RETHINKING THE ONLINE EXHIBIT

Cezar Mocan
Advisor: Holly Rushmeier

Computer Science
Yale University
May 2016

ABSTRACT

Ever since the computers entered our lives and access to information became ubiquitous, the art world went through a democratization process which allowed people all over the world to admire works of art from the comfort of their homes. The evolution of the graphical user interface to something more complex than a monochrome terminal, has brought attempts of taking the museum experience into the virtual realm. The first such efforts span from the beginning of the 1990's, when the first user friendly 3D rendering technologies made their way to users around the world. This led to software companies creating and delivering "Virtual Museums" for personal computers: simple virtual 3-dimensional spaces, vaguely reminiscent of the architectural structure of physical museums, with programatically rendered art objects for the users to admire. Once the Internet became widespread, museums and galleries have gone online through the creation of exhibitions, catalogues, tours or installations entirely accessible from the browser. Very often, the online presence had the goal of supporting the physical one, but, as we have understood through this research, that is not always the case.

This project attempts to both survey some of the existing online exhibitions, and create one. Concretely, the first goal is to explore the current ecosystem of web based exhibits, understand the design and technology choices, the limitations and effectiveness. The final deliverable consists of building and iterating an online prototype for an upcoming exhibition of bronze statues at the Wadsworth Atheneum Museum of Art in Hartford, based on the knowledge acquired in the initial research phase.

The [designer] has the job of erecting a window between the reader inside the room and that landscape which is the author's words. He may put up a stained-glass window of marvellous beauty, but a failure as a window; that is, he may use some rich superb type like text gothic that is something to be looked at, not through.

—Beatrice Warde

Every film is about filmmaking. [Hitchcock's] great genius is that he is able to mold the form into his style in a genuinely unique and entertaining way. The meaning of his work is not in the story but in the storytelling. Designers also trade in storytelling. The elements we must master are not the content narratives but the devices of the telling: typography, line, form, color, contrast, scale, weight. We speak through our assignment, literally between the lines.

—Michael Rock

1—INTRODUCTION

Museums are the result of our organized effort of getting in touch with different times and places. Museums are accessible to people who are in their vicinity. Museums collect objects. Museums exhibit objects. Museums are shared spaces. Museums are sequential—sometimes. Museums offer an interactive experience, but the objects they are hosting often do not. Museums are medium agnostic. Museums are not medium agnostic. Museums are real. Museums are physical. And lately, museums are virtual too.

The early days of the Web brought the accessibility revolution in the art world as well, as established museums understood the outreach power of the new medium and started using it in order to attract visitors to their physical exhibitions. A physical—virtual dichotomy made its way into the world of museum lovers, with technology enthusiasts enjoying the benefits of widespread access to information, and skeptics affirming that the physicality and materiality of exhibitions are two essential characteristics that could never be replaced by a virtual environment. The latter category was right in being uncontent with 2-dimensional screen-rendered *reproductions* of the original objects—but this was not the first time the humanity was facing such a problem.

In his seminal 1936 essay, *The Work of Art in the Age of Mechanical Reproduction*, Walter Benjamin *[Benjamin 2011]* tackles this very issue: the loss of what he calls the object's *aura*, through the reproduction means made available by the industrial technological advances of the time.

> *"This image makes it easy to comprehend the social bases of the contemporary decay of the aura. It rests on two circumstances, both of which are related to the increasing significance of the masses in contemporary life. Namely, the desire of contemporary masses to bring things "closer" spatially and humanly, which is just as ardent as their bent toward overcoming the uniqueness of every reality by accepting its reproduction.* ***Every day the urge grows stronger to get hold of an object at very close range by way of its likeness, its reproduction.*** *Unmistakably, reproduction as offered by picture magazines and newsreels differs from the image seen by the unarmed eye. Uniqueness and permanence are as closely linked in the latter as are transitoriness and reproducibility in the former. To pry*

an object from its shell, to destroy its aura, is the mark of a perception whose "sense of the universal equality of things" has increased to such a degree that it extracts it even from a unique object by means of reproduction."

His argument could not apply better to the digital revolution we have been experiencing over the past two decades. More than anything, the Internet has gone all the way through in satisfying our *desire to bring things closer*—of course, in a way conditioned by both the inherent limitations of reproduction as a process and the technological limitations of our entry points into the virtual world. Pixels. So, one might ask, where stands the work of art in the age of digital reproduction?

2—GOALS AND METHODOLOGY

The goal of this project is two-fold: gaining an understanding of today's online exhibition ecosystem and creating an online exhibition prototype for an upcoming show. For the first part, we seeked an understanding of how certain design and technology decisions influence the user's way of experiencing the exhibitions. Exploration of multiple online exhibitions with different authors (museums, art lovers, techies, galleries, etc.) has been key in gaining an overview of this subset of the online world, by finding the common threads between different approaches and crystallizing a list of factors which influence the visitor's perception. The exploration was led by a simple question: *What is the relationship between physical and online exhibitions?* While it may seem like the answer is obvious—or that the question is nonsensical, depending on who you're asking—it has proved to be the driving force of this research. In order to construct an answer, we took the concept of an online exhibition to an abstract level, identified its characteristics and compared them to their physical counterparts. We came up with the following list of 6 factors (which is by no means extensive), list that will be pursued into further detail in the next section.

A. The visitor's role
B. Type of interaction with the exhibition space
C. Main focus of the exhibition
D. The exhibition's temporality
E. The exhibition as a shared space
F. The exhibition's medium (online, physical, etc.) and the implied hierarchy between them

As the research phase concluded, we became intrigued by two of the aforementioned characteristics—temporality (#4) and the exhibition as a shared space (#5), as the contrast between the physical and the virtual in these two areas is

the most obvious. The prototyping phase represented our attempt at appropriating the physical realm expressions of the two factors into the virtual. The online exhibition experiments have been built with the purpose of potentially supporting a future exhibition of bronze statues at the Wadsworth Atheneum Museum of Art in Hartford, CT and will be presented in detail in Section 4.

3—EXHIBITION CHARACTERISTICS

We analyzed a set of 23 existing online exhibitions *[Annex 1]*, with a wide range of approaches to presenting art online. Given the variety of the analyzed websites, an important difference to be made is the one between the *virtual exhibition* and *digital collection [Schweibenz 2013]*, which we are tackling in Section 3.3. As a way of encompassing the two approaches, we have used the term *online exhibition* throughout this report, as our analysis includes examples of both. The next subsections will go into details on the exhibition characteristics we identified in the previous section, as well as show innovative examples within each category.

3.1. The visitor's role

Perhaps the most important question creators and entrepreneurs need to tackle in the early stages of their journeys is *Who is the user?*. The difficulty of answering lays in the question's generality, wide range of responses as well as in the existence of answers which have stood the test of time. This holds true especially in the case of art and exhibitions—traditionally, the user (or visitor) has been a mere observer, quiet and cautious, placed exclusively on the receiving end of the experience. The late 20th century art movements brought a certain democratization to the process, by allowing visitors to contribute to the creation, or curation of a piece[1]. This phenomenon found its place in the world of (online) exhibitions as well—with a different intention in my opinion, closer to reasons pertaining to getting users involved and excited than to a revolutionary act.

