distribution of categories within a specified time range. In summery, the main abstractions are events, migrations and distributions. Each of these can be explored in multiple levels of detail and in multiple formats, by using the tooltip, changing the time range and switching between 2D and 3D, which will all be elaborated on in the next section.

[5] `http://planetaryjs.com/`
[6] Data-Driven Documents: `https://d3js.org/`
[7] `https://github.com/d3/d3-geo`

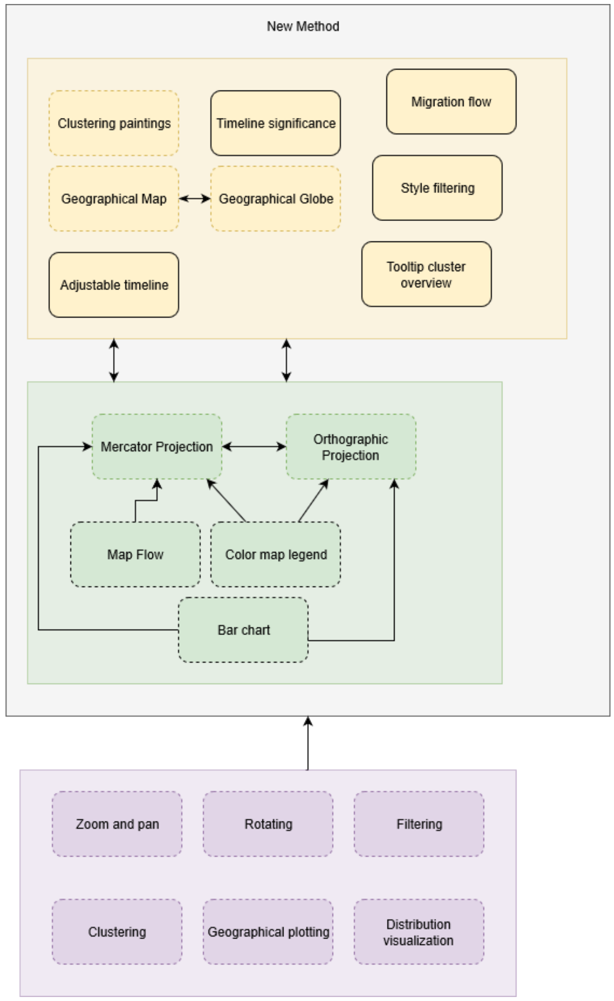


Fig. 2: Nested Block model of our visualization [2]. The blocks are Algorithm (purple), Technique (green) and Abstraction (yellow).

2 The Proposed Framework

2.1 Data Collection and Preprocessing

The public Omni-Art dataset does not contain locations for each artwork. Hence, we had to collect this data. We experienced that finding information about the birthplace of an artwork is more difficult than finding the birthplace of an artist. Therefore, we made the decision to consider the origin of the artwork equal to the origin of the artist.

The data was collected from multiple sources. The WikiArt API [8] was used to find wikipedia pages for each artist in the WikiArt dataset. We pattern matched the data on the Wikipedia page to find the birth place of the artist. For all artists in the OmniArt dataset that we either could not find a match with in the WikiArt database, or of which the wikipedia page did not contain a birth place, we used the API of DBpedia to find the birth place using RDF queries. [9].

In the visualization, the data is prepossessed by clustering the dimensions of time and space. Specific details about the paintings were mapped within a new view, containing the paintings within that cluster. Fig. 4 shows a cluster of 3 paintings, and illustrates the tooltip display when hovering over the cluster. The area of each cluster (circle radius) logarithmically scales to the number of artworks that it contains, to prevent the clusters to become too large. Additionally, the clustering bin sizes are adjusted according to zoom level.

[8] WikiArt: https://www.wikiart.org/
[9] https://wiki.dbpedia.org/

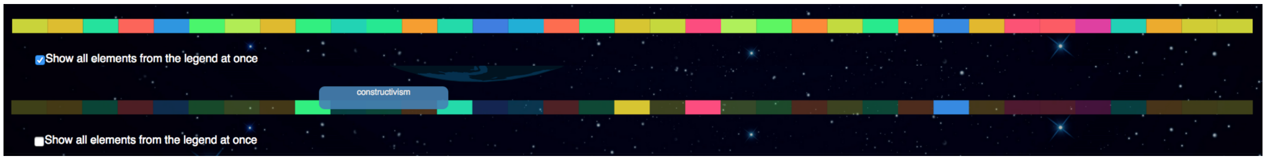


Fig. 3: The legend, before and after selecting sub categories of the data.

