Interactive Semi-Ambient Display with Narrative Visualization

Interactive ambient visualization to support the workflow of the Artist & Repertoire division of a music management company

DOMONKOS HORVATH
En Interaktiv Semi-Ambient Skärm med berättande visualiseringsfunktioner

ABSTRAKT


# Interactive Semi-Ambient Display with Narrative Visualization features

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**ABSTRACT**

Ambient displays present useful information in the periphery of the users and normally they don’t support interactions. Technological advancements in digital displays, computing power of smart phones and faster wireless networks enable new forms of interactions. The purpose of this thesis is to explore the design space of ambient displays and make an inquiry into the future state by designing and implementing an interactive prototype for a specific use case. The context of the project is a music management company, its Artist & Repertoire division and their work-flow. The work introduces a novel concept of Interactive Semi-Ambient Displays with Narrative visualization features. The thesis is a comprehensive documentation of an iterative Research through Design process and its final outcome, an interactive prototype. The prototype consists of a Semi-Ambient visualization, integrated with narrative features and a mobile application to interact and control the visualization. A formative focus group evaluation of the prototype was conducted to evaluate the final outcome of the process. Results suggest that the concept is a viable way to effectively visualize information in office environments and support the work-flow of co-located groups. Based on the comments, future directions for the general concept and the project are discussed.

**KEYWORDS:** Semi-Ambient Displays, Ambient Information Visualization, Narrative Information Visualization, Novel interactions, Collaborative sense-making, Research through Design

1. **INTRODUCTION**

1.1 **Background of the project**

As part of my Final Degree Project, I joined the team of Augify in February 2016, as an interaction design intern. Augify specializes in designing and developing data analytics applications with their advanced Machine Intelligence, Generative Narrative, and Immersive Experience platforms. As an interaction design intern, I was involved in various tasks in one of the ongoing projects that aims at developing a platform for music management companies. The goal was to augment the data of music industry with machine intelligence solutions.

The project was twofold. The first part focused on designing and developing a web application for data analysis and exploration. The second part was an exploratory project to design and develop an interactive visualization prototype for a large screen in an office environment. The goal of this project was to support the work-flow of the Artists and Repertoire (A&R) division of music management companies. The application aimed to be an extension of the web app, by residing in the periphery of the user and supporting collaborative sense-making and visual exploration of music data. During my internship, I was working on the latter.

1.2 **Motivation**

Digital displays surround us and we use them every day in different aspects of our life. Using large screens to present work related information in office environments is not a novel idea. Technological advancements (ultra high definition displays, powerful smart phones, faster wireless networks) offer new ways to improve the utility of these systems. Ambient Displays aim to provide useful information in the periphery of the users, but the majority of them does not support any form of interaction. The motivation of this project is to explore the design space of Ambient displays and make an inquiry into the future state of an Interactive Ambient Visualization. Furthermore, the project aims to explore new types of visualizations for ambient displays, that leverages the power of storytelling.

1.3 **Research scope**

The research scope of the project stands at the intersection of ambient displays and visualizations, narrative visualization features and novel interactions with these systems. The project for music management company narrows down the scope of this work to co-located displays, co-working groups and collaborative scenarios in visual data exploration. The goal of the project is to answer how can we design interactive visualizations for ambient displays, that support the work-flow of co-located working groups in an office environment.

1.4 **Map of thesis**

The remainder of the thesis is organized as follows. Section two provides an overview of the existing literature about Ambient Information Displays, Collaboration in Information Visualization and Narrative Visualization. Section three introduces the methods I used during the project to design and develop a prototype. Section four provides a detailed overview of the design process I employed during the project. Section five gives a description of the final prototype and its application architecture. Section six describes the evaluation of the project and its results. Section seven discusses the findings and the final section draws conclusions from them.
2. RELATED LITERATURE AND WORK

2.1 Information Visualization

Information visualization creates a graphical representation of abstract data. Gershon et al. [7] define information visualization as a process "that transforms data, information, and knowledge into a form that relies on the human visual system to perceive its embedded information. Its goal is to enable the user/viewer to observe, understand, and make sense of the information." In order to understand the massive amount of data that surrounds us, information visualization has become a part of our everyday lives.

Over the last decades, the field of information visualization has evolved in many forms. As computers have become ubiquitous, we shifted from static information visualizations to powerful, interactive ones. As a result of technological advancements of digital displays, visualizations are not exclusive for our desktops anymore, but they reside in our everyday environment. Applications began to support collaborative tasks with visualizations. The increasing popularity and computational power of mobile phones offer new ways to design interactions. A recent movement called narrative visualization incorporates narrative features into visualizations to create "data stories" that increase comprehension and memorability.