[Pulh and Mencarelli 2015] make an extensive analysis of the impact the Web has had in redefining the visitor-museum relationship, and point out a trend towards the desacralization of the museum space, through changes in the traditional visitor

[1] For example, Hans Haacke's *MoMA Poll.*

role. They classify two newly created roles for visitors as *"Museum Mediation Agents"* and *"Full-Blown Artists"*. In the first case, a common approach[2] is achieved through *folksonomy*, a user-centered tagging system for exhibited objects. This places the visitor in a curatorial position—even though their input might be further curated by the exhibition staff. Another example presented by *[Pulh and Mencarelli 2015]* is the crowdsourced *Boston Loves Impressionism* exhibition organized by the Boston Museum of Fine Arts in 2013, which used an online voting system in order to determine which artworks would become part of the physical exhibition. The second approach allows users to generate content which will instantly or later (upon curation) join the original artworks as part of the collection. One example of such an endeavor is the Dutch *Rijksmuseum* which, through its online *Rijkstudio*[3] project invites users to respond visually to the existing digitized versions of the artworks in the physical museum and upload their creations—digital creations that are later displayed as complements to the initial artworks.

3.2. Type of interactivity in the online exhibition

In 2001, the IBM T.J.Watson Research Center conducted a 10-month long user experience research for the purpose of developing "the design concept of a multi-institutional art and culture website."*[Vergo et al. 2001]* The final report of the study, titled "Less clicking, more watching" became one of the most cited works in the field. Its title summarizes the findings perfectly: a strong preference in users towards watching and consuming the contents as TV-like media, as opposed to complex interactions with the website. We can find multiple counter-arguments to these findings and their actuality: the fact that the web user-friendliness and aesthetics were still very limited in 2000, the tested interactive experiences not being the most creative ones ("chat rooms, information search systems, or user curated tours"), and the list can continue. Nevertheless, the study confirms the intuition that the passive receiving of information often makes for better "user experience" than active seeking.

[2] According to Pulh and Mencarelli, The Philadelphia Museum of Art and The Brooklyn Museum are two renowned institutions who have taken this path.
[3] https://www.rijksmuseum.nl/en/rijksstudio/instructions

We analyzed the interactivity type of the online exhibitions and found a wide spectrum of strategies used in displaying the content, ranging from a minimal amount of required user interaction (e.g. a simple cursor move) to assisted exploration, in a way similar to computer games. Below we present four examples with innovative (in our opinion) types of interaction.

3.2.1. Black Sun[4]

This is an exhibition organized by Fondation Beyeler as an homage brought to Kazimir Malevich at the 100th anniversary of his iconic *Black Square*, with the purpose of showcasing the Malevich's influence on artists of later periods. The online presentation of the exhibition has an incredibly simple design, which places the emphasis fully on the artworks. *(Fig. 1)* A single interaction is required to navigate through all the artworks of the website: mouse movement. Every mouse movement triggers the loading of a new artwork, with a morphing black quadrilateral making the transition between different pieces. *(Fig. 2)*

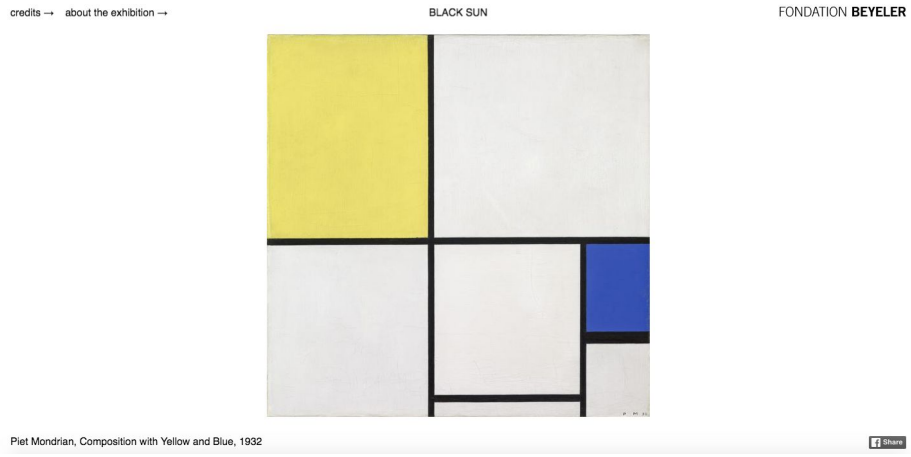


Figure 1—Black Sun

[4] http://blacksun.fondationbeyeler.ch/

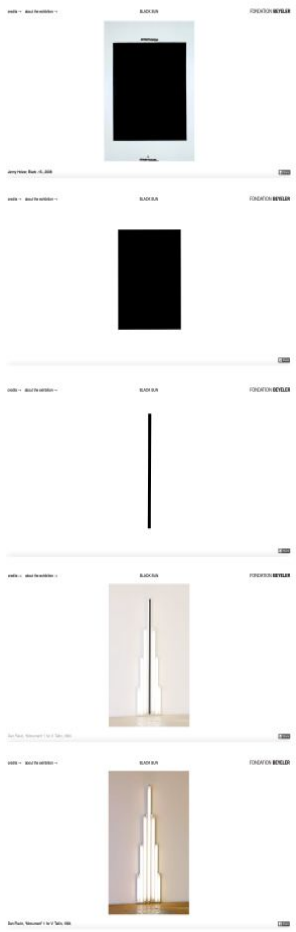


Figure 2—Black Sun, transition between artworks, triggered by a single move of the cursor

3.2.2. Gallery of Lost Art[5]

Organized by the Tate Museum in collaboration with Channel 4, the Gallery of Lost Art uses the term *online installation* in order to define itself. Its aims to shed light on over 40 artworks from the last century which had been (partially) destroyed, censored or have simply decayed, through presenting parts of the artworks and

[5] http://isodesign.co.uk/projects/gallery-of-lost-art

contextual information related to them. The user is presented in the browser with a photographic floor plan, containing people, desks and plenty of objects spread out all over the place, and can find out more details about each object by clicking on it. *(Fig. 3)*

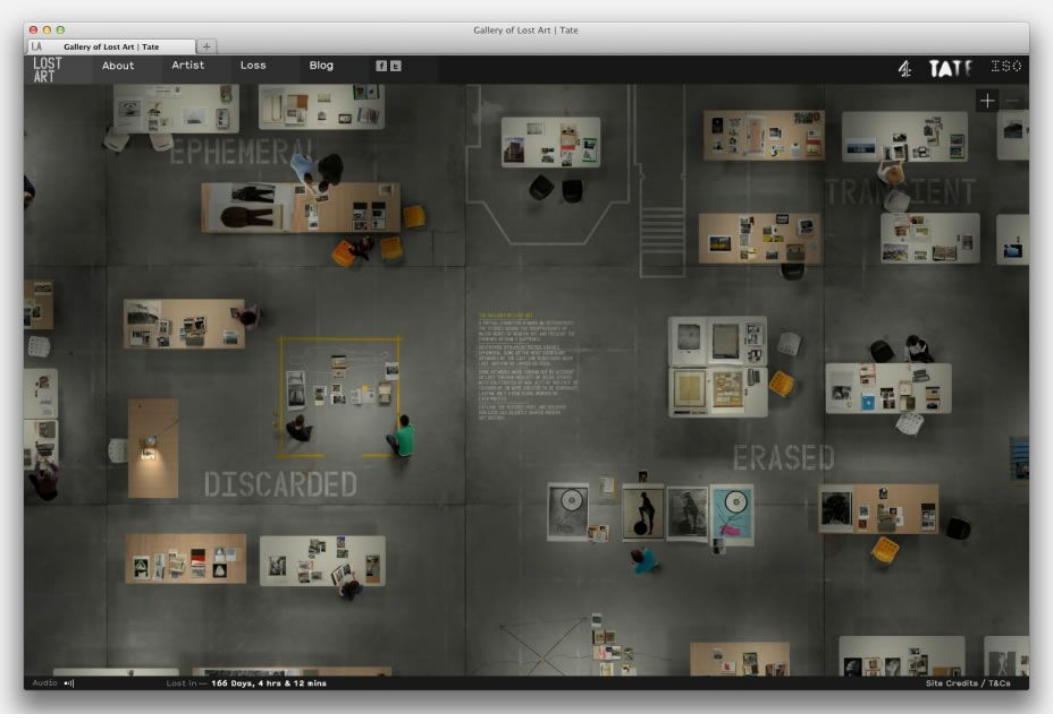


Figure 3—Gallery of Lost Art

3.2.3. Tate Afterdark[6]

For five nights during August 2014, the Tate placed robots equipped with video cameras and lights inside the halls of its galleries, created a web interface for broadcasting the video captured by the robots and allowed randomly chosen visitors of the website to control the robots for short intervals of time—a great mix between the physical and the virtual, and an example of the previously mentioned space desacralization.

