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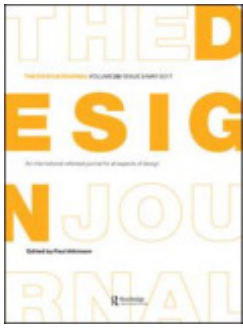
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Interaction design applications for museum spaces. New exhibit paths driven by a Bluetooth sensor's system.

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Abstract: Visitor fatigue and hypercongestion are two key issues in museum visitor studies. This paper investigates some solutions recently developed by different European museums, which are based around the creation of thematic or time based trails or tours. Furthermore, this paper presents an interdisciplinary activity developed at a large scale museum in Italy, modelled on the contextual needs of the visitors. The preliminary stage of this case study involved manual mapping and analysis of visitors' behaviour. Subsequently, proximity sensors will be introduced. Proximity sensors detect visitor clustering and time of permanence near the artefacts along the museum display. This sensor system can be used as a testing tool for visitor behaviour, but also as a tool to devise a personal museum tour. The main contribution of this paper is the design for the implementation of a non invasive sensor system that aims to track visitor's behaviour, and suggests new museum pathways.

Keywords: Visitor studies, Interaction Design, Museology, Bluetooth tracking, Human Centred Design

1. Introduction

1.1 Hypercongestion and museum fatigue: physical, spatial and mobility issues.

Museum fatigue[1] and hypercongestion have recently become a key issue, and they have acquired more resonance[2] in contemporary times. These matters have become increasingly important due to the changing role of the museum: from a more educational appearance lately it has started to turn into a place of leisure in which to spend quality free time. The evolution of the museum's social role

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[1] Gilman, B. 1916. Museum fatigue. *The Scientific Monthly* 12: 62–74.

[2] Borun M., Chambers M. & Cleghorn A., 1996 - *Families Are Learning in Science Museums*. Curator, 39/2: 123-138.

has started to engage a wider range of the public. Museums have always been trusted for educational purposes, but from the 70's they slowly started to acquire more relevance as new social gathering stage.

According to (Loomis, 1987), museums gradually changed their mission, from a mere educational establishment they started to introduce themselves inside a cultural context, strictly bound to the local community they aim to become part of it. This community can be strongly rooted to the territory and the town where the Museum is established but could be also have an international exposure. This kind of exposure is nowadays reached thorough a deep social media interaction, that can put each museum in closer contact with the visitor's need, but also helping an effective networking with other museum institutions. The transformation and the development of a new, and wider, museum visitor community has forced the museums establishment to rethink their vision and mission, in order to appeal to the public and preserve their collection. To accomplish the new mission museums have started to invest time and effort into the preservation of the cultural heritage and the development of new methods of engagement in order to make the museum collections more appealing.

The design can play a helpful role in this intent, because the aim is to enlarge the accessibility to a wider range of public, it's vital to think about the usability of each solution. As Lidwell says "Objects and environments should be designed to be usable, without modification, by as many people as possible"[3]. The principle of accessibility claims that any design's product has to be accessible to people with diverse abilities, with any particular adaptation. This claim can be notably helpful in our case study, where visitors who will interact with our design product will be part from diverse backgrounds and cultures.

According to many in the field of museum studies, the visitor's ability to concentrate is essential to understand the display, but the attention span can be reduced by many factors as the physical and mental fatigue occur. This phenomenon of museum fatigue has been analyzed by (Loomis, 1987), and furtherly investigated by (Falk, 2012) which described this issue as one of the key factors that can influence the museum fruition.

In this paper we will discuss how the design approach was adopted to to conduct this exploratory study about a cross-disciplinary research project. We aim to partially solve the museum's hypercongestion due to the increasing number of museum's visitors and to reduce museum fatigue making the artefacts easier to understand to a wider range of public.

1.2 Enhance visitor experience: Methods and the Metadesign approach to service and Interaction design.

Before proceeding to examine this cross-disciplinary research project, it's essential to underline the importance of the design and meta-design approach we adopted. In order to highlight a representative scenario of the museum visitor's needs, it has been necessary to underline what are the needs and the requirements we should understand in order to coordinate the entire research project. To put together in a constructive dialogue, the research entities, and to better develop a service design necessity, has been crucial to analyse the current scenario, considering the issues of hypercongestion and museum fatigue, and most of all enhance a better museum experience (Falk, 2012).