2.2 Ambient Information Systems

The idea of distributing information displays in our everyday life originates from the concept of Ubiquitous Computing [1], where computing resources are distributed in our daily environment instead of being retained in regular workstations. Ubiquitous technologies, according to Weiser, [8] "weave themselves into the fabric of everyday life until they are indistinguishable from it". Various alternative definitions are in the academic literature for Ambient Information Displays. According to one of the most common definitions, "Ambient displays are abstract and aesthetic peripheral displays portraying non-critical information on the periphery of a user’s attention" [9].

2.2.1 Design Space

To better understand the characteristics of Ambient Information Displays, researchers analyzed numerous prototypes derived from academic literature. Features of the prototypes helped researchers to classify different types of Ambient Information Displays and improve the related design space and taxonomy [10, 11].

Ames & Dey’s taxonomy [12] proposed eleven different dimensions for classifying Ambient Information Displays. Some of the distinct dimensions are Intrusiveness, Persistence, Over-view to Detail, Interactivity, Level of Abstraction, Location and Content. Another widely known taxonomy by Pousman & Stasko’s [13] suggest four dimensions: Information Capacity (number of information sources that is shown on the display), Notification level (how the system informs the user), Representational Fidelity (data encoding) and Aesthetic Emphasis.

2.2.2 Related work

Various prototypes have been developed that belong to the category of Ambient Displays. Examples (Figure 1) include:

- Informative Art [14, 1],
- Aesthetic Awareness displays [4, 15, 16, 5],
- Information Awareness displays [17, 2],
- and Interactive Ambient displays [3, 6].

2.3 Designing Ambient Displays

The questions that designers deal with, when designing Ambient Displays are: what data to use, how to represent the information, where to place the screen in particular contexts and last but not least, who will use it?

2.3.1 What?

Ambient displays are built to present and convey information to users. The information is generally important to the user’s awareness, but not critical to their work [13]. The scope of the information must be clearly linked to the placement of the display and its potential users. Displays could show exact information or only an overview of the dataset in
question. Large, high-resolution displays allow designers to convey multiple metrics, however, researchers claimed that displays, that give the user only a "sense" of the data, are more sufficient for every day use. Detailed information, related to the display’s dataset, could be accessible from other information sources. Ultimately, users could also learn over time how to get detailed information from abstract encoding [1].

2.3.2 How?
Large screens provide a dynamic domain and more space for complex information mappings of multiple data sources. There are different ways to depict information on Ambient displays. Some displays purely use abstract visualizations, others combine visualizations with textual data [2]. The MoneyTree [16] display for instance, visualized real time data of stock prices with a tree metaphor. Exploring ways in which the visual information is organized to engender a narrative experience could improve sharing the information through large displays.

Presenting information in the physical environment without distracting the user is vital for Ambient displays. The rate of change in ambient visualizations should be "frequent enough to promote relevance" [1] but also should avoid being intrusive.

Another aspect of Ambient displays is the Aesthetic Emphasis. [1] examined the balance between aesthetics and functionality and stated, that "aesthetic concerns become a major issue when a visualization is integrated with a larger environment". Therefore, Ambient visualizations have to blend in with the environment in an aesthetically pleasing way, besides showing useful information. [18] claims that correctly designed and placed Ambient Visualization Displays should become a natural part of the users’ everyday surroundings. For instance, the Butterfly/Dragonfly Ambient Art [15] was deployed into a picture frame in a private office environment among similar artwork. Results from other research studies also suggest that "enhancing the artistic merit of a visualization can result in a more effective and more productive visual analysis" [19].

2.3.3 Where?
Ambient Displays are generally located at the periphery of the users’ view. With regard to the location and context of displays, [20] categorized Ambient displays into private, public and semi-public (co-located) displays. Ambient visualizations in form of co-located displays could foster awareness and collaboration among group members [21].

Holmqist et al. suggested that Ambient Information Displays could be employed in companies’ premises to show continuously updated information of organization data for employees [1]. One case for this type of utilization is the Butterfly/Dragonfly piece of Ambient Art [15] that visualizes information about stocks in an office environment. Another example is the MoneyTree [16] display that visualized real time data of stock prices with a tree metaphor.

Guidelines of [20] suggest to place semi-public displays in frequently visited location and choose useful content for the co-working group.

2.3.4 Who?
A clear user group in mind determines the placement and content of Ambient Displays and govern the design process of how the information should be presented. Holmqist et al. [1] considered every visitor, to the place where the Ambient visualization was installed, a possible user. In case of semi-public displays, every member of a co-working group is a potential user.

2.4 Collaborative Information Visualization
The majority of existing visualization tools concentrate on single-user data exploration and analysis [22], which do not make them appropriate for collaborative activities [23]. Working together in co-located groups is natural and has many benefits. Sharing expertise for complex tasks can speed up the work-flow.

According to [24], collaborative activities can be introduced at any phase of the information visualization pipeline. Sense-making is the process where "information is collected, organized, and analyzed to generate knowledge and inform action" [25]. Sense-making in forms of visual analysis is hardly a solitary activity. To facilitate collaborative sense-making, interactive visualizations should support social interactions.