[6] http://www.afterdark.io/

3.3. The exhibition's focus—Bringing the context to light

The differentiation made in the beginning of this section, between the virtual exhibit and the online catalogue, becomes relevant when thinking about the goal an online exhibition. While the virtual exhibit aims, by definition, to create a self-contained experience for the user—whether it has the purpose of supporting a physical counterpart or not, the online catalogue has a more pragmatic role: to organize. For years, museums have built and used content management systems in order to showcase their work online and, in most of the cases, the information hierarchy of such systems places the visual renderings of the artworks higher than the afferent contextual information.

Admittedly, it is almost impossible to leverage the context in any creative way if the scope of the online catalog is too large: there might just not be any feature common to all of the works to serve as a basis. Nevertheless, the Art Genome Project[7] succeeds to a certain extent in making its visitors understand the larger picture and draw connections between different pieces, by making use of available metadata. Through a robust recommendation algorithm and a tagging system curated by professionals, containing tags pertaining to formal qualities of the objects, historical period, authors, subject matter and others, the project makes it incredibly easy for users to find works of art based on a wide range of criteria. While the project has been built for high-end art trading purposes—art collectors, galleries, etc.—it manages to be a great educational tool at the same time.

Functioning within a more limited scope, we find Yale's Photogrammar Project[8]—a tool for "organizing, searching and visualizing" a large collection of photographs created by the United States Farm Security Administration and Office of War Information in the 1935—1945 period. It takes a data-visualization oriented approach towards organizing the photographs, allowing users to access photographs taken in specific regions of the country (through an interactive map), filter by photographer, period or categories associated with the photographies. It is, the author's opinion, a successful data-driven approach towards organizing art.

[7] https://www.artsy.net/categories
[8] http://photogrammar.yale.edu/

3.4. The exhibition's temporality and served purpose

The temporality aspect became one of interest in the development of the prototype once we articulated its role in the difference between physical and online exhibition. Simply put, the physical is almost always intended to be ephemeral, while the online is almost always intended to be permanent. That is the *normal* way, we might be tempted to affirm—the physical exhibition represents the main attraction point, while its online counterpart exists as a support: for giving access to people who lack the physical access, for informing potential visitors and for keeping a record of the event once the physical space is repurposed. This implies a straight subordination hierarchy between the two, hierarchy that, in our opinion, takes away from the power of the online exhibit. Just as the physical exhibit leverages the characteristics of the physical world, the online one should apply the same principle within the virtual world, and establish itself as an independent expression of a common idea, using a different canvas—the browser. We are not claiming that denying eternality to the online exhibit is the universal solution towards its independence. It is more a question of choice, as it is so often in the creation process, and of refusing to take for granted all the possibilities offered by our medium.

In our research, we have found two examples of ephemeral online exhibits, both belonging to the Tate Museum. The previously mentioned *Gallery of Lost Art* existed online for exactly one year, from the 1st of July 2012 to the 1st of July 2013, after which it "became lost", just as the art it was exposing—an appropriate form for the exposed content. *Afterdark* is the other one, having existed for 5 nights, but we believe the reasons behind this decision were of pragmatic nature.

3.5. The exhibition as a shared space

The act of exploring an exhibition, walking through its quiet hallways, moving from artwork to artwork, looking at the objects or reading their descriptions is designed as a collective journey, and we should be thankful for it. Throughout the time spent with the art, a visitor is constantly aware of the presence of his fellow visitors, sometimes even bothered by it. The online exhibition does not share this aspect. While a server is able to accommodate multiple connections at the same time, we

have not found an example of an exhibition which brings awareness to its users of other presences in the virtual space at a specific moment in time. There is a wide range of possibilities for achieving this purpose, going from chat rooms (as exemplified in *[Vergo et al. 2001]*) and other functional full-fledged features to subtle ways whose only purpose is to raise this awareness, without diluting the essence of the exhibition's goal.

Designing appropriate ways of creating the shared space, and finding the technology to back them up has been one of the pursuits of our prototype, which will be presented in the next section.

4—PROTOTYPING

Designing the online presence of an exhibition which will see the light of day in the near future sure is a daunting challenge. The collection we have been working with will be on show at the Wadsworth Atheneum Museum of Art in Hartford starting in 2017, and consists of a set of about 20 bronze sculptures created more than 2000 years ago.

The prototypes we have created represent works in progress, and should be treated as such, for two reasons. First, since the museum exhibition will be on show starting more than eight months from today, full access to the objects (both high-quality photography and metadata) has been impossible. Phone-camera quality photos of the objects were used in some of our iterations, and placeholder photographs of different 3-dimensional sculptures in others (more details to come.) Second, the focus of this project has not been the creation of the best designed and most user-friendly online exhibition. As mentioned in the previous section, we became interested in two specific characteristics of exhibitions—ephemerality and collectivity—and pursued their expression in the online environment. We have also experimented with a different type of user interaction: using the web camera instead of the mousepad for certain actions.