Fig. 4: An illustration of the tooltip functionality: right is the tooltip window that pops out when hoovering over the cluster. The cluster contains 3 paintings, of which 1 is shown to demonstrate. When clicked on the window, the detailed description on the left pops out, that displays all paintings in the cluster and a detailed description.

2.2 Interaction Design

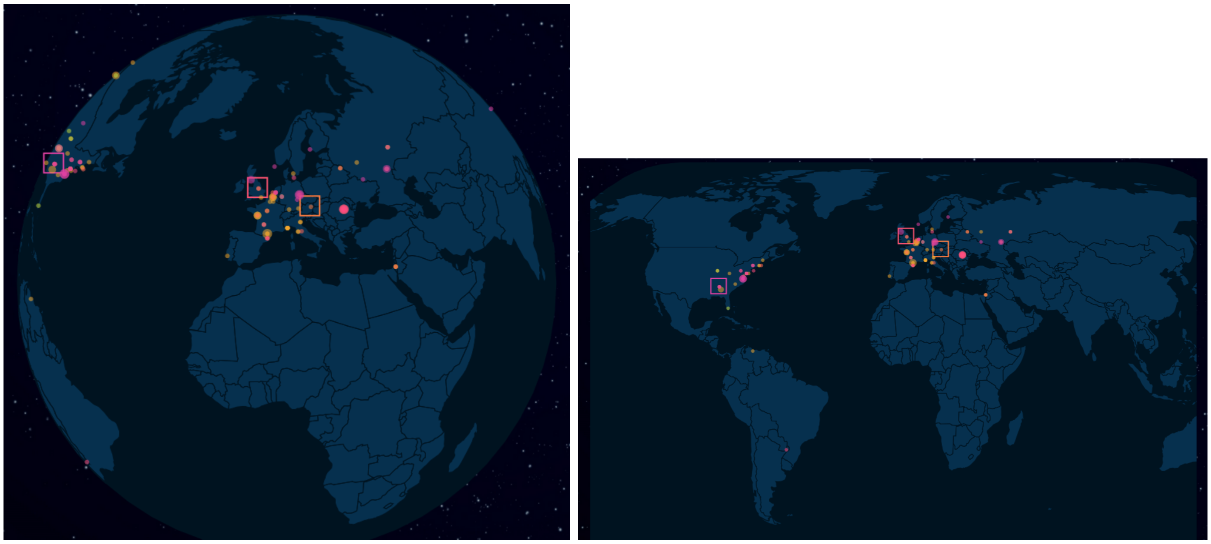
Categories of Yi Information visualization employs two main components; representation and interaction. Both are dependent on each other, however, the representation component received a vast majority of attention over the years. From the book Illuminating The Path, more research in interaction was urged to be done in the interaction component area.

Yi et al. [8]. also urges to put more effort in this area of research, since some limits of a representation can be overcome via interaction, and the cognition of a user can be further amplified. In their research they recognized 7 interaction techniques which are widely used in InfoVis and can be used as a framework as well as to discuss and evaluate interaction techniques, which we will do for our visualization. Each of the categories of Yi[8] will be elaborated in separate paragraphs.

Select: mark something as interesting When exploring around the globe (see explore for more details) the user has the option to pause the animation if they found something interesting. Aside from this, it is also possible for the user to select different kinds of styles or media from the legend (Fig. 3), showing only the data corresponding to the elements the user selected (marked as interesting). However, there is no direct option to mark a cluster as interesting for keeping later in the visualization.

Explore: show me something else The exploration category is very prominent in the visualization, as several interactions are possible which enhance the exploring experience:

- Time-slider: The slider can be adjusted to a specific point in time or to specify a time range in which paintings must be shown.
- Rotating the globe: The globe rotates automatically, making sure that the user will be able to see all parts of the world and corresponding art. The user can rotate the globe manually as well.
- Switching style/media: The user can switch from visualizing the styles of paintings to visualizing the media (creation tools) of paintings and back using a button.
- Timeline button: the user has the possibility to see the automatic transition of time from the start again, either visualizing the timeline of all styles or media or visualizing the timeline of selected styles or media.



a) Globe (3D) b) Map (2D)

Fig. 6

Reconfigure: show me a different arrangement The two main components which show re-configuration on the data are within the button section of the visualization (see figure 7); the user has the option to switch between the 3D globe to the 2D map and the other way around. Both representations show the plotted clusters of the created paintings in their corresponding geographic locations, either showing the parts of the world (globe) or the whole world at once (2D map). Aside from switching between 2D and 3D, the user also has the option to rotate the globe. When the user rotates the globe, the data shown is dependent on the part of the world visible to the user.