There are different forms of collaboration. In respect of location and time, the existing literature distinguishes co-located or distributed and synchronous or asynchronous collaboration. Prior research studies focused on synchronous - co-located scenarios, but recently visualization tools (Many Eyes, GeoTime Stories, Tableau, etc.) started to incorporate features that support asynchronous and distributed scenarios [24, 25].

2.4.1 Co-located collaboration
Co-located collaboration generally involves shared displays. Large or wall-sized displays, tabletops allowed researchers to create collaborative environments for special use cases. Isenberg and Carpendale built an interactive tree comparison tool for collaborative information visualization on a tabletop device [26]. Another study interconnected co-located users to a big screen with heterogeneous devices [27]. Other applications include soldiers collaborating to discuss issues regarding battlefield conditions or multi-user table top applications for spatial data exploration [28, 29].

Earlier studies clearly indicate, that collaboration in information visualization is a growing research topic. With modern technologies researchers could develop different applications that support collaborative activities like, sense-making, presentation of stories, developing a common ground, raising awareness and decision making [25].

2.5 Semi-Ambient Displays
Normally, Ambient displays do not support interactions [18]. Semi-Ambient displays however, require or support interactions [11]. These displays still provide information in the periphery of the user but they could be more utilitarian with interactions. Detailed information is accessible when interaction occurs. Results of the ResearchWave Ambient Display [2] evaluation showed, that users criticized the lack of interactions with the display and expressed the desire to control the visualization’s source. Semi-Ambient displays in co-located environments could serve as a potential medium for collaborative visualization analysis.

The majority of previously mentioned collaborative applications relied on touch-based interactions, both with tabletops and large, wall-mounted screens. Articles by the Nielsen
Norman Group demonstrates that large screens have special characteristics regarding interactions. While sharing a large wall-mounted screen comes naturally to the users and it facilitates collaboration, touch interactions for user input are often awkward and require an extra physical effort [30, 31]. Faster wireless networks, web sockets foster the communication between heterogeneous devices. Due to the increase in popularity and computing power, smart mobile phones have the potential to be used for interactions [32]. Semi-Ambient Displays, with this modern hardware setup could reside in the environment of co-working groups, visualize relevant information from distance, and turn into collaborative applications when interactions occur [33].

2.6 Narrative Visualization

A recent movement in information visualization is the emergence of narrative visualization, a creative way to share information with an audience in an engaging way. The Oxford English Dictionary defines narrative as "an account of a series of events, facts, etc., given in order and with the establishing of connections between them" [34].

Narrative visualizations leverage the power of storytelling to increase comprehension, memorability and recall. Stories have proven to be an efficient way to package and share information. Additionally, the order of events in a story roughly corresponds with time, which supports understanding causality [35].

2.6.1 Design space

Narrative visualization features become popular among journalists due to their effectiveness to share "data stories". Segel and Heer [22] have analyzed many visualizations, observed emerging patterns, and organized the design features of narrative visualizations into coherent categories. Their design space and taxonomy is practical for visualization designers to communicate information efficiently. The design space consists of three main blocks: Narrative structure, Visual narrative and Genres. The narrative structure block is a set of tactics for arranging a path for the users to discover the story. Additionally they collected the most important features regarding interactions. While sharing a large screen comes naturally to the users and it facilitates collaboration, touch interactions for user input are often awkward and require an extra physical effort [30, 31]. Faster wireless networks, web sockets foster the communication between heterogeneous devices. Due to the increase in popularity and computing power, smart mobile phones have the potential to be used for interactions [32].

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2.6.2 Storytelling

To transform raw data into visually shared stories Lee et al. introduced the Storytelling process [37]. The process have three main phases:

1. Explore data (Selecting interesting excerpts)
2. Make a story (Order story pieces)
3. Tell a story (Share the story in visual form)

During the process designers have to adjust the visual story to external factors, including the audience and their interest, settings of the storytelling such as location and lastly the medium which will be used to communicate the story.

3. METHODS

3.1 Research through design (RtD)

Research through design (RtD) is a relatively recent research methodology that utilizes design practice methods and processes. Over the recent years, the popularity of RtD has increased in the field of HCI. It allows interaction designers to employ their real design skill set to make research contributions. Zimmerman et al. [38] state that "contributions should be novel integrations of theory, technology, user need, and context". Contributions in RtD are artifacts that come from the intersection of new technologies and a "theoretical scaffolding". Through an iterating process, researchers attempt to move from a current state to a future state. The outcome of this type of research is a thorough documentation of the process and a final prototype [39, 38].

3.2 Choice of methods

Besides a few general guidelines for designing Ambient Information Systems, there is no universal design process in the academic literature. Context specific design problems require distinct design approaches and methods. Therefore, I employed an iterative RtD process (Figure 2) accompanied
by various design thinking and user centered design methods.