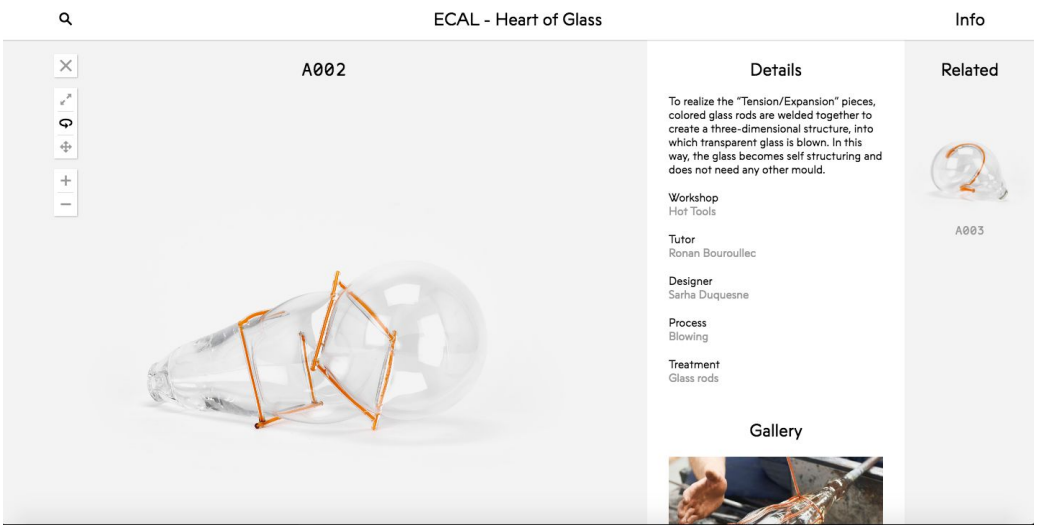
4.1. Early experiments

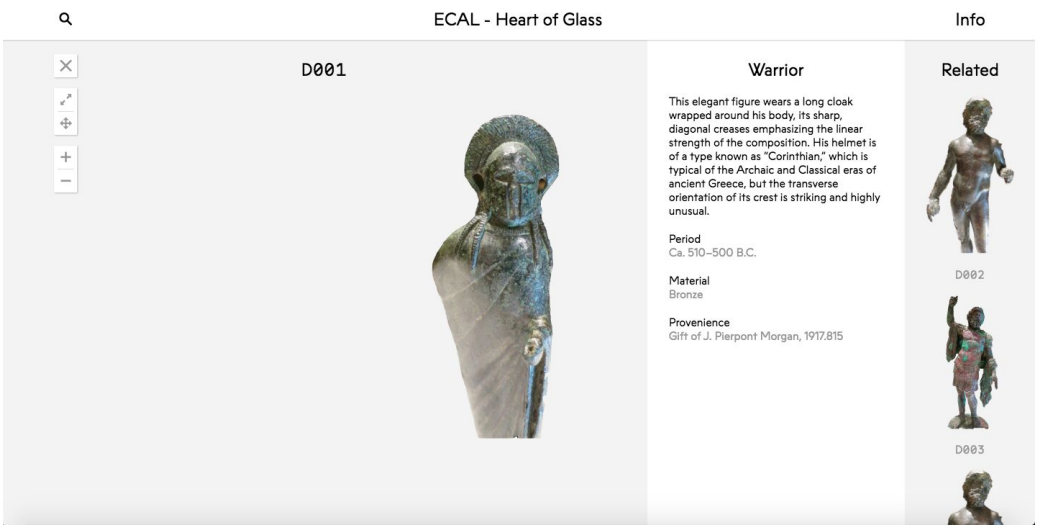
The research phase of the project proved extremely useful in seeing and understanding the different types of interactions used by existing online exhibitions and paved the way to an important question: *How can two different designs be compared?* The design of each exhibition reflects to a certain extent the contents of the showcased collection, and we were interested in understanding what type of UX design would suit the objects we were working with best. As a result, we decided to recreate five of the exhibitions analyzed in the research phase using the objects in our collection. Keeping a constant element on the page—its subject in our

case—allows for a much easier comparison of the different designs and how they influence the user's perception.

For each of the websites, we only re-created the page displaying the objects of the collection, and appropriated the user actions related to 1) interacting with an object and 2) moving through the collection. The contextual information pages were not of interest for our question. Below you can find images of the five experiments, for both the originals and our recreations. The complete interactive web pages can be found on the project's website.

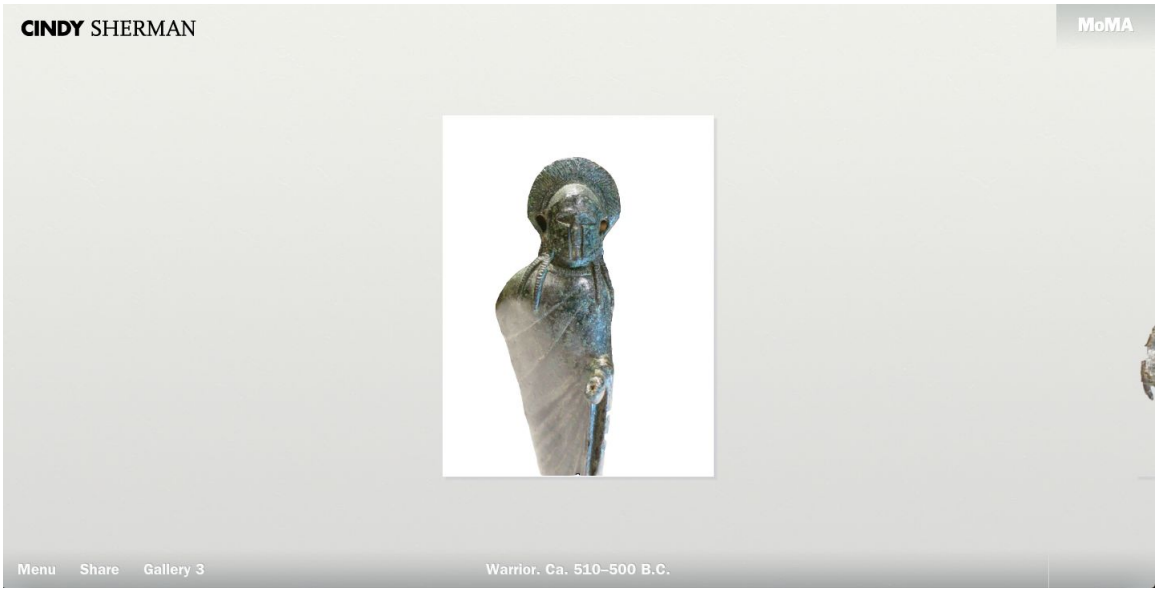
A. ECAL—Heart of Glass[9]