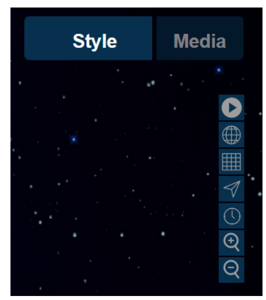


Fig. 7: The navigation menu

Encode: Show me a different representation For encoding, the main components are the scented widget above the slider and bar chart. The scented widget shows the distribution of all artworks over the complete timeline, highlighting the selected time period. In the bar chart the most prominent styles or media are shown according to their distribution specific to the currently viewed time period.

Abstract/Elaborate: show me more or less detail There are two abstraction and elaboration actions the user can perform; the user can zoom in on a specific location, to see more clearly how many different styles or media are present in that location. The user can zoom out again to see the the different styles or media over the complete map.

Aside from zooming, the user can make use of cluster tooltips to obtain more information.The user can hover over a cluster to obtain information about how many artworks are available in the style or media of the cluster at that specific location. When clicking on the cluster, a window will pop up showing thumbnails of all the artworks present. If the user wants to obtain more information over a specific painting, the user can click on one of the thumbnails and a new window will pop up displaying the artwork including some information about the artwork.

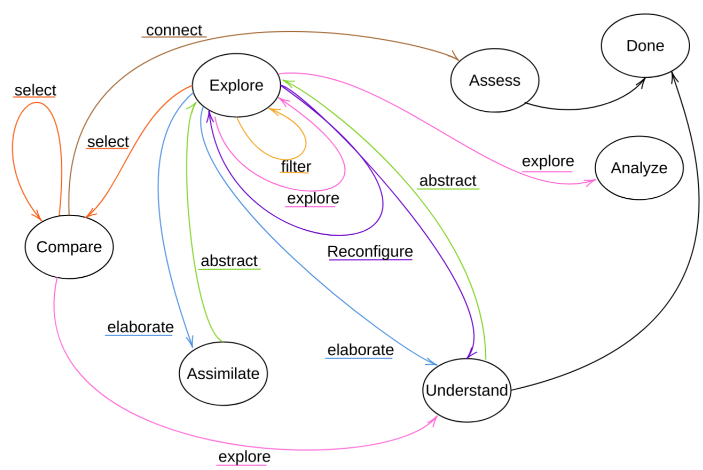


Fig. 8: State diagram of our visualization using the terms of Yi

Filter: show me something conditionally Filtering can be done by clicking on the colored bars of the legend. Multiple categories can be selected and the visualization will change

based on the selected elements, showing only the selected
style(s) or media. It is also possible to show all categories at once, which is convenient for the user to revert back changes made while filtering paintings. Aside from the legend, the data can be filtered using the slider. The slider is used to filter data based on the date the artwork was created, showing only the artworks created within the specified range of time. The slider has an automatic transition of time, but can also be controlled manually, giving the user the option to see art from the time period the user is interested in.

Connect: show me related items The connection to other related items in the visualization is twofold; the user has the option to view the migration of styles or media. By selecting to show migration, the user will be able to see how the styles or media (of either all elements or the selected elements in the legend) traversed the globe from the location of origin to all other (currently visible) locations of that/those specific style or media, thus showing the temporal and geographical relationship between artworks.

Next to this, on the right hand side of the globe, a bar chart is shown in which the eight most prominent styles or media are shown. By hovering over the bars of the bar chart, the corresponding clusters on the map or globe will be highlighted. The user can now pinpoint the locations of these types of paintings more easily.

In figure 8, the state diagram corresponding to our visualization and the categories mentioned above is shown.

2.3 Evaluation Design

From the lectures there are three main ways to test the visualization, namely: questionnaires, benchmarking and insight based. Our visualizations' purpose is to lay the emphasis on exploring paintings and style/media migrations across the world. As an addition to this we also want the user to gain knowledge about the periods where painting styles were emerging and where they are located, helping the user to get an interest in art itself.

Questionnaire Before we want to benchmark the visualization by doing demo's to get the users' feedback on how insightful our visualization really is, we first want to create a questionnaire to find out how useful the components of the visualization are and if we should improve some of them.