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[3] Lidwell, W., Holden, K., Butler, J., & Elam, K. (2010). *Universal principles of design: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design*. Beverly, MA: Rockport.

Germak has been one of the first to describe the importance of the design as a mediator of knowledge, and reported that:

> "There are many todays who ask why design is not concerned only with giving shape and content to the physical product but also with non-material products, new scenarios and strategies, cutting across the role of other disciplines. The reason is the flexibility of design. It is capable of connecting different fields of knowledge, from technical sciences to the humanities, and of developing wide-ranging themes, from work to health, diet, transport, cultural assets and disasters. Furthermore, it is able to communicate conceptual pathways and views that are normally discussed and understood only within the academic and scientific spheres to the entire community by way of popular media."

This approach has often been used to coordinate the development and the prototyping of industrial objects, but in our case study has been applied to the design of a non-material product. *This method has been applied in order to understand how to better coordinate a project that involves the development of an intangible asset: a new museum experience through new visitor's pathways.* Visitors' pathways will be designed on the visitors' needs because: "Meta-design is a conceptual framework aimed at defining and creating social and technical infrastructures in which new forms of collaborative design can take place" (Fisher, Giaccardi, 2006, p.2).

The flexible design approach, that connects different fields of knowledge such as technical sciences and humanities can also boost the collaboration with the Politecnico di Torino, the Egyptian Museum and the TIM, as we are going to describe in our case study.

To deepen and complete the methodology process was also taken into account the Innovative research method applied by the Innovation Design Lab at Politecnico di Torino (Gaiardo, Tamborrini, 2017) but also the ADDIE model phase process revised by Khalil (Khalil, Elkhider, 2016). The ADDIE model was slightly adapted to our case study in the aim to combine different factors and the Metadesign approach.

This case demonstrates the need for better strategies to make the museum experience more engaging, trying to simplify the visitor's navigation inside the collection. The large scale museum we are describing it's located in the north of Italy, and reported more than one million visitors in just one year after its total renovation. The main issues expressed by the museum institution were the visitor's hypercongestion of its showcase and the average visiting time. The average visitor should take approximately four hours to discover the whole museum's display, that is settled up on four floors. The entire museum's showcase is currently developing on about ten thousand square meters, and it causes stress and fatigue to the visitors who are willing to run through the entire collection.

The case reported here illustrates ongoing co-design process, that generate needs and requirements according to the Metadesign approach. The following figure shows the requisite system of use defines the needs of the individual actors who will come into contact with the product. This means not only the needs of the museum visitors, but also those who handle it (curators, scholars, museum management etc.) and others who are related to the museum visitor experience in different ways (Germak, 2008).
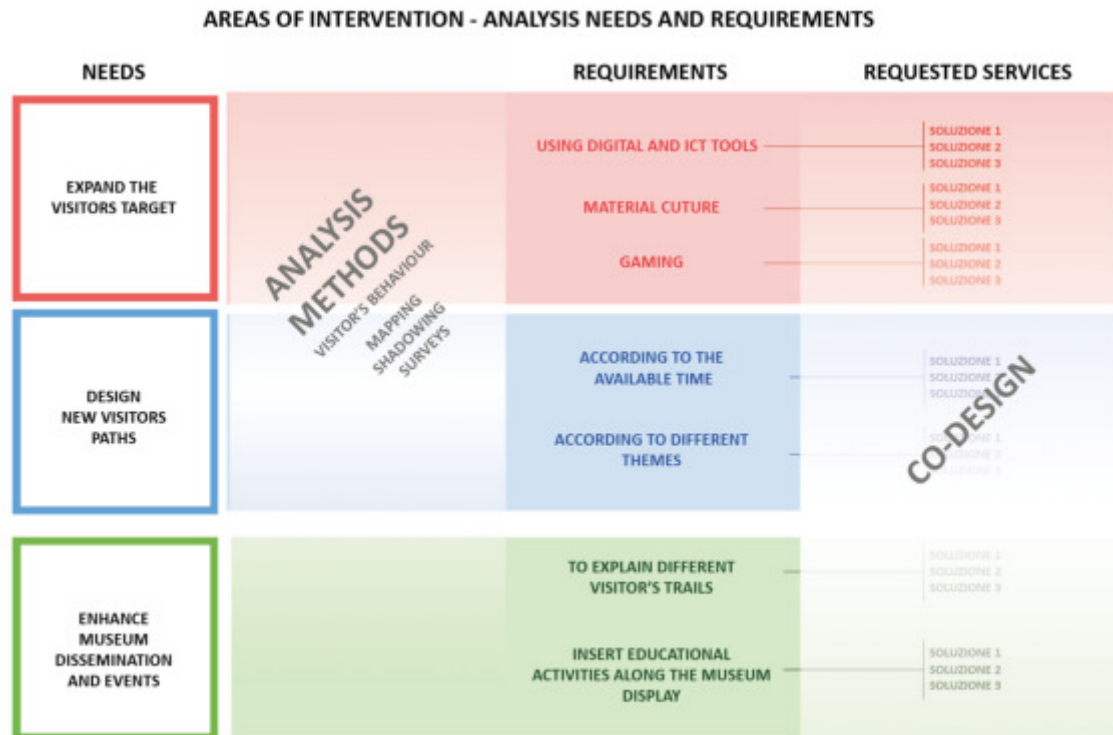
Figure 1. The needs and requirement scheme used to develop the meta-design process.