[9] http://heartofglass.ch/

B. MOMA Cindy Sherman Retrospective[10]

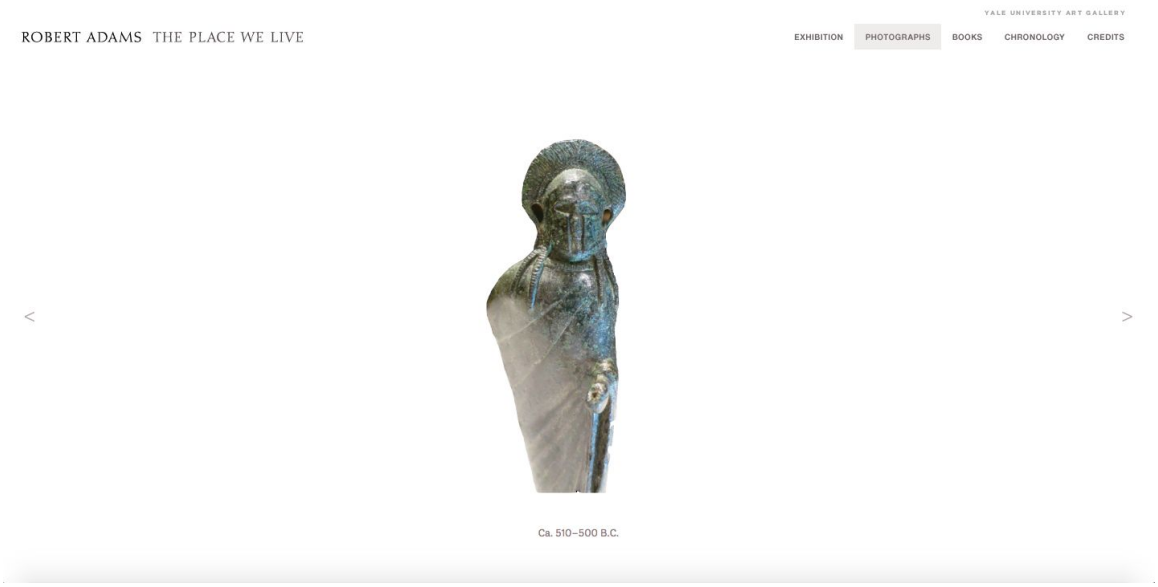


[10] http://www.moma.org/interactives/exhibitions/2012/cindysherman

C. Fondation Beyeler—Black Sun[11]

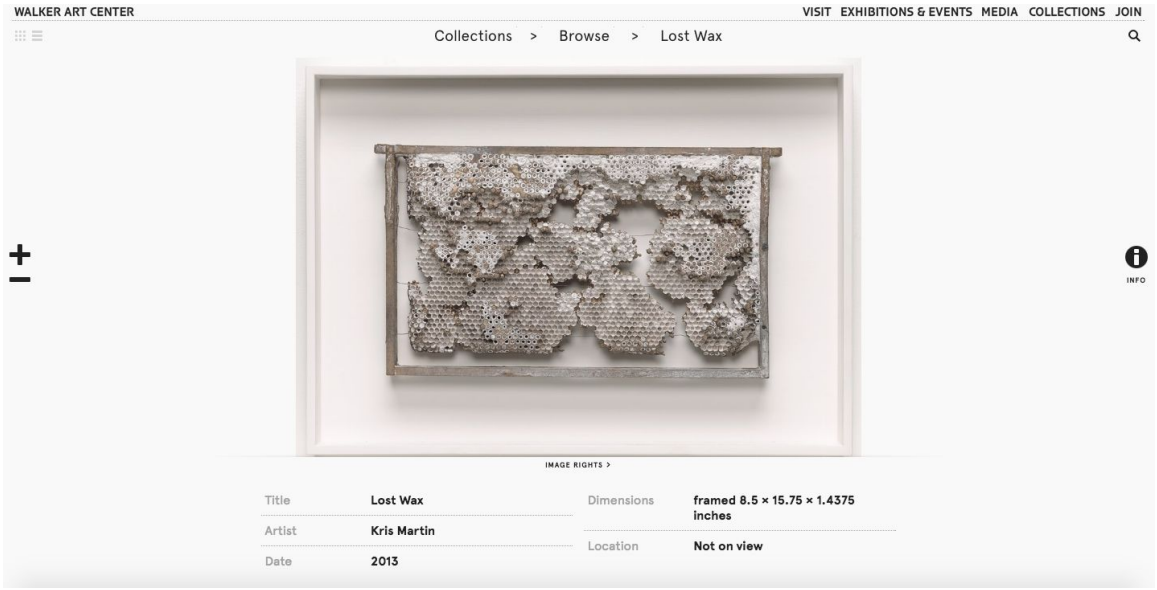
[11] http://blacksun.fondationbeyeler.ch/

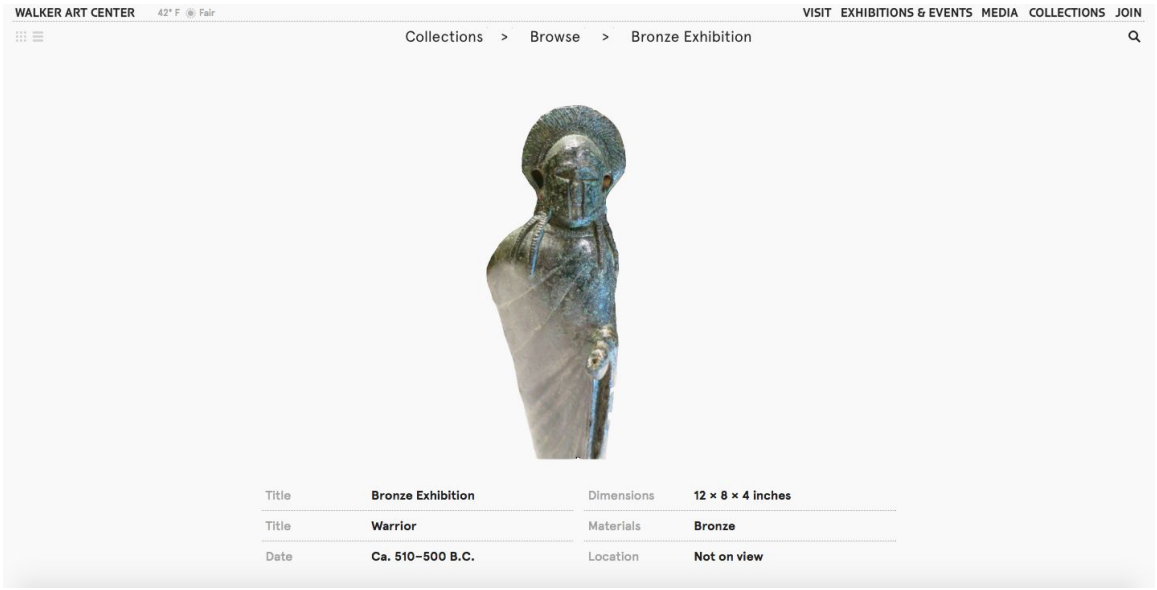
D. YUAG—"The Place We Live", a Robert Adams retrospective[12]



[12] http://media.artgallery.yale.edu/adams/landing.php

E. Walker Art Center[13]





[13] http://www.walkerart.org/collections/artworks/lost-wax

4.1.1. Future work

These graphic and interaction design recreations could be used for a future user research, in order to better understand the impact of each individual form on the user's perception of the bronze statues.

4.2. Design directions

In coming up with potential designs for the exhibition website, we pursued an understanding of the nature of the objects, their characteristics and their historical context. The information we had access to was limited, so the only factors we could work with were the following:

A. All of the objects are bronze statues (3-dimensional objects)
B. All of the objects are about 2,000 years old
C. All of the objects have been created in Ancient Greece or the Roman Empire

4.2.1. The timeline approach

Providing contextual information using a map was out of the question, as the geographical data was insufficient. The only characteristic that we found could be used as a starting point for the design was the age, so we built a few mock-ups based on it. The idea behind this direction was to go all the way in making visitors fully aware of how old the sculptures are, through providing them with a timeline of historical events they are familiar with—starting in the present day and going back in time until the period of the oldest object. As you can see in *Fig. 4*, the entire page of the exhibition is one long scroll, decision that we made in order to minimize the amount and diversity of user interaction. Through the repetition of scrolling (or clicking on the "down" arrow), a user would be taken throughout the main moments of history until reaching the objects.

Upon further investigation, this approach seemed forced and we decided to abandon it.

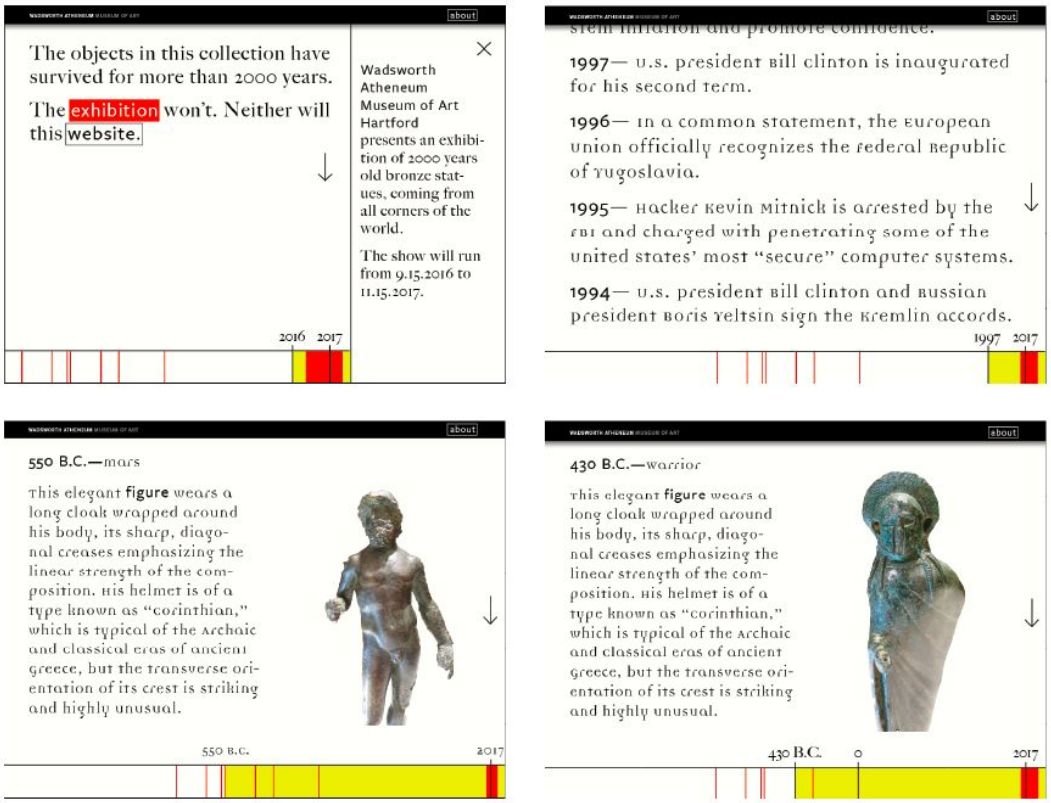


Figure 4—Timeline idea mockups

4.2.2. The conservative approach

A more fruitful approach, which we ended up developing into a working prototype, started out as a "traditional" approach to online exhibition design, on top of which we added a few layers as a way to incorporate the results of our research phase thought process, as well as leverage the 3-dimensionality of the exhibited objects.