Example of questions These questions should be answered by using a 1-5 scale, where 1 is "not at all" and 5 is "Firmly agree"

1. After some time using the visualization I know what the goal is of the visualization
2. The timeline helps me in finding paintings I like
3. The visualization is clear without too much clutter
4. The migration flow is useful and shows me interesting information about migrating styles of that time period
5. The legend is clear and helps me to reduce clutter and show me interesting paintings/migrations
6. The bar chart helps me to find the most prominent styles or media
   (a) The bar chart helps me to find the styles or media in which I am interested in
7. The function of the buttons are clear and help me navigating through the visualization

Benchmark insight based Further, we also want to user to gain insight. Therefore, we evaluate this by adjusting the benchmarks to support insight based evaluation, thus, letting the benchmark tasks dependent and let the user explore the visualization freely. During the demo, where the user is in control, we will support the think out loud protocol and let the users write their insights on paper. Finally, we will create categories where the possible insights are based on and put the respected answers from the candidates in the right category. By doing so we can evaluate the amount of insight gained in our visualization.

Categories The categories of insight which we would use are the following:

1. The user observes the distributions of paintings according to the specific timeline between the style or media of paintings
   (a) The user observes simple details about the paintings related in the specific timeline of search

2. The user observes patterns between migrating styles or media, and the distribution of paintings according to the specific timeline
3. The user observes complex patterns between the migrating styles or media, and new births of styles or media of paintings
4. The user creates hypotheses about the complex pattern between distribution of paintings, new births of styles or media of paintings and the migration between countries of these paintings

2.4 Visual Analytics Design

Firstly, the components Model, Data, Visualization processes and User-machine interaction will be elaborated on. Lastly, the process of sense making, and the corresponding exploration and verification loop, will be discussed [4].

Our visualization does not make use of a model, thus making our visualization weak regarding this component of the Visual Analytics model and leaving room for improvement in this area. Since there is no model present in our design, the visualization processes are all based on the data, all user-machine interactions present consist of changing the visualization directly and the user gains knowledge directly from the visualization.

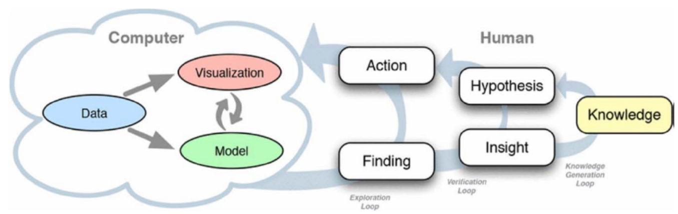


Fig. 9: Visual analytics model

In our visualization data is cleaned by filtering out all unknowns in variables deemed needed. Next to this, the data set used was complemented with geographic information scraped from the internet. With the interactive components in the visualization, such as buttons, an interactive legend and a slider, corresponding parts of the data are selected to be shown, making sure that the does not have to see all the data at once (however, it is possible to see all data at once if the user wishes). Everything combined makes the visualization quite strong regarding the data.