The project started with a systematic literature review to explore the design space of ambient visualizations and study related work. To gain a comprehensive understanding of the target users and their context, I used qualitative research methods [40], such as informal interviews and user observations. Using the gathered information, I framed the design problem by defining the design objectives for the project. These goals described the characteristics of the desired outcome of the process.

Affinity diagramming and the Storytelling process were employed to organize available (and soon-to-be-available) data, and transform interesting pieces into visually sharable stories. Design Thinking methods (Ideation, Divergent and Convergent thinking) were used to generate alternative solutions and later narrow down the ideas. I used design sketching [41] for creating low-fidelity mock-ups of the ideas to evaluate them early in the design process. Based on feedback from users and domain experts I selected the best concept. Next, I used SketchApp 3 \footnote{http://www.sketchapp.com/} for designing wire-frames and high-fidelity mock-ups.

As the final outcome of my RtD process, I developed an interactive prototype with web technologies. For the information visualization part of the prototype I used D3.js, a visualization library for the web. At the end of the project, a formative focus group evaluation was conducted to validate the design process and several design dimensions of the final prototype.

4. DESIGN PROCESS

4.1 User study

To collect information about the users and the context of the project, I conducted user observations and informal interviews with employees of the music management company. Based on my observations, I identified the users of the application and their goals. The main user group is the Artists and Repertoire (A&R) division of the company. They are responsible for talent scouting by keeping an eye on promising artists. Other employees of the company are also potential users, since the screen will be placed in an open office area.

Figure 3: Simplified work-flow of the music management company

4.1.1 User Goals

Based on my findings, I identified high-level and low-level user goals for the target user group:

<table>
<thead>
<tr>
<th>High-level goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sign promising artists</td>
</tr>
<tr>
<td>• Make successful business decisions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low-level goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Stay informed about the industry and unsigned artists</td>
</tr>
<tr>
<td>• Collect information about prospective artists</td>
</tr>
<tr>
<td>• Share information with coworkers</td>
</tr>
<tr>
<td>• Collaborate and review artists</td>
</tr>
</tbody>
</table>

4.1.2 Work-flow

Figure 3 illustrates the simplified work-flow of the A&R division and the roles of the two applications. The Ambient display’s role is to raise awareness about promising artists and their recent activity. The large screen also fosters collaborative sense-making and visual data exploration. For comprehensive data analysis, users can turn to the web application.

4.2 Available data

Augify’s platform continuously harvests massive amount of music industry related data from different sources. Furthermore, they employ state-of-the-art machine learning algorithms to analyze the data and uncover underlying insights. In order to organize the data and ideas, I used affinity diagramming. Available data included:

| Data from leading music streaming services (music plays, playlists’ coverage, chart positions, number of followers, etc.) |
| Social media data (sentiments, number of followers, likes, comments, posts, etc.) |
| Media and industry news (articles, mentions, etc.) |
| Events linked to individual artists (social media activity, performance peeks, album and song releases, etc.) |
| Daily ranks of six categories for artists’ performances and additional predictions calculated by machine learning algorithms |
| Acoustic features of different songs and genres (Danceability, Loudness, Tempo, Energy) |

4.2.1 Update rate in data source

Predictions and ranks are calculated for each artist on a daily basis. The rest of the aforementioned data sources are updated more frequently, and some of them get updated real-time.

4.2.2 Data stories

During data exploration, I used the Storytelling process to collect interesting excerpts for visual storytelling. I focused on data pieces for a story, that could serve as a starting point for in-depth data exploration by raising awareness amongst the users, and supporting comprehension of complex data.
4.3 Design objectives

Following the user study, I conceptualized the system design for the interactive semi-ambient visualizations. Using the gathered information and the theoretical background I defined the following design objectives for the desired outcome of the project.

4.3.1 Utility

The initial goal of installing an ambient information display in the office was to present useful, up to date information in the environment of the coworkers. To make the system more utilitarian, the system should support interactions to display detailed information on-demand. The content of the display should be frequently updated and provide a daily starting point for the users. The wall-mounted display must be placed at a high-trafficked location in the office. Furthermore, the screen and its content should be perceivable from a distance.

4.3.2 Comprehension

The information presented on the display must be comprehensible with and ease by any user with relevant domain knowledge. Due to the open-office location, abstract visualizations should depict the data in a way that is easy to perceive from a distance as well. The display should provide an overview of the selected data source and reveal more details via interactions. To increase memorability and comprehension, the visualizations should incorporate narrative features and use data stories to communicate the information.

4.3.3 Intrusiveness

The system should find the right balance between responsiveness and calmness. It must be updated frequently to promote relevance, but also should avoid distracting users.

4.3.4 Aesthetic Emphasis

While the display communicates information in the periphery of the users, it also should blend in with the environment of its permanent location. Therefore, the visualization of the content designed within an aesthetic framework. The visual design of the interface should be in sync with the style of the web application and the interior design of the office area.

4.3.5 Interactivity

Interactions with the display should be effortless and intuitive. The system should take advantage of the ubiquity of smart phones, their advanced computing power and the faster networks. Using a mobile application to interact with the display can overcome many disadvantages of a touchscreen. The user does not have to be close enough to the display, interactions do not require an extra physical effort and sharing a screen is easier for larger groups. The mobile application provides an additional information channel that is available, even if the user walks away from the display. Lastly, this channel can be used to present confidential or personal information to the user and preserve its privacy.

4.3.6 Details-on-demand

Semi-ambient displays support interactions to offer more information on-demand. The visualization should support quick information queries to reveal more detailed information. These fast interactions can maintain the ambient nature of the display, while increasing the level of utility.

4.3.7 Collaboration / Shared Use

Large displays afford collaboration because sharing them comes natural to the users. Multiple users should be able to share the display for data exploration. The available interactions should also consider collaborative scenarios.

4.4 Design sketching

With the user goals and design objectives in mind, I used divergent thinking with design sketching to generate several ideas for the system and its visualization. The low-fidelity sketches helped to quickly explore and validate different ideas. Figure 5 shows some of these sketches. During the ideation process I explored various visualizations for selected data pieces. Ideas included:

- Album and song release and its impact on social media and other factors
- Visualization of Acoustic features, the footprints of most popular tracks and genres
- Artist engagement: real-time social media reaction to artist’s posts with sentiments
- Visualizing the distribution of music plays for artists
- Interactive comparison visualization for songs over time, growth and decay rate based on different metrics
- Network visualization of collaborations between artists over time
- Chart position visualization with interactive timeline
- Story of the week: modular visualization of the fastest growing track or artist every week
- Future sounds: visualization of most promising unsigned artists and their individual stories

4.5 Final concept

Following several iterations, I selected the best concept with the help of early user feedback. The "Future Sounds" feature in the web application predicts the impact of unsigned artists every day, based on their activity in six areas.
I combined this feature with a narrative visualization of each artist's most recent story. The goal of this concept was to support the daily work of the A&R division and increase the comprehension of the prediction algorithm's output. The concept could raise awareness and foster discussions that result in questions, which ultimately lead to deeper analysis.

The system consists of two visualizations and a smartphone interface to perform interactions. The two views for the wall-mounted display are:

1. **Ambient view**: Overview of unsigned artists (establishing shot)

2. **Narrative view**: A detailed visualization of individual artists’ stories

The goal of this concept was to serve the dual role of Ambient display or Narrative display depending on the proximity of the user. As an Ambient display, the visualization shows an up-to-date aesthetic overview of the most interesting unsigned artists. As a Narrative display, visual stories of individual artists are shown. Both roles support individual and collaborative visual exploration scenarios as well.

### 4.5.1 Content

For the content of the visualizations, frequently updated data pieces were selected that also satisfies the common interest of the target user group. The topic of the display is unsigned artists and their individual stories. The following fragments of the available data set were used:

- **Predicted impact**: Daily prediction for each unsigned artist regarding their future impact. Each artist receives a rank on a scale of 100. The rank is an aggregation of six different daily ranks. Furthermore, based on the rank, artists belong to four different groups: Growing (0-25), Promising (26-50), Hot (51-75) and Epic (76-100).

- **Events**: Music related events associated to individual artists. Examples: Album or song release, Twitter or Instagram post, weekly peek in new followers, live performance, ticket sales for concert, etc.

### 4.5.2 Layout

The layout for the ambient application consists of three parts: a header, a footer and the main stage. The header contains system information, like the current date, name of the application. The footer contains all the information for selected artists: picture, name, active track, six ranks values and the aggregated predicted impact number. The main stage serves as a container for both visualizations, an overview of the artists and details about a specific artist.

### 4.5.3 Ambient view

The Ambient visualization is the standard view of the system. The goal of this visualization is to raise awareness amongst coworkers about most promising artists.

The visualization shows the daily top unsigned artists (maximum a hundred artists) ordered by the predicted impact rank. For the representation of the data I designed a bee swarm plot\(^2\), which is a one-dimensional scatter plot like "stripchart". The chart has a closely-packed layout which makes sure the points are non-overlapping. Each node/circle represents an artist. The circle’s position on the horizontal axis represents the artists’ rank.

\(^2\)http://www.cbs.dtu.dk/~eklund/beeswarm/
The abstract representation provides a daily overview about all the interesting artists. Since the data gets updated every day, the visualization serves as a starting point for the A&R division. A distant view of the visualization can inform the user, how many interesting artists are there today based on their activity from yesterday. A closer look at the visualization can tell more about the artists. The display also promotes interactions with the mobile phone, that could reveal even more details about particular artists in the next view.