4.2.2.1. 360° Objects

We considered using the fact that the subject of the exhibition is sculpture a necessity in creating the prototype, as it was one of our few consistent pieces of information about the objects. Therefore, we decided to present the objects in a 360° view, using 18 photos for each object—roughly one per 20° turn of the object. As

we were not in the possession of such photographs for our bronze statues, we used placeholder objects, as a proof of concept. Going further with this idea, we tried finding the most natural type user interaction for rotating the sculptures, as we were not content with the click & drag approach used by websites with a similar presentation of the objects. We found our response in the web camera and a face tracking library, and decided that the rotation of the objects would be directed by the user's head movement in front of the computer screen. A head movement to the right causes the object to rotate to the left, such that the user can see the right side of the object according to his orientation, and vice versa for a head movement to the left. We will go into the specific implementation details of this choice during Section 4.3.

4.2.2.2. Website navigation

The use of the webcam opened up a new possibility: a new type of website navigation, different than the traditional mouse-click approach. We ended up implementing navigation based on head position in one of our prototypes, but we were somewhat limited by the accuracy of the face tracking library. The API provides the programmer with 3 variables: the X, Y and Z axis offset of the user's head in relation with the webcam, expressed in centimeters. For example, the (-5, 1, 52) triplet means that the center of the detected face is 5 centimeters above the webcam, one centimeter to the right and the distance between the face and the webcam is 52 centimeters. After multiple experiments, we concluded that the Y value (left-right offset) was the only one reliable enough to stand as a base for navigation. X and Z were generally correct, but often times there was too much noise in the readings. Fortunately, a left-right head movement is more natural and has a wider range of action without diminishing the user's effort (you can try it yourself.) You can see how the head tracking navigation works in *Fig. 5* and you can experience it on the project's website.

4.2.2.3. Ephemerality

Ephemerality was in fact the first concept we became interested in introducing into our exhibition. We seeked a creative way of making our website disappear after a period of time, in order to emulate the existence in time of a physical exhibition (a more detailed description of our thoughts on this subject can be found in Section

3.4.) The process we came up with was a simple one: every time a visitor accesses the exhibition page, an active pixel of the page becomes dead (meaning that it is rendered as a black pixel.) This way, the exhibition will gradually fade away in time, visitor after visitor. Upon the exhibition having hosted a few millions of visitors (the exact number depends on the visitor's screen resolution), it will have become *digital junk*—an empty dark screen.

4.2.2.4. Collective experience

One last characteristic borrowed from the physical exhibition takes the form of the collective experience (explained into further detail in Section 3.5.). Briefly, we wanted to make visitors aware of the fact that they are not alone in their visit. Our approach to ephemerality touches on this aspect, as every dead pixel represents a user's visit to the website and brings awareness to the fact that our exhibition is a shared space. We wanted to go further though, as the dead pixel approach lacks the placement in time of the space sharing. Our goal became allowing a user to know how many other visitors they are sharing the virtual exhibit with at any point in time.

The approach we ended up taking uses the webcam once again. In the end result, a visitor is able to see screen traces of the relative position of his own face with respect to his webcam, as well as the face positions of all the other visitors present on the website. We believe this results in an intriguing effect, as every online user has an extremely shallow channel of communication with all the other online users, and is incapable of breaking or moving it to the next level. We implemented two iterations: one in which the pixel corresponding to the user's face position gets colored (with a different color for each user*;* colors are not removed, so you end up with a "pixel-history" of all online users head movements during the time spent on the page *Fig. 6, Fig. 7*) and one in which a small circle moves in real time as the user moves their head in front of the computer (*Fig. 5*. Every visitor can see the real-time moving circle for all the other online visitors—see example in *Fig. 8* for multiple users.)

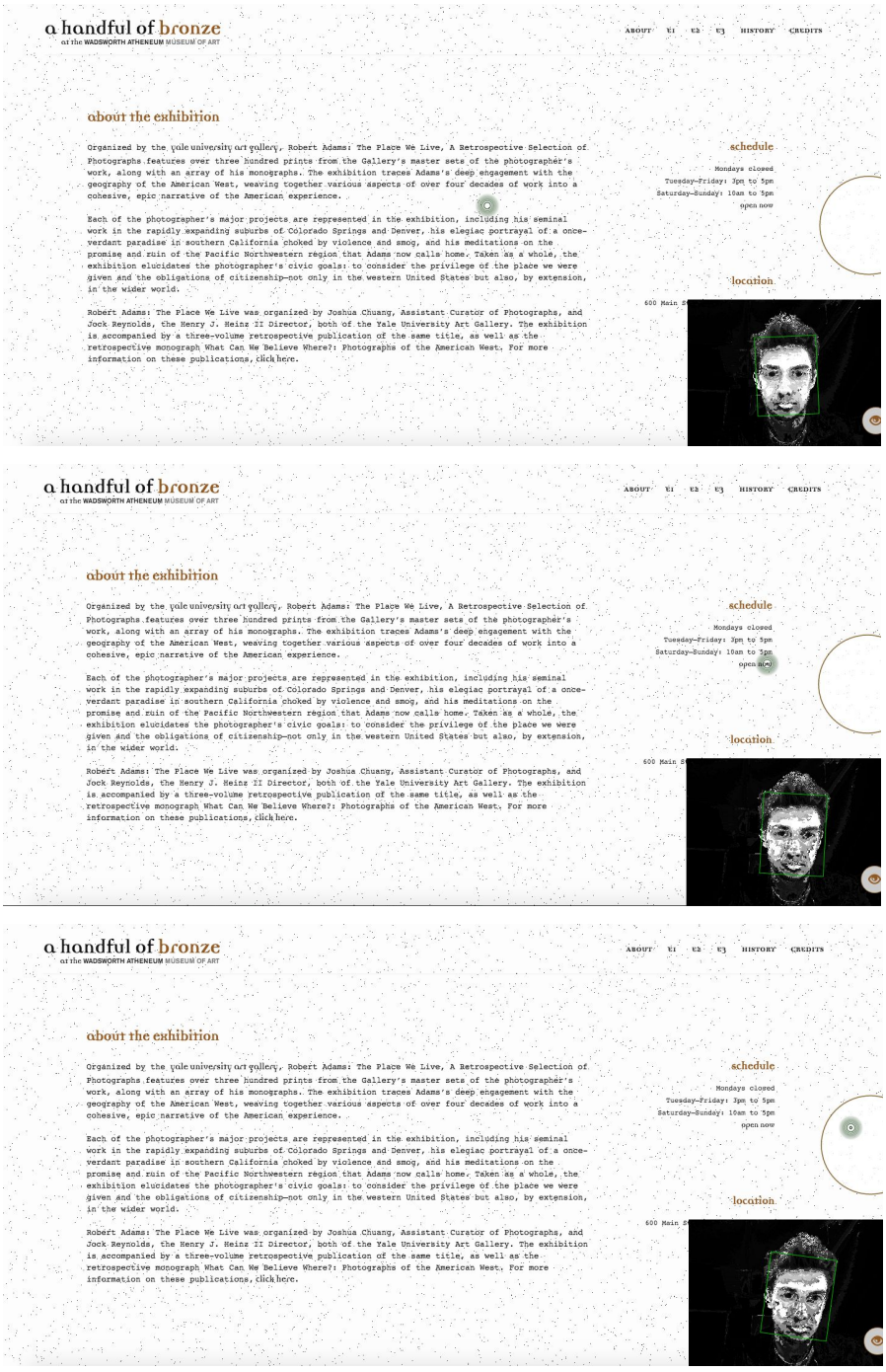


Figure 5—Navigation using the head position. The small green circle represents the mapping of the head position into screen coordinates. Moving the green circle into the larger white circle on the right side leads to navigation to the next page of the exhibition. Camera image for debugging purposes.