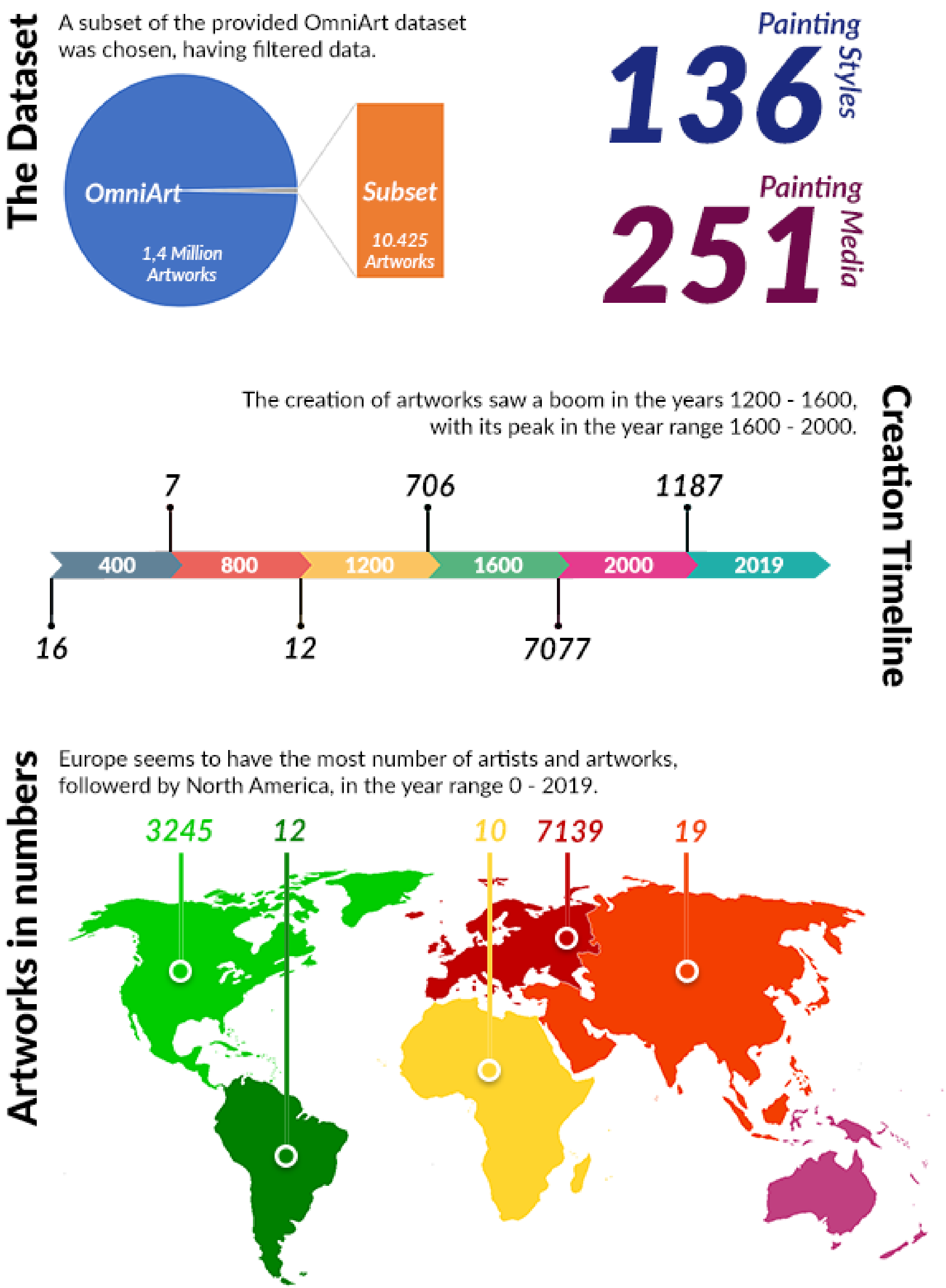
As mentioned before in the section Interaction design, the visualization has a prominent exploration component. Because of this, the user has the opportunity to observe quite a lot of information/data, which can lead to specific findings about the data, when and where certain styles/media originated or what kind of artworks belong to a certain style/media. Based on these findings, the user has the option to perform actions that interact with the visualization, such as changing the time period or visualizing migration, changing, connecting or elaborating the data displayed. This could lead to either new findings (which could initiate new actions for the user to perform) or insights with regards to the data, leading us from the exploration loop to the verification loop of the visualization.

In the verification loop the user gains insights from the observations and findings obtained during the exploration loop. Based on these insights and the possible interactions being able to be used for a targeted search, the user can formulate hypotheses and can either reject or accept the hypotheses based on (new) insights gained from directed actions performed to obtain new information. Combining the insights gained from the exploration and verification loop, the knowledge generation loop is completed

A possible extension on the current system could be to add an explicit comparison tool. That way the user can see information from multiple styles/media right next to each other, making it easier to compare artworks for instance. Next to this, it would be nice for the user to have the user history saved somewhere, being able to see the options they explored and the actions taken.

2.5 Story Telling Design

We illustrate the insights that can be gained using our visualization by means of an infographic:


The Dataset
A subset of the provided OmniArt dataset
was chosen, having filtered data.
OmniArt
1,4 Million
Artworks
Subset
10.425
Artworks
136
Painting
Styles
251
Painting
Media
The creation of artworks saw a boom in the years 1200 - 1600,
with its peak in the year range 1600 - 2000.
Creation Timeline
7
706
1187
400
800
1200
1600
2000
2019
16
12
7077
Artworks in numbers
Europe seems to have the most number of artists and artworks,
followerd by North America, in the year range 0 - 2019.
3245
12
10
7139
19

2.6 Visual Thinking Design

The user that will employ our visualization will have a goal in mind that will steer his attention. Using our use case from the introduction, this could be a specific style or country of interest. The information coming from the visualization will be combined with this goal in the *visual working memory* of the user [7]. The resulting inference is a pattern matching process in which the user matches the visual features (bottom-up) with its cognitive features (top-down) to find patterns. In order to enable the user to find these patterns, we have to incorporate the properties of *visual thinking*. Visual thinking explains how much and which information from the visualization will arrive at the visual working memory.