Over these issues, other needs have been expressed to the design research team, and they were:

- Expand the demographic, trying to include more young adults
- To Design different visitor's pathways
- To facilitate the communication of the museum's events and activities devolved for the visitor's

The findings of this peculiar requisite system suggest that the museum experience can be enhanced with the design of new different visitor's pathways. The new visit trails can accomplish both the need to expand the demographic and the necessity to ease the dissemination of the museum's events.

2. The project: how to design different visitor's pathways, methodology and evaluation phase

2.1 Analyzing the visitors' behaviour to define the scenario and the guidelines

The museum fatigue is affecting many visitors, and it can be the trigger for some behavioural patterns that affect the quality of the visit. The visitor's behaviour can be investigated through a mapping and an analysis activity conducted inside the museum display. This analysis follows a well known methodology in the museum studies (Bitgood, 2006) that is focusing on understanding the visitor's behavioural scenario and defining a visiting pattern. In our case study it was possible to define a pattern using evaluation or sensible mapping technique that is often used in urban planning (Sepe, 2007).

To define this scenario can be crucial to take into consideration the environmental and spatial issues occurring inside the museum space, such as people's clustering, the accuracy of the indoor signage, the the visitors' time of permanence near the showcases. Overall, these ergonomic, social and spatial variables can support a broader view to design an Interaction design tool to:

- Improve the dissemination of the museum's collection and evaluating the actual effectiveness of the display, captions, panels and all the indoor signage.
- Support the museum's facilities such as the café and bookshop, evaluating the accessibility and general service management standards.
- Understand the needs and design specific pathways for families, young and old visitors, while analyzing people's personal interests inside the museum space.
- Understand the relationship between visitors and collections. How the public lives the museum experience, underlining the weaknesses and the strengths inside of the existing tour.
- Emphasize the attractive potential of some artefacts along the installation, identifying the most and less visited areas by visitors along the way.
- Improve the visitor experience by decreasing the museum fatigue and hypercongestion phenomena, by estimating the visitors' permanence time and aggregation areas along the trails.

To conclude this section, the above statements are intended to defines our project's guideline in order to design an interaction design tool: the proximity sensor system. This sensor system can be used as an evaluating tool for monitoring visitor behaviour but also to suggest new paths to the visitors. Proximity sensors also make it possible to reduce the number of signs and devices along the display diminishing the amount of noise of symbols that can disturb the visitors. The project also includes a stage of communication design to make people aware of and able to use the sensor system, allowing a better fruition of the museum's display.

2.2 Mapping and customer's survey analysis, time and space as variables in our case study.

Before implementing the digital proximity system, we worked on a manual mapping and analysis of the given museum's scenario. To better understand the museum display engagement, it was essential to map visitor's clustering along the museum's display and the time of permanence of the public inside the museum. To analyse visitors' behavioural pattern, we applied an ethological approach such as the mapping, and we prepared a visitor's survey. These methods can show some limitations, but they find large adoption in museum studies (Schuman, Scott, 1987) since they can support an agile preliminary overview. Especially in our case study, where we have used a foregoing manual analysis of the public behaviour.