4.5.4 Narrative view

While the ambient view’s role is to provide a daily overview for the users, the narrative view presents visual stories of particular artists. The overview shows who are the interesting unsigned artists, and the narrative view explains why. It is composed of three layers: a visualization, a timeline and a label layer. The visualization layer contains a multi-series line chart that depicts the time-series data of all six daily ranks of a particular artist in the past ten days. The timeline, is the heart of the narrative view. It displays a series of events in chronological order. The long bar labeled with dates and circles that represent a single event, linked to the selected artist. The label layer, underneath the timeline, acts as a container of labels for the events. The layout of the labels is packed, so they are non-overlapping. The link between the labels and dots is depicted by curved lines that connect them.

The combination of these three layers is a view where users can spot trends and the temporal causality between events. In collaborative scenarios it facilitates discussion and promotes deeper visual analysis. Ultimately, the view also serves as a unified, reusable narrative frame for every artist’s story.

4.5.5 Mobile User Interface (UI)

Fast wireless networks and the ubiquity of smart phones lay out new ways for cross-device interactions. To offer effortless interactions with the large screen, I designed a mobile application that connects to the wall-mounted display. Similarly to the big screen application, the mobile app has two views as well: one for the ambient visualization and one for the narrative visualization view.

Figure 9: User Interface for mobile app

The first view contains a list of the most promising artists. Each item in the list consist of the artist’s photo, name, active track and predicted impact number. The data represented in the list view and in the visualization of the ambient view is the same, which is determined by the selected day. Additionally, the UI has a date-picker at the bottom of the screen that allows the user to change the selected day.

The second view of the application shows the selected
4.5.6 Interaction flow

Figure 7 shows the interaction flow between the views, controlled with the mobile application. When a phone connects to the Ambient Visualization, the application reveals a list of the artists for the particular day. The user either changes the visualization by navigating between days or selects an artist. By tapping on an artist, the ambient visualization highlights the selected artist to show its position and greys out the rest of the artist in the bee swarm plot. Additionally, the footer of the display reveals more details. The user can repeat this action to highlight different artists.

The mobile application also highlights the selected user in the list view and reveal an extra option to go to the narrative view which shows the artist’s story. Taping on the narrative button switches the big screen to the narrative view and updates the mobile interface as well. In this view, the user can navigate between the dates with the date picker. The corresponding label on the timeline gets highlighted along with the events that happened that day. The six daily ranks in the footer also show the daily numbers. Furthermore, the user can control the visualization to highlight specific ranks only.

4.6 High-fidelity mock-ups

As a next step in the design process, I designed high-fidelity mock-ups for the system to address the design objectives in more details. Increasing the fidelity of the designs helped to prepare a thorough design plan for the prototype. In addition, the visual design addressed the aesthetic emphasis objective of the ambient display. The consistent visual language and the dark theme with vibrant colors brings attention to the content and blends in with the elegant office environment.

4.6.1 Ambient view

The beeswarm plot consists of a horizontal line, vertical ticks with labels and the visualization. The horizontal baseline is the scale for the predicted impact number. The vertical ticks indicate the borders of each group (<25: Promising, 25-50: Growing, 50-75: Hot, 75:< Epic). Extra labels for each group are placed over the visualization with number of artists per group. Each circle of the plot is filled with the artist’s black and white filtered photo. The border color of the circles is determined by the horizontal value and the categories. The result is four distinct groups with specific colors. The distant view of the visualization can tell users, how many interesting artists are in each group.

4.6.2 Header, Footer

The header and footer parts of the application provide a visual frame for the ambient and narrative view. The
headline / name of the feature indicates the content of the visualization. The date in the middle of the header aims to promote relevance. The small icon and informative text in the top right corner demonstrates interactivity. It acts as a feed-forward to encourage users to connect to the screen with their smart phones.

The placeholders for the artist’s name, photo, ranks, etc. in the footer suggest to the user that additional information can be accessed. This technique also promotes interactions. When the user connects to the display with the smart phone and selects an artist, the footer shows additional information. The most recent six ranks are visualized with bar charts with the exact values next to it. The aggregated predicted impact number in the bottom right corner draws attention with large text size.

4.6.3 Narrative view

To visualize the time-series data of daily ranks, I explored different alternatives, like Streamgraphs, Small multiples, Area and Line charts (Figure 13).

Finally I selected the multi-series line chart, since it can show all six ranks at the same time. Additionally, by interacting with the visualization, users can highlight different ranks to create more focused views. The six ranks are color-coded. Each rank has its distinct color to indicate the connection between the horizontal bar charts in the footer and the lines in the visualization.

Events, represented as circles on the timeline, are linked to labels underneath the timeline. Each label contains the pictogram and name of the event category. During interactions, the active / selected date in the view highlights the corresponding timeline label and event(s). The second view in Figure 14 demonstrates an example where the user only focuses on one rank over the time and the view suggest causality between the three highlighted events and delayed peak. This example clearly shows the goal of the narratives, which is providing a way to the user to customize the view and unveil unexpected connections that could lead to deeper analysis.

4.6.4 Mobile application interface

To have a consistent visual language, the color palette of the mobile application is the same as the ambient display’s. When the user selects an artist in the list view, the narrative button, that takes the user to the second view, slides in. The narrative view of the application contains the selected artist’s details, daily events, and the controllers for the visualization. The same color-coding is used for each rank in the application to support visual connection between the line chart and the buttons. Each button has two states: active and disabled (Figure 15). The buttons can highlight and fade out the a rank’s line in the narrative view.

Figure 14: High-fidelity mock-up of the Narrative view

The date picker at the bottom of the screen has a dual role. In the first view, it lets the user explore the ambient visualization on different days. While, in the narrative view it allows the user to navigate through the storyline. The selected day is always synchronized with the date in the big screen application.

Figure 15: Two states of the visualization controls

Figure 16: High-fidelity mock-ups for the mobile UI
4.6.5 Narrative features

Narrative features intend to share visual data stories with the users. The ambient view serves as an establishing shot. Each circle represents an individual story of an artist. The visualization gives control to the user to navigate between the stories and decide which one is interesting. The narrative view allows the user to control the macro-structure of the story (daily ranks and events) and reveal more information about the micro-structure (event details and temporal causality between them). The label layer serves as the messaging of the story. The goal of this structure is to assist the A&R division’s work-flow. Users can rely on the display as a starting point for every day and discuss different artists’ activities by analyzing their visual stories.

5. PROTOTYPE

Using the final designs of the system, I developed an interactive prototype with web technologies. The goal of the prototype was to be able to test the system and its user experience. The prototype consists of two web applications, the large screen web app (visualizations), and the mobile app (controls). Figure 17 illustrates the system architecture.

Figure 17: System architecture of the interactive prototype

For the back-end I developed a webserver with Node.js, Express.js and used Socket.io to support bidirectional event-based communication. The mobile app communicates with the large screen through the web server using websockets. Every interaction in the mobile app emits an event to the big screen app. With this approach, the mobile application can control the large screen app without perceivable latency.

For both application’s front-end, I used the Angular.js framework. The application consists of many reusable components. The most important ones are the services that provide the data for the visualizations. Currently all data is notional in the application and stored in JSON files. The service components can be easily changed later to connect Augify’s API and get real data for the visualizations. For styling the applications I used semantic-ui and custom CSS.

5.1 System Hardware

To test the applications throughout the development phase, I used an iPhone 6 for the mobile application and a Samsung LED external screen for the large screen app. For web browser, Google Chrome was used for both applications. The system was tested with a 55” high-resolution LED display as well to make sure the text is legible and the application is responsible. The system can be easily deployed on any external display with high-resolution. Later, the application will be installed on a wall-mounted display in the office with a Google Chromecast device.

5.2 Visualizations

To implement the visualizations, I used D3.js. The ambient visualization (beeswarm plot) was developed with a custom forced layout. The circles are packed along an axis based on their values and collisions are detected between them. Custom gravity drives the circles towards their desired position along the x-axis. A light preference is used on the x-axis to each circle’s group. This creates a less tightly-packed layout, but the data is represented accurately.

For the narrative view, I developed a multi-series line chart visualization. For the timeline, the events and their labels I used the D3Kit timeline library. The labels are packed with the D3 force layout to avoid overlapping.

5.3 Transitions and Animations

The application incorporates several dynamic behaviors, which play an essential role in conveying the underlying meaning of the data and provide feedback for interactions. The ambient visualization uses meaningful animation by supporting the information hierarchy of the dataset. It shows first the most important artists from the right and flows smoothly to the left, creating a path for the eye to follow.

Staged animation is used for switching between the ambient and narrative view. First the ambient visualization fades out, then the line chart fades in followed by the timeline and the events layer.

The horizontal bar charts in the footer get updated with animations. When a user selects an artist the length of the bar animates from the initial state to the final state. When the user connects with a phone a pulsing animation indicates in the top right corner, that the device is connected.

6. EVALUATION

6.1 Focus Group

To assess the prototype, I conducted a formative focus group evaluation. The group comprised three domain experts with experience in visualization and interaction design. For a comprehensive evaluation criteria, I used the predefined design objectives of the project accompanied by the Ambient Heuristics [9]. Participants were asked to discuss the design aspects of the visualizations and the interaction technique with the display.

6.2 Results

Results of the focus group evaluation validated many design decisions of the final prototype. However, participants pointed out several issues as well. All of the participants found the information of the ambient visualization useful and relevant for the target user group. The abstract representation of the top 100 artists is easy to comprehend, even from distance. One issue was the lack of direction for the horizontal baseline. One participant pointed out, that the order of the circles on the x-axis is not apparent, and suggested an arrow or legend for the visualization to avoid ambiguity. Participants also recommended to emphasize the labels of the four groups, instead of the number of artists per group, by increasing the text size.

The information capacity of the display is appropriate, and the overview provides just enough information for the users. Interactions worked well to reveal more details. Due to the daily update of the data source (daily ranks and predictions), using the visualization without interactions felt...
sightly static for the participants. Therefore, they suggested three different ways to overcome this issue:

- use an automated walk-through for the most interesting artists by highlighting them for a specific period of time with revealing the details in the footer section,
- show granularity of the data by animated zooming for specific groups of artists,
- encode more data about the past activity of artists, such as fastest moving artists, first time artists or artists that appear in the top 100 with a significant trend.

These solutions can be explored in the future, however, the display should keep its ambient nature and balance between promoting relevance and calmness.

The structure of the narrative visualization provides a good view at the story of individual artists. However, participants pointed out the underuse of narrative features. More messaging for the narrative view would emphasize the visual story. Recommendations included:

- emphasizing movement for navigation between days with highlighting daily points in line chart and setting the opacity of the rest of the visualization lower,
- highlighting peaks in the time-series of ranks with extra annotations, numbers and facts together can make the data relatable,
- use a marker to indicate the visibility of state (selected day)

Overall the whole story structure (establishing shot with individual stories in the application) works well. More text (headlines, captions, annotations) can lead to more powerful storytelling, therefore more narrative features should be incorporated.

The visual framework of the application is consistent and aesthetically pleasing according to the participants’ feedback. It can blend in with an office environment easily. The color coding of the groups and six ranks is also effective and easy to perceive.

The participants found the interaction technique engaging and playful. Using personal smart phones to connect to the display comes natural to users. One issue in the interaction flow was the “back icon” (large X in the top right corner of the second view). The meaning of the icon was not explicit and participants recommended to use text instead of an icon. Controlling the visualization for the narrative view was an intuitive experience. The visualization reacted to the user interactions quickly, however, the short animated changes on the screen were not always perceived by the controlling user. The dual role of the date picker is not clear. Participants did not realize immediately the switch between its role for the two different views. Furthermore, the feedback for changing the date should be more prominent in the header of the large screen app.

Participants found easy to share the display for visual exploration of the data. The group members expressed the desire to control the display simultaneously, since the prototype currently supports only one device at a time.

7. DISCUSSION

The goal of this study was to explore the future state of ambient displays in a special context and inquiry into what might be promising for future research. The project focused on a specific target user group, their work-flow, and a way to support it with visualizations that reside in their working environment. An iterative design process resulted in an interactive Semi-Ambient Visualization that users can control with a mobile application. The content of the display was tightly connected to the target user group main goals and interest. The visualizations utilized narrative features to communicate the underlying data effectively. Eventually, the interactive prototype was developed and evaluated by a focus group of domain experts.

The general feedback from the participants regarding the concept was encouraging. According to the participants’ comments incorporating narrative features into ambient visualizations could foster discussions and promote deeper visual analysis. Interactions with the displays that surround us is intuitive with our smart phones. Furthermore, the interactive behaviour of the display engage users and allow them to utilize large displays in collaborative working scenarios.

Although the work was focusing on a specific setting, the resulting concept can be further explored in different application areas. Besides focusing on co-working groups and their environment, similar displays can be installed in public places for wider audiences as well. The design process and final prototype of this project could inspire and inform future research to tackle similar “wicked problems”. Employing similar design process can result in more utilitarian ambient visualizations in different contexts.

7.1 Future work

The results of the focus group evaluation highlighted some issues with the interactive prototype. As future work, I will follow up on the comments of the focus group by improving the interactive prototype. Following that, the next step would be introducing the system gradually in the work environment with real data from Auggys’s API. First the Ambient visualization only, then integrate the Narrative visualization with the interactive behaviour. This approach would allow users to slowly familiarize themselves with the application. Ultimately, additional feedback through interviews and questionnaires would be collected. This feedback loop will help to revise the general design characteristics and improve them. The long-term goal is identifying a generic set of visualization and interaction design criteria for Interactive Semi-Ambient Visualizations with Narrative features, which can be utilized in future projects.

8. CONCLUSION

The purpose of this research was to explore the design space of more utilitarian Ambient Displays. The thesis’ topic was located at the intersection of research on novel interaction techniques with Ambient Displays and Narrative visualization features. The special context of the project included a music management company and its A&R division as a target user group. The conceptualization and design of the system were rooted in the results of a detailed analysis of the target user group, their professional environment and their work-flow. As the result of the work, I introduced a novel concept for an Interactive Semi-Ambient Display
with Narrative Visualization features. Using the theoretical background and the collected information, I employed an iterative Research through Design process to design and develop an interactive prototype. Eventually I evaluated the prototype and the results were encouraging. The evaluation revealed that providing interactions for ambient displays, could increase user engagement, support collaborative scenarios and result in a more useful system. Moreover, incorporating narrative features into visualizations resulted in better presentation of the underlying data stories. Finally, the future of Interactive Semi-Ambient Displays with Narrative Visualization features in workspaces looks promising. Future work will focus on refining the design space of the concept.

9. REFERENCES


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