According to Ware [7], humans can capture about 3 to 5 objects in their visual memory when switching from one fixation to another, also referred to as *visual queries*. Thomas and Cook [1] provide a framework to enhance cognition at multiple layers. The following sections explain how we used each layer of the framework for our visualization.

Increased Resources To increase cognitive resources, we avoid the usage of text and numbers as much as possible, since these are processed in parallel and hence require more visual queries. The numbers in the timeline and the labels under the bar chart are kept small, to steer the focus towards pre-attentive features such as shapes, colors and movements. The tooltip that is attached to each cluster, shows the paintings in that cluster (Fig. 4). The textual information is only requested upon further exploration, such that the user is not too much distracted by text when the tooltip hoovers over a cluster. Finally, we used symbols for our navigation that in our opinion will match the semantics of most users, to replace textual navigation, which allow for undisruptive navigation (Fig. 7).

Reduced Search The information is highly compressed such that the user can see all the dimensions of the visualization patterns (diversity, activity, migration and origin) in one fixation such that it can process it all in parallel since we only use simple shapes and colors. Additionally, the user can use the globe instead of the Mercator map (Fig. 5a), to filter out the part it is not interested in by rotating it to the back. Where zooming is a hard boundary that removes parts of the visualization from the screen, the round globe shape makes less important locations fade away gradually, which could be a more smooth way of reducing search space. We also think that rotating the globe is more intuitive and smooth than zooming in, zooming out, panning and zooming in again, which allows for easy exploration of multiple locations without being distracted.

Enhances Recognition of Patterns Visual thinking emphasises on the preference of recognition over recall [1]. Time variate data such as ours is a challenge for this preference since events disappear over time. To help the user to 'recall by recognition' we have implemented two features. The first feature is the scented time line, as shown in Fig. 10. The timeline is scented with a quantity bar chart that shows how many paintings where created at that time instance. The colored boxes show the diversity by plotting the creations of novel styles or medias. Future work is to remove boxes using the legend to reduce clutter, currently the squares form a rainbow spectrum when many novel classes are created close in time. While events on the globe come and go, this part of the visualization remains static. Such that when you forget when the style you are tracking was created for the first time, or any other information that you 'forgot' about a specific time period, you glance above and there is the information presented. Secondly, the user can expand the time range of the visualization to be able to see all events needed to find a pattern.

Additionally, we have chosen the enhance the patterns by putting emphasize on the origin of the artwork. The squares are a clear distinction, but do not over dominated the regular event blobs or the migration flow arrows. By putting this extra feature into the visualization, we enable to recognise patterns that include such an origin event. For example there could be a causality between the migration of two styles towards a city, and a new style being born in that city a couple of years later.

Perceptual Inference The migration flows are a good example of something that is understood faster when visualized. The arrows that go from point a to b over the globe are self evident, and many people will also find the locations on the map self evident, having learned the global during their live. Probably easier than reading each migration flow, and the locations in a textual manner, one by one. When visualized, it will be obvious in one fixation to which countries the style or media migrated.

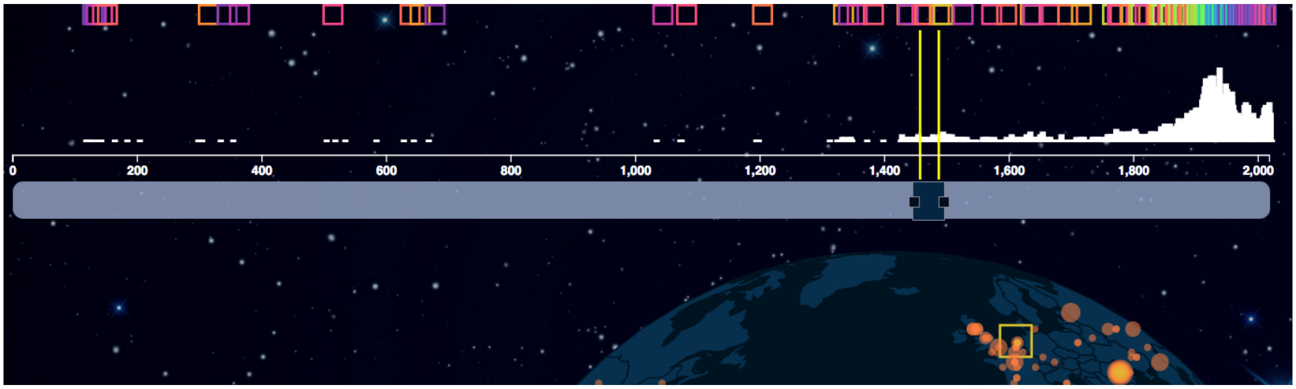


Fig. 10: A scented time line that shows the number of paintings in a bar chart (in white) and the creation of a novel style or media class (colored squares). The time range of the visualization is dynamic and can be increased and decreased by the user.