To analyse the visitors behavioural pattern inside the museum we took into consideration four specific guidelines:

- The clustering, where the visitors are more incline to generate large groups
- How much time visitors spend to see the whole display
- In which range visitors can be classified and listed (age, interest…)
- In which days the mapping has been applied (festive days, weekdays etc.)

With these given guidelines was possible to map visitors and to understand which actions can be occasional and which ones can be a part of a behavioural pattern. The first two guidelines based on

time and space as variables have been helpful to develop the clustering thermal maps, while the second two guidelines have been applied to design the customer's surveys.

The thermal clustering maps have been implemented with visitor flow analysis charts, these two tools together can give a broad overview on the museum visitors' behavioural pattern. To achieve this preliminary overview was necessary to make an on-site investigation realised from an observer. The observer has been collecting the whole data for a period of about three months, between March and June 2016.
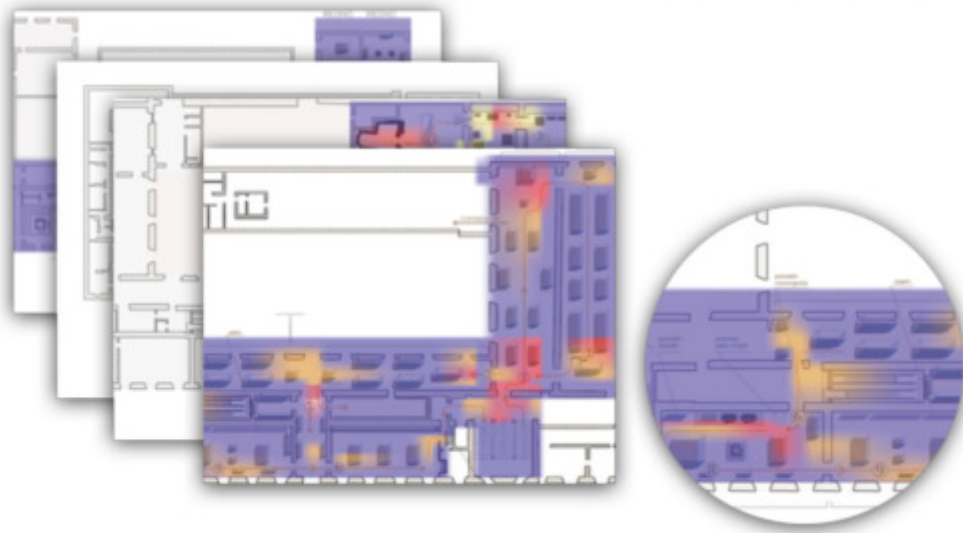