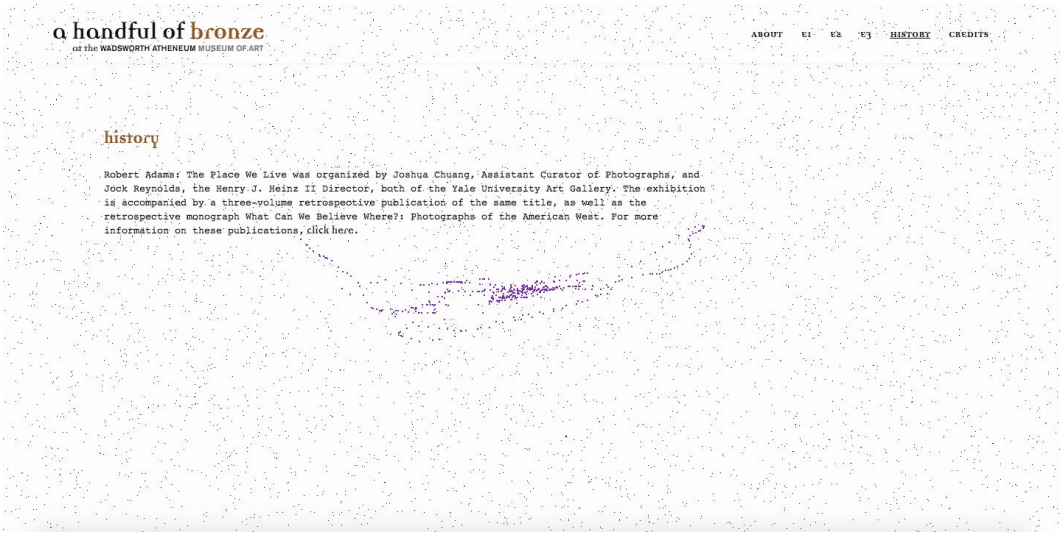


Figure 6—Traces of a single user's head movement left on the screen.

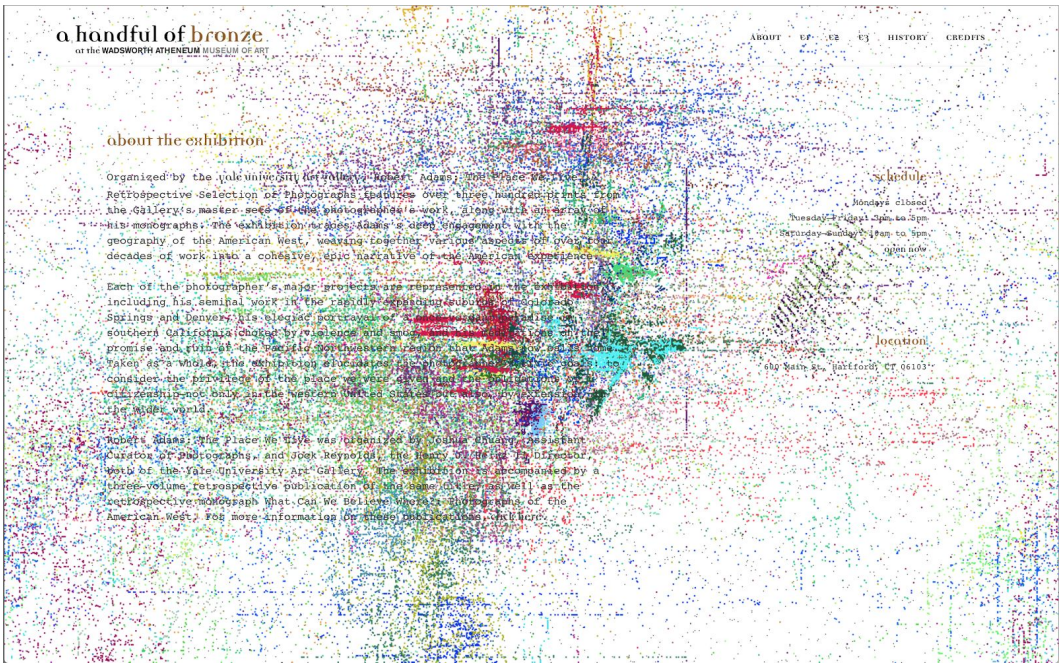


Figure 7—The web page, after being left open for a significant amount of time. Different colors encode different users or different sessions of the same user.

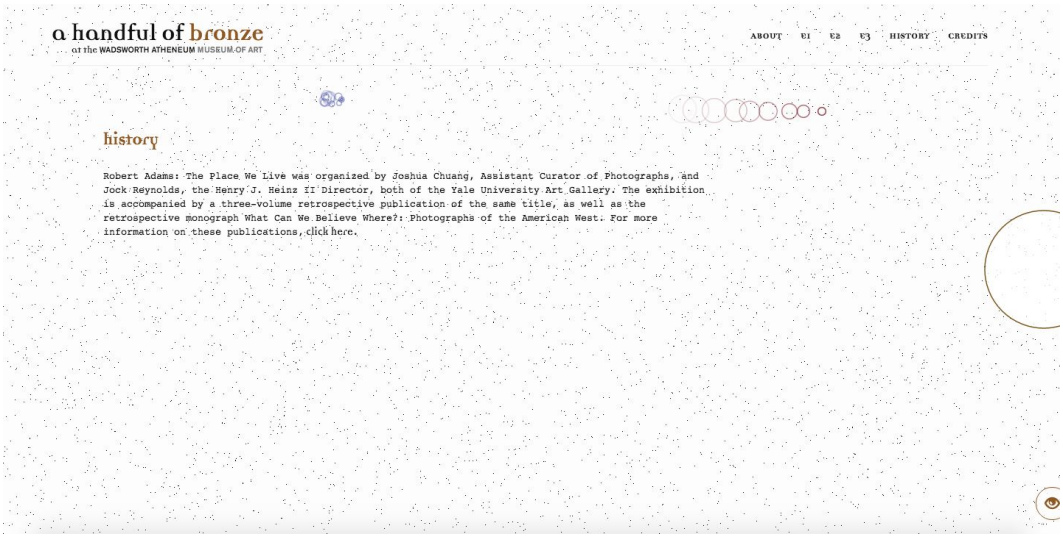


Figure 8—Two users being online at the same time

4.3. Prototype implementation details

The stack of our project includes the following technologies, products and libraries:

A. **Deployment**—Heroku
B. **Version Control**—Git, with the repository hosted on Github.
C. **Dependency management**—NPM, Bower
D. **Database**—PostgreSQL
E. **Backend**—NodeJS, ExpressJS, Socket.IO
F. **Frontend**—HTML5, JavascriptES6, LESS, ReactJS, GulpJS, Bootstrap, SocketIO
G. **Web camera face tracking**—Headtrackr

The NodeJS / ReactJS combination is a popular one, and we chose it based on our experience working with the two technologies. We are not going to go into the details of setting up the website, routing, navigation, server API endpoints and different pages, as they represent common practice and are pretty straightforward once one is familiar with the technologies. In order to set up the stack from scratch, we have loosely followed the steps presented in an online tutorial *[Yalkabov 2015]*.