Fig. 11: The same configuration and view, but hoovering over different styles, results in a different visualization.

Perceptual Monitoring Perceptual monitoring is exactly what our visualization is made for: the monitoring of a large amount of events, by making them stand out in a pre-attentive manner. The pop-out effects that we use are shape, color and motion. Where the circles make pulse movements when you hoover over their bar chart. Fig. 11 shows the same view, but with pulsing for different sub classes. The pulses are circles that pop out and decrease in size, like an explosion.

Manipulable Medium The parameters that the user can manipulate are time, time range, zooming level, projection (2D or 3D), class (media or style), the sub-classes filters, and if the migration arrows are shown or not. We acknowledge that all these parameters are visual specific. Future improvements on the flexibility would be to enable manipulation of data parameters such as using different path finding algorithms for the migration flows, or different cluster algorithm. Additionally, especially expert users should be able to rename styles and re-assign artworks to different styles when not agreed upon the classification. We recommend this for further developments.

3 Scientific Excellence

According to North et al. [3], insight is considered complex, deep, relevant, qualitative and unexpected. In this section components which contribute to insight will be described using these categories.

Complex The visualization is highly dimensional, and all dimension interact. This allows for patterns of complexity.

Deep By using the timeline, the user can freely flow throughout the history of art. Migration flows can closely be inspected by zooming in and out, such as turning the globe. More details about paintings will also enhance the deepness of the visualization.

Qualitative The visualization has the option to explore freely around the history of art and allows the user to make own conclusions about what the user sees. The bar chart helps the user to understand the more statistical parts of the dataset but can be interpreted in several ways: showing where paintings reside on the globe / map or how many paintings there are in a specific part of the timeline.

Unexpected The unpredictability is certainly present in this visualization as art is ever changing throughout the time. Because the user can explore freely through this timeline, explorations about the different styles or media of paintings can be very unexpected. For example: exploring multiple clusters in the same time period shows, according to the user, different types of paintings. The truth however is that they seem to be from the same type of paintings. As can be seen, creativity plays a role here. The user can accept the fact that the clusters come from the same style or that the cluster with the deviating style (according to the user) is different. To check this, the user might enable the migration flows to see if the origin of both paintings is influencing the styles in this particular case.

Relevant The visualization gives insight in the paintings located around the world in a certain timespan, the migrations from types and media of paintings across the world and specific painting details. It does not matter if the user is an expert or not, these insights will add knowledge to the domain of art.

4 Conclusion and Future Work

We propose an information visualisation framework that captures spatial-temporal structures by proposing novel abstractions of the data: migration of art styles and the materials they are made of, and events that indicate the creation of art or innovation of a new category. We propose the visualization of these abstractions with pre-attentive features to enhance the ability to match patterns. Varying levels of pattern complexity are captured by using multiple views, that visualise interactions between the different abstractions at different levels of detail. Quantity, diversity, origin, and migration are dimensions of the insights that users can experience when interacting with the visualization. The framework is designed to trigger insights that can be both effortlessly pragmatic as surprisingly complex, to be relevant in various use cases.

The implementation of the framework is promising for real use cases, but also leads to a wide range of possible improvements and future research. Exploring different color allocation algorithms for a large amount of classes that align in time and space is needed to increase the contrast between patterns of different categories. Future implementations should include the ability for the user to change categories, years and origin of artworks, based on their expert knowledge or semantics. Finally, we propose the implementation of various cluster algorithms for the spatial-temporal clustering, and various path finding algorithms that shape the migration flows.

5 Reflection

5.1 Project Rating

The project itself was very interesting because most of the team members are more familiar with data mining and not the visualization of data. In the four weeks working on the project, we had a team meeting with Gjorgji every week to discuss the progress of the project and to add new functionality to the visualization. Because of this, the end result of the visualization is promising.

An improvement for the project could be to give students more time in total. This would allow for more fine-tuning and improvements for the visualization before the demo-day.

5.2 Group Functioning

Oscar Ligthart Studying Artificial Intelligence at the UvA. Mainly worked on: creating a prototype of our visualization, creating the 3D view of the map and its automatic rotation, the functionality of the time line and slider and being able to show the lifespan of selected styles. Prototype consisted of a 2D map showing a subset of data. Time line made sure that data is shown according to the selected range as indicated by the slider and fully operable by a user.