Figure 2. The thermal early mapping results on the visitors' flow analysis

From the fig. 2 above, at first glance it's possible to understand the people's spatial clustering along the museum's floors thanks to the graphical rendering. It's impressive to observe how some areas of the display are almost completely blue, with minimum visitors' affluence. Instead it's surprising how some showcases can attract more people than others, just depending on the artefacts locked inside.
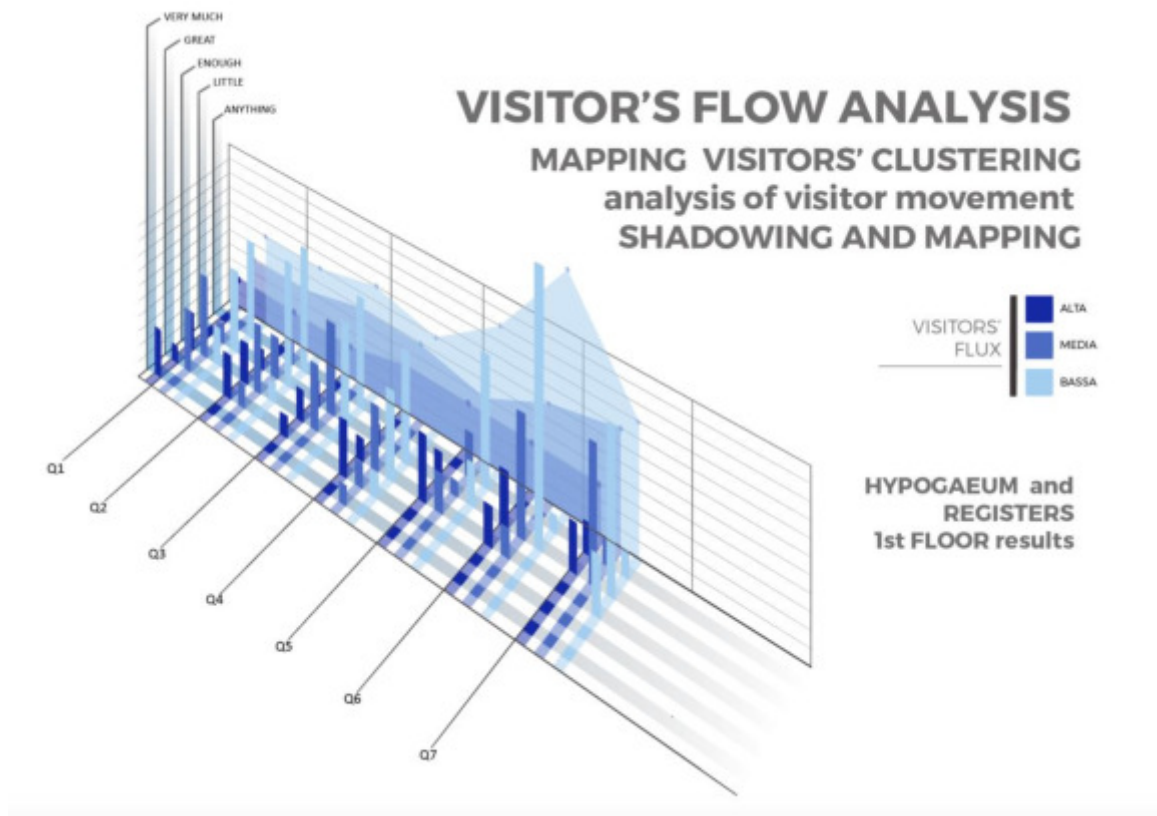
Figure 3. A graphic showing some early mapping results on the visitors' flow analysis

In the fig.3 we can observe how the preliminary visitor's flow analysis data can significantly change upon the public affluence at the museum. For example, during holiday's time, when there was a huge flux of visitors, the navigation and the display spatial issues are much more relevant compared to the days of low visitors' affluence. With these data is also possible to understand where the indoor signage can be implemented to avoid visitor clustering and other navigation issues.

Moving on now it's important to describe the last analysis tool, the visitor survey or questionnaire, we have designed to complete the museum's visitor behaviour scenario. The questionnaire will be dispensed from the month of January 2017, it will consist of a series of twenty question focusing on different areas of interest: display's fruition, personal attitude and interests toward the collection and customer satisfaction.

2.3 how other museums have applied a change for the diversification of visitors' pathways.

Some European large scale museums have been also implied in the diversification of the visitors' trails, and in the analysis of their own customers' need.

The customers' needs have been the trigger for these studies pursued by a famous Museum such as the Louvre. This French institution in partnership with the MIT Seanseable City lab, have been conducted a research on people's clustering alongside the museum's masterpieces. This research was aiming to analyze Hypercongestion visitor's stress by placing some Bluetooth proximity sensors (Yoshimura, et al, 2014). The Louvre visitors' mapping had a strong academic motivation, but an Italian museum, the science museum of Trento MUSE, instead, used a simple Bluetooth technology

to suggest people new visiting trails using a pop-up system interface installed on a tablet view. At the MUSE the ICT technology is used for the direct interaction with the visitors. This sensors' system project at the MUSE has a commercial purpose and is aiming to supply the museum with an interactive museum's trails path, our aim instead, is to combine the academic and the commercial use to enhance the visitor experience.

2.4 Our case study, the proximity sensor system as a tool for understanding the artefacts and design new trails

As we mentioned in the previous chapters of this paper, we manually mapped visitors' behaviour inside the museum in order to install a proximity sensors system that can digitally analyse and map people's behaviour. Proximity sensors will be able to detect visitors' clustering and their time of permanence near the artefacts along the museum display, while recording a huge flux of navigation data. This navigation flux of data can be used to define the top areas of interest in the museum's halls, and to instantly identify the Hypercongestion areas along the display.

The sensor system will be supported by a graphic interface running on an android based software, that could be distributed on the existing audio-guide devices as well as downloaded as an App on the visitors' own device.

This research project aims to create a system that proposes customized visitor's paths tailored on the customer needs and interest, but also we will use the time and thematic parameters to define this interaction design tool. The visitors which will start to use the proximity sensor system will be able to set up a specific range of time for the visit and, furthermore, they will be able to choose a specific topic in line with their personal interests.

3. Visitors' path as an inclusive design project
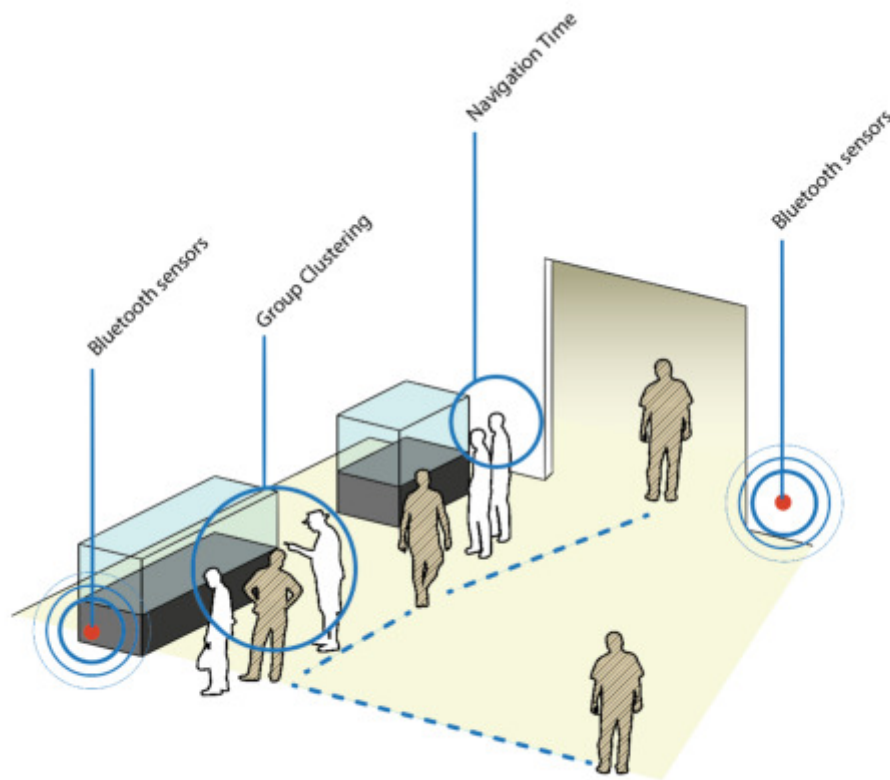
3.1 Early results and future works

Figure 4.   A scheme that shows the non-invasive position of the proximity sensors.

This ongoing research project and analysis is meant to be an implementation of the museum as an experience. To enhance the museum experience and the cultural dissemination has been necessary to merge different areas of knowledge. This merging of intents and expertise was essential to design and develop a proximity sensor system that can include visitors inside a museum's collection, helping them to widely understand their cultural heritage.

From the end of January 2017 will start the first beta test the app on smartphones Android, with the help of the proximity sensors. Inside the museum, the location and the areas of placements for the sensor system has already been identified with the curators and the research team. The areas of allocation to install the sensors have been on the basis of visual density maps of Fig. 4. After installing the sensor system, we will require a data collection phase of about ten weeks, in order to deepen and improve qualitative analysis of user's behaviour (also depending on the flux of visitors). After that it will be possible to structure the visitor trails and the related multimedia content through the devices.

In addition to proceed with the system optimisation, an algorithm will be implemented in order to achieve a real time scanning and mapping realizing a digital heat map of the museum floors. These heat maps will be created with the data gathered from the Bluetooth sensors.

3