Using big data to design user-centric museums.

From visitors loyal to museums to museums loyal to users

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With a view to design-led digital applications that meet the material world, we create hybrid spaces, where the user/visitor is active and takes part in one action in the material and virtual world. So, today, museums all over the world face the opportunity to re-invent themselves and their relationships with their visitors. They establish a complex non-linear dynamic ecosystem. This transformation brings out series of queries, such as the role of the architect that redefines the museum process and the new terms in the museum context. This paper refers to the dynamic changes that define a hybrid environment, describes the transformation into a user-centric museum and the approach to create visitor/user-centered museum and how this was applied into the Archaeological Museum in Chania, Crete. A museum that places visitors at the center of its mission.

Keywords: *user-centric museum, hypersonalisation, museography, experience, architecture*

A. INTRODUCTION
DEFINING NEW SPACE

Nowadays there is massive progress in technology and in the way, we use data. Services that required complicated infrastructure years ago, they are both simple to use and set up now, yet the most important, they are easy to create the environment not only to extract value fast but also to be able to optimize the offered service or product faster and better than ever. Architects are required to interpret the relationship between virtual and physical and "create" their involvement. Thus, the question is how we can combine the architecture whose foundations are based on locality, history, memory and geometry with digital forms of which characteristics are nonterritorial,

uncountable, continuous and the lack of a material form in order to develop a hybrid architecture that responds to the needs of today's society.

The space, in an analogue approach, is a factual event, energy, communication way, whereas in digitization is defined as information and metacommunication or network. The movement inside the space is approached in a new way. The result is an object that expresses the idea of change, which characterizes the way of creation, an "object-event". Digital culture is linked to the continuous increase of interfaces between the physical and digital space. The aesthetic depiction of these interfaces lies in the uniqueness of each user and becomes more personal, aimed at interacting with other users. In this

paper, we will focus on the change from entities of users, objects and space, in the relationships that are created between them. Architecture, as a part of the society and culture, is always influenced by techniques of its era, and therefore its technology. Using a new tool, a new architecture is inevitably created and as a result, new meanings are being used.

Time is enrolled in space and the space is the information transmission mean through time. An architectural design is an "assemblage" of spatial and material symbolisms, which can be decoded. The destabilization of architecture resulted in change of the ontological basis of architecture design, from a representation to an "organism". From a two-dimensional entity to a three-dimensional or four-dimensional one. From a picture to an event.

REDEFINING MUSEUM SPACE

In some cases, autonomous spaces, "heterotopies" -term by Michel Foucault (1984)- are used in parallel, and not in direct dependence, by their urban social environment. There are many cases of buildings that exceed the strict limits of the space -indoor and outdoor- and make use of transformable spaces. This choice is a key factor in the development of the museum narration. Departing from the Kantian view, which considers space a structure of the human mind, we accept the dynamic interaction between human and spatial environment which is affected by the cultural characteristics of social groups. In a world of information, entertainment is becoming increasingly digital, leading museums and cultural institutions to adopt the idea of a "museum in progress".

Identifying the museum space today, it is much more than a dynamic situation, it is an organism. The museum of the 21st century is characterized by its digital content and the use of digital media, with the aim of involving the visitor: the visitor as a user, user-generated content, social networks, and global access to collections are some of the features of the new era.

The museums are made relevant to a broad range of visitors of varying ages, identities, and social backgrounds. Nowadays, they become interested in its outward image, and so the concept of the visitor as a "consumer" gradually emerges.

The museum is no longer the voice of authority for the visitors through the exhibitions, but it has been transformed into a multifaceted experience that invites them to discuss and interact rather than to a simple storytelling.

B. FROM COLLECTIONS TO VISITORS
MUSEUM PLACE, A PLACE OF HUMAN ACTION

Maurice Merleau-Ponty is referring about space, "it's the whole body and not only the eye that sees". Our understanding of museum space is influenced by some characteristics, like the atmosphere, the reverberation of the voices, the sense of walking on a hard floor, the colored surfaces, the smells. So, the choreography of a space is decoded by each user, by using personal collective tools. Visitor actions are enrolled in this.

When a visitor enters a museum, he perceives the space with all his senses, decodes it with his personal and cultural experience and eventually collides with him, attempting to impose upon it his actions, his own practices and meanings. In other words, he experiences his own "place".