Muriel Hol Studying Artificial Intelligence at the UvA. Mainly worked on: collecting creator birth places from wikipedia and wikiArt with API and regex. Spacial clustering of the data for visualization, and adapting the clustering to zooming level. Color dividing mechanism to make colors of classes close in time as distinctive as possible. Projecting the squares that indicate an origin on the globe. The bar graph and origin plot above the timeline. The pulsing movements of the blobs when hoovering over the bar chart.

Rohit Shaw Studying Computer Science (joint degree) at VU/UvA in the Big Data Engineering track. Mainly worked on: Bringing the idea of having a rotating 3D globe to the table and created a prototype of it. Aesthetically pleasing jQuery timeline slider, a rotational knob for timeline control, and prototypes for both. None of the prototypes made it to the final visualization presented. Also worked on the design of the navigation bar, the loading splash screen, and cleaned up the final code.

Nicole Ferreira Silverio Studying Artificial Intelligence. Mainly worked on: folding and unfolding of the map (2D to 3D and the other way around). Migration flow; finding the origin, the locations of the corresponding other artworks and drawing the arrows. Legend(navigation) bar and corresponding functionality; making sure all elements of the visualization react to user interaction with the legend (removing deselected data from map, highlighting selected legend elements, tooltips of legend elements, select all button)

Kjell Zijlemaker Studying Computer Science (joint degree) at the VU/UVA in the Big Data Engineering track. Mostly focusing on data mining and supporting data science by gathering data and offering this data structured for further analysis. Mainly worked on: Adding information from external data sources, bar chart which shows the distribution of paintings' styles and media, the dragging of the globe, and hiding and moving clusters when turning globe accordingly, painting details when clicking on a cluster.

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Appendix A

Overview of the visualization

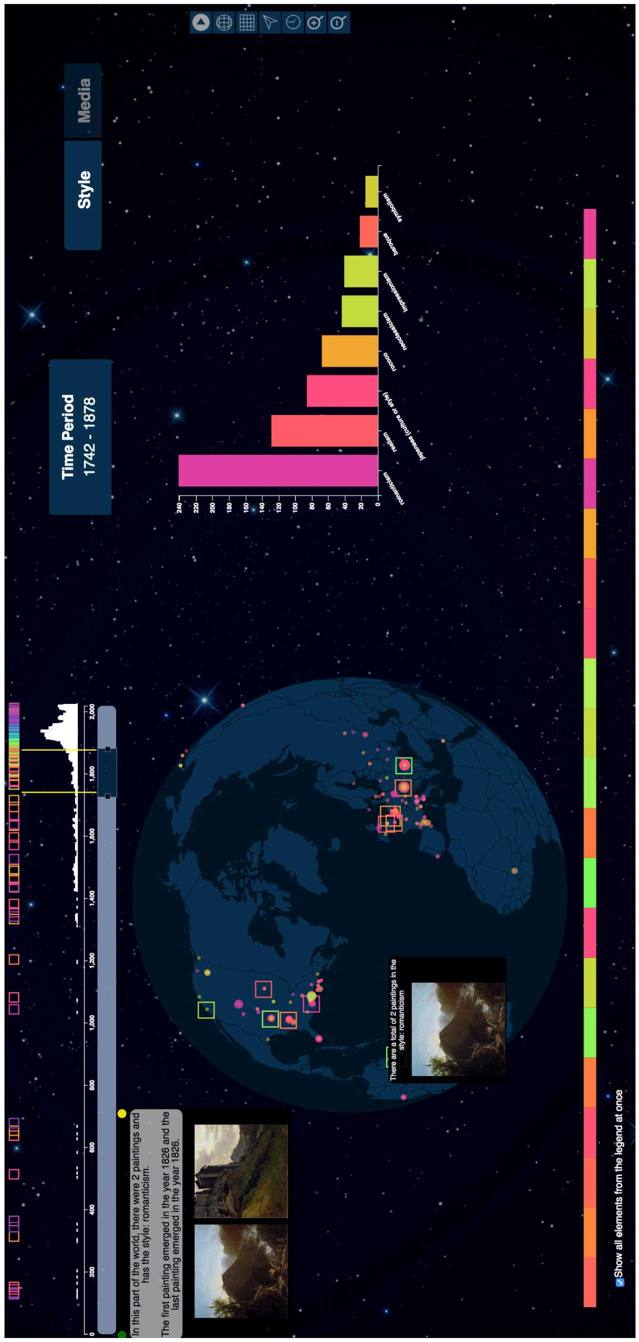

Fig. 12: Complete picture of the visualization