The rendering of both "dead pixels" and user head position has been done using the <canvas> tag of HTML5[14].

The most technically challenging part of the project has been the creation of real-time updates for all the connected users with the head positions of all of the other online visitors. In order to construct the constant stream of updates and broadcasts, we have used a wrapper library (SocketIO) for HTML5 WebSockets[15]. The WebSocket protocol is built on top of TCP and represents a relatively recent development in web programming. It allows for two-way communication between the client and the server, without having the need for the client to poll the server for updates (which is the case in traditional HTTP.)

In order to achieve a smooth and continuous rendering of the positions of all online users, the update rate can not drop under 20 per second—meaning that each client needs to stream 20 messages per second to the server, containing the values of the face tracking API, and the server needs to broadcast 20 messages per second to all clients, with the list of all connected users' face coordinates. This has proved to be too heavy of a load for a single server when more than 3 clients are connected, as the incoming messages were "jamming". The observable result was that updates from one or two clients were being processed at the expected rate of 20 per second, while the rate of incoming messages from all other clients dropped to less than one per second. We were forced to lower the update rate to 8 per second, and do predictive analysis of future head positions on the client-side, based on previous movement. By doing this, we avoided lag in each user's head movement rendered trajectory. We used a simple algorithm for updating the positions 24 times per second with our predictions, which were made by calculating movement velocity, with the premise of constant direction. Velocity computation was based on the previous two server updates, by taking the timestamp difference and position difference. Of course, this approach is prone to failure in the case of sudden head movements in opposite directions, but the nature of our online exhibition's webcam interaction does not require (or encourage!) that. Improving the server performance and avoiding the client predictions could be an interesting challenge for future work.

[14] https://developer.mozilla.org/en-US/docs/Web/API/Canvas_API
[15] https://developer.mozilla.org/en-US/docs/Web/API/WebSockets_API

CONCLUDING REMARKS

Surveying the world of online exhibitions, understanding the reasons behind design choices, thinking about the technological methods necessary for materializing such decisions, as well as designing new types of interactions in order to support a future museum exhibition are each individual rewarding experiences. More so, bringing them together creates a complex intellectual endeavor, composed by pure thinking, creation, iteration, curation and technical problem-solving, which makes the entire project represent more than the sum of its individual parts.

The present prototypes represent works in progress—in terms of design, implementation and content, and work on them will likely continue throughout the next semester. Shall the organizers of the museum show choose to pursue further any of the presented designs, our focus will shift from experimenting different ways of user interaction towards robustness and scalability. The design focus could change as well, as a transition towards a more user-centered approach might be necessary.

Two essays whose subject matter tackles graphic design ideology, Beatrice Warde's *Crystal Goblet [Warde 1956]* and Michael Rock's *F*ck Content [Rock 2011]* place themselves at apparently opposite ends of the same spectrum with regards to a critical question: *What is the purpose of design?* While Warde advocates for a complete selflessness of the design in accepting its role as a content support, Rock claims not the opposite—that design should be supported by content, but rather that design should *be* content. Throughout the course of the project, this question has been a recurring one. Our views have shifted back and forth, indecision that is visible even throughout this report. While Section 3.4. presents a miniature manifesto for the online exhibition's "independence", the second paragraph of the current section admits to the eventual necessity of prioritizing more pragmatic aspects. More than other types of form, exhibitions exist, by definition, in order to display, to expose, to honor. The expression of the physical exhibition is heavily constrained by constant factors, such as the architectural space, and its very existence could not be imagined without the objects that compose it. The Web as a medium frees us from many these burdens, fact proved even by something as simplistic as the early experiments in Section 4.1—in their creation, there was a point at which no objects existed in the

exhibitions, but the existence of the exhibitions themselves could not be questioned. The question is, how should we take advantage of this freedom?

ANNEX 1—Inventory of examined online exhibitions

1. Black Sun – http://blacksun.fondationbeyeler.ch/
2. Heart of Glass – http://heartofglass.ch/
3. Proxy | Whitney Museum of American Art – http://whitney.org/Exhibitions/Artport/Commissions/Proxy
4. David Hammons Yves Klein | Aspen Art Museum – https://www.aspenartmuseum.org/exhibitions/24-david-hammons-yves-klein-yves-klein-david-hammons
5. Rhode Island Furniture Archive | Yale University Art Gallery – http://rifa.art.yale.edu/
6. Robert Adams "The Place We Live" | Yale University Art Gallery – http://media.artgallery.yale.edu/adams
7. Isa Genzken Retrospective | MoMA – http://www.moma.org/interactives/exhibitions/2013/isagenzken/
8. Cindy Sherman | MoMA – http://www.moma.org/interactives/exhibitions/2012/cindysherman/
9. ArtUK – http://artuk.org/
10. Miroslav Balka "How It Is" | Tate – http://www2.tate.org.uk/miroslawbalka/
11. Gallery of Lost Art | Tate – http://galleryoflostart.com/
12. Miroslav Tichy | International Center of Photography – http://www.icp.org/exhibitions/miroslav-tich%C3%BD
13. Art Expanded | Walker Art Center – http://www.walkerart.org/collections/publications/art-expanded/contents/
14. AfterDark | Tate – http://www.afterdark.io/
15. Art Maps | Tate – http://artmaps.tate.org.uk/artmaps/tate
16. Rijkstudio | Rijksmuseum – https://www.rijksmuseum.nl/en/rijksstudio?ii=0&p=0
17. Temporary Stedelijk | Stedelijk Museum – http://temporarystedelijk.com/
18. Ouvroir | Chris Marker – http://chrismarker.org/chris-marker/ouvroir-the-movie-by-chris-marker/

19. Chris Ofilli "Night and Day" | Aspen Art Museum – https://www.aspenartmuseum.org/exhibitions/65-chris-ofili-night-and-day
20. Fisher Collection | SFMoMA – https://www.sfmoma.org/artists-artworks/fisher-collection/
21. Art Genome Project | Artsy – https://www.artsy.net/categories
22. Google Art Project – https://www.google.com/culturalinstitute/u/0/project/art-project
23. Photogrammar | Yale University – http://photogrammar.yale.edu/

REFERENCES

Vergo, John, Clare-Marie Karat, John Karat, Claudio Pinhanez, Renee Arora, Thomas Cofino, Doug Riecken, and Mark Podlaseck. 2001. "'Less Clicking, More Watching': Results from the User-Centered Design of a Multi-Institutional Web Site for Art and Culture." http://eric.ed.gov/?id=ED482072.

Rock, Michael. 2011. "Fuck Content." *Graphic Design: Now in Production. Minneapolis, MN: Walker Art Center*, 14–15.

Warde, Beatrice. 1956. "The Crystal Goblet or Printing Should Be Invisible." *The Crystal Goblet: Sixteen Essays on Typography*. New York, 11–17.

Yalkabov, Sahat. 2015. "Create a Character Voting App Using React, Node.js, MongoDB and Socket.IO." *Sahatyalkabov.com*. July. http://sahatyalkabov.com/create-a-character-voting-app-using-react-nodejs-mongodb-and-socketio/#overview.

Pulh, Mathilde, and Rémi Mencarelli. 2015. "Web 2.0: Is the Museum-Visitor Relationship Being Redefined?" *International Journal of Arts Management* 18 (1). Management International: 43.

Schweibenz, Werner. 2013. "Museum Exhibitions - The Real and the Virtual Ones: An Account of a Complex Relation." *Uncommon Culture* 3 (5/6): 38–52.

Benjamin, Walter. 2011. "The Work of Art in the Age of Mechanical Reproduction." *Visual Culture: Experiences in Visual Culture*, 144–137.