This distinction between the physical and the living place, based on Martin Heidegger's thought, is an essential tool for apprehending the spatial dimension of educational museum activities. In other words, we should approach the museum space not as an individual aesthetic expression of a creator/artist, but as a product with a social context, as a reflection of visitor's behavior. At the same time, the solution come through changing the current management strategy, from an "artifact-centric" model, towards more participative models, to a "user-centric" model.

Furthermore, the intention of increasing the number of visitors has enriched the museum's program. The idea of a public square, which includes works of art and is expanded with facilities

such as restaurants, libraries, bars, shops, meeting spaces while periodical performances or speeches take place, increases the flexibility in temporal and spatial planning of museum events in a specific controlled area.

Museums mean different things to different people. People connected to the museum are the visitors and the staff. It is a fact that museum directors, curators, exhibition designers are at center stage in a dialogue with visitors. Ultimately, the subject is focused on the idea of a visitor-centered museum: a museum where visitors matters as much as collections.

"But who's our audience and what do they need from us?" For a visitor-centered museum, this question is the starting point. This new view includes the need to exam multiple voices and multiple sources of knowledge. Furthermore, considering the variety of needs that come with a more diverse public, opportunities or "entry points" for connection with the public is vital. Understanding where visitors are coming from, their preferences and expectations helps museums to engage them in a dialogue with the artworks. It is believed that visitors are a population that museums have historically been happier to speak to than to listen to-and that two-way communication is what visitors have to get.

"USING" COLLECTIONS OF MUSEUM
Nowadays, there is the design of the diffusion of computing power in a number of cooperating points distributed rationally in physical space. So, part of the design of the museum space is the design of this allocation. Small digital units are distributed in the physical space, and they collaborate to create functional sets to support the activities that are already taking place in this space. In this way, digital technologies interfere with the existing localities.

The museum absorbs the digital technologies. It is the "ground" to receive the "Digital Ground".

Furthermore, the artworks are coded power objects. They are either the mean into profound experience or are simply objects in space. The power of artworks is to create a narration, through its scale and its capacity, to involve not only our physical bodies in real space, but also our mind and feelings. As a result, we have to create a multimedia program with interfaces that can extend beyond what we are used to and evolve some of the qualities of scale, texture, approach that we use in experiencing artworks in real time and space.

Meanings are created through relationships-through insertion in a network of references. Obviously, one primary way of presentation is with texts -the wall label- and preferably with images, videos, animations, and other artworks as well. Each of these kinds of association has already been included in the cultural multimedia practice. New technologies enable us to create relationships and references beyond what is visible in the gallery. The practices of the museums are about connecting past objects with present issues, inviting visitors to co-create exhibitions, providing new ways of looking at artworks.

C. NEW MUSEOGRAPHY
HYPERSONALIZATION
Museums up to now were places where change and adaptation of new services had a slow pace, but this seems to have changed since they can be more relevant to the user/visitor. In the industrial world, all the major organizations work on how to transform and optimize their services by using the relevant technology. This paper intends to define and present the term "hypersonalisation" in relation to modern museums as well as to its users' museum understanding. In order to do so its essential to understand why people visit museums and as a result map the reasons behind it.

Numerous works and researches illustrate the "museum visit and usage" as a form of leisure activity, as famously portrayed in Falk and Dierking [1992]. People visit museum for various reasons, accompanied by children or alone as recreational activity; encouraged by the reputation of a museum or by an exhibition, out of interest (in the exhibition/museum/event) [Durbin, 1996] or simply because they are in need of an activity in a controlled environment

[Falk, 2009]. Falk, based on an extensive and in depth research in this field, and came to the conclusion that the notion of identity is important for understanding the reasons that stimulate a person to visit a museum and to fully grasp their goal. Five major categories of identity-related groups are considered: the Explorer, the Facilitator, the Experience seeker, the Professional/Hobbyist and the Recharger. Nowadays, we observe a transformation in subject, from "the visitors" to "the users" in relation to a museum. The users appreciate the content of a museum, as well as the way in which it effects the ecosystem.

Falk put major emphasis on whatever the visitor sees or does is influenced by the combination of their identity, their personal context (prior knowledge, experience and interest), the physical context (the specifics of the exhibition, the artefacts, the flow, the way the information is shared) and the socio- cultural context (the within- and between-group interaction that occurs in the museum). Consequently, museums should aim to address visitors/users' context, expectations and personalization while they are visiting the museum. The main objective is to explore a conceptual and technological framework which will allow the user to experience customized interactive stories along with the validity of the specific cultural content. Big Data Analysis can now play a key role in augmenting the cultural experience. Each visitor would be able to have a unique tour and experience an exclusive "spatial episode". The new space is constantly transformed according to the customized needs of each user.

The personalization aims to adapt the cultural experience with the experience, interests and knowledge of each visitor. In this context, the technology is utilized, first, to record details of user behavior. This recording is usually done with the user classification in a profile (persona), based on responses of questions. A second type of recording includes the total number of the user's visits to cultural sites (what kind usually visits museums, how museums visited in his life, etc.). A third way of recording the behavior and preferences of visitors based on content that the visi-

tor publish (user generated content) on social media. A fourth case concerns the dynamic recording of visitor behavior while moving in this museum, which focuses on the kind of exhibits that the user prefers, the time that passes in front of them, although returns to some exhibit, if seen in the order etc. These recording modes of behavior are indicative and are often used in addition more than one way of gathering data.

The museum narration will take its final form from the way that each visitor moves through space and time. Considering that people primarily perceive the space through their movements, we will realize that the visit is not a set of "stops", but a continuous move with entry and exit points. At the same time, meetings with people and objects take place into the exhibition. There are several attempts and technologies that have been proposed to record the movement of each visitor within a given museum space and the way that it changes when some of the spatial elements are differentiated. Detailed recording of the visitors' movement in different museums has given interesting facts about the way in which spatial data influence the route followed by visitors, which sections to visit, in what order, how much time will spend on each of them.

Falk and Dierking developed a holistic methodology, "Personal Meaning Mapping," which investigate how a particular experience affects the user and the process of producing meaning and attempts to evaluate the depth of visitor learning and not just its quantity. During and just after the visit, the visitor constructs meaning from the experience, in relation to the user's identity. If a method is to improve the visitor's experience, it is achievable by taking into account the "visitor type", their personal context (prior knowledge, experience and interests), their social background, their expectations, their behavior and digital footprint on other platforms of the museum's physical context. To our understanding there is a very big amount of research on what defines and describes the experience within a museum. But the majority is focused on simply addressing how technology can be used in order to serve museums and

their purposes. The approach was to create, through the use of cutting edge technology new services, new products and new ways visitors could experience museums.

Until now, by taking into consideration visitors' average time, museums can make people either consume more information or make sure that the visit will address their expectations. An event which was not connected to visitor's life and moments of truth before or after the visit.

Therefore, it becomes important for museums to be more and more relevant to users' context. And in order to achieve this they need to understand that relevancy is the result of how well we understand users

RELEVANCY = F (T,C,I,S,A,L)

- t, for time; on the available to spend time
- c, for commitment; how committed museums are to interpret people's needs and expectations. Therefore, it becomes important not only to thoroughly map the profiles of the museums users but also their likeliness.
- i, for insights; how well they work with data to understand peoples' journey to and from the museum
- s, for speed; on how fast they are to understand the insights, and connect the dots between peoples' expectations, there and their context
- a, for agility; on how agile they can adapt to new technologies, new ways of working and of course to experiment with dynamic models of addressing users needs and expectations
- l, for lean; how the processes they have in place are built around what users need and not what the technology or the trends are

IMPLEMENTATION IN ARCHAEOLOGICAL MUSEUM OF CHANIA

Having information about the position, the interests and the movement of each visitor, museum would be able to offer a unique tour and experience an exclusive "spatial episode". This environment information, together with the inferred relative movement of the user, is compared against the digital maps, produced by machine learning algorithms on a platform, to obtain the user's precise location. Using an indoor positioning system is a great way to engage museum visitors in a new, interactive way.

Indoor Atlas has been utilized in a number of case studies in retail, healthcare, public venues, transportation, government organizations and many other fields. We see a great potential in combining an Indoor Positioning System with Big Data Analysis in cultural heritage and more specifically in cultural institutions. So, the last part of our research is the use of information mapping with the indoor positioning systems in the Archaeological Museum of Chania, in Crete. It is a museum located in the center of Chania, which is going to transfer its collections in one or two years in a new built space.

Until then, it would have been valuable to collect information on how and where visitors are, depending on the exhibits, so that this information can be used in the museological studies that can specify how the collections will be set up in the new museum.

Figure 1
Fig. 1. Indoor view, Archaeological museum in Chania

The Indoor Atlas is a geomagnetic hybrid indoor positioning technology. Indoor positioning systems (IPS) locate people or objects inside an existing space using radio signals, geomagnetic fields, inertial sensor data, barometric pressure, camera data or other

Interactive Indoor Navigation App for Museum Visitors

sensory information collected by a smartphone device or tablet. The case of having a hyperconnected, personalized "lifelong" user model provides a starting point for personalization. So far, we could understand users' conducts from the past, analyzing their behavior prior and after their visit and comparing it with other users trying to find common points. Hence, allowing museums to design their events based on studies conducted. Our approach allows to create a model where the most pivotal element is relevancy and how quickly museums can address the needs and adopt to the users' expectations in the most fulfilling way. By taking advantage of the state of the art technology, users, carry with them, and museums have access to.

The approach is experiences that use interactive digital systems, which meets the personal narratives convey visitors (needs, desires, familiar places). Since visitors pass through the exhibition without being engaged, museums are leaving major potential unused. Also, what the visitors get to listen to is not always what they are interested in, sometimes resulting in visitors cutting their tour short. Furthermore, in large exhibitions, finding one's way around the building or to certain destinations can be quite challenging. In the Museum of New Data there is no linear presentation of the exhibition, but there will be many entrance points from which a visitor can begin his movement around the exhibition area.

To focus on this, visitors can submit, in special places within the exhibition (stations), their own views. Similar functionality is also being built into the drag-and-drop relationships which is embedding in a timeline. Through an Interactive Experience Model, the visitors have to select the artworks and encourage the artworks to "talk" with each other. Some ideas we're using with beyond normal pan-and-zoom tools include a life-size detail of an artwork, scaled to
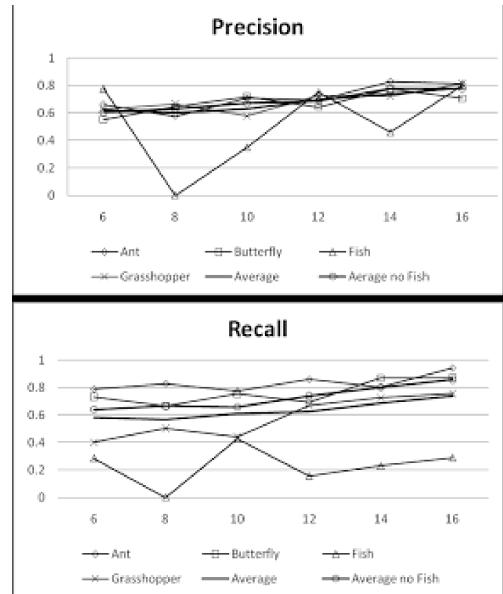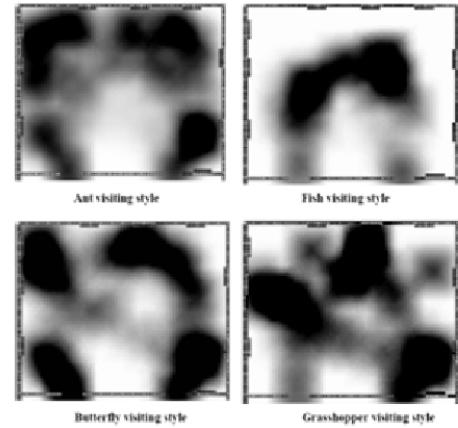
the size of the monitor display, and shot with enough light to see and feel the surface texture.

Also, a proposal for the museum design activities suggests the adaptation of the content according to the learning style, which is diagnosed by the visitors' movement to the space. For example, the distinction of different models of movement can be made based on Veron & Levasseur's proposal (1983), which distinguishes museum visitors in those who follow a linear motion and spends a lot of time observing the exhibits (ants), those who often change direction and make stops frequently (butterflies), those who move to the center and try to get a general picture (fish) and those who have a preference for preselected exhibits and spends a lot of time observing them while ignoring the others (grasshoppers).

For "ants" visitors, the educational material and narrative stories are organized linearly, for "butterflies" there is provided a non-linear organization of the educational material and alternatives for independent information about the exhibits; for "fish" general information on the exhibition is provided and the top-down organization of information is supported, and more detailed information on exhibits and route suggestions is proposed for "grasshoppers". This proposal aims primarily at content and organizing activities during the movement rather than activities that require more complex interaction with museum objects.

Ant visiting style

Fish visiting style

Butterfly visiting style

Grasshopper visiting style

Precision

- Ant — Butterfly — Fish
- Grasshopper — Average — Aerage no Fish

Recall

- Ant — Butterfly — Fish
- Grasshopper — Average — Average no Fish

Another way to use these tools is by inviting visitors to participate actively in creation of the exhibition. This can happen with a visitor card used to activate informational stations within the exhibition. If the visit card has a password, then the media seems to

talk with each visitor individually. This method can be used to provide additional information, bibliography, and every visitor can have a personalized visit. Other uses may be, for example, the transfer of information organized by static means into presentation software, interaction with simulations (the shadow effect) where the user/visitor can observe different results to be produced by altering different parameters by computer, follow a story through space movement, interacting with digital characters, or finally interpreting data provided to define the next point of navigation in space.

Indoor navigation within the new Archaeological museum, 2D/3D building maps, geo-based triggering of media content and different multimedia prototypes can be developed at an exhibition, such as interactive video production tables embedded in each of the exhibition themes, an iPAQ (International Physical Activity Questionnaire) Gallery Explorer PDAs (personal digital assistant) handheld with video clips of artists, a Make Your Own Gallery application where visitors can be invited to attend their own exhibition and comment on a kiosk based on a program that treats artwork on the screen as well as on them. The artworks have no borders. Moreover, the key factor of this technology except for education, would be the connection of other services, as commerce and research facilities.

D. CONCLUSIONS

The relevancy framework we described above that came into research has been conducted according to the angle of lifelong. Nowadays, it is essential to consider an additional aspect to define users' experience and excitement during a visit in a museum; where users' digital footprint and digital twins exchange data with various services, search engines and AI engines. As a result, museums do not only access technologies capable of allowing them to be more relevant to their users' context, but also to make sure that they design hyperpersonalised experiences in order to address the needs of our physical selves as users, as well as the conversations our digital twins have with various search and AI engines. Therefore, the challenge museums face is not only to address the various contexts but also to find a way to become part of an non-linear dynamic journey of humans/users life.

Characteristics of the Next Generation Museums:

Scale_ vary in size and scale. They can be represented either alone or with expandable facilities and there are no restrictions in space. So, museums can display objects on walls, in rooms, or by creating innovative approaches.

Environment_ exhibitions in one or two buildings, while other outdoor ones.

Flexibility and Evolution - change is a continuous process in next generation museums. Visitors have to realize that museums are evolving very quickly in new environment. Different museums, different shapes, spaces, rooms, with more or less collections and exhibitions.

State-of-the-art facilities - Visitors are in contact with high technology. Through a three-dimensional graphical environment, people make use of technological media, and interact with the enhanced environment, physical and digital.

Visitor Commitment - the main objective of each Next Generation Museum is to convince its visitors that they really deserve to spend some time on it, to experience various situations, and most importantly, to persuade them to come back to give them more experience.

Social interactions - museums are places where visitors have many opportunities for social interaction. The visitor can relax in a cafe or a shop, meet other visitors, exchange ideas and views on existing exhibitions, discuss about art and generally get in touch with others.

Various types of collections_ people can visit or not with physical presence and time constraint.

Targeting the audience - trying to gather information about visitors' identities. In addition to measuring the number of visitors and encouraging them to leave comments in the guestbook, there are ways via technology and social platforms that the museum can learn more about its visitors.

In conclusion, the museums of the future will have spaces - nodes that will function as collective housing areas that will act as creators of social relations. Units / spaces will consist of a fixed framework of uses, necessary for the operation of the unit, but also of other uses of (co) designing with the participants. The user-friendly framework will include auxiliary spaces, electrical / mechanical facilities, and one or more spaces capable of hosting a variety of different uses (projections, performances, lectures, seminars, discussions). Visitors/users should go beyond the physical boundaries of the museum, adopt new perspectives and promote their social activities.

The museum attempts not only make an audience that will co-modify its museum experience, providing many levels of knowledge, but also to make a common participant in setting up exhibitions according to their desires and finally bringing visitors back in the museum again and again. It is perceived that the above reflects wider social and cultural trends, most of which come from the visitor, which we can now call "user". In the 21st century it seems that the museum is the mean.

The traditional museum is a building. The museum of the future will be more of a process or an experience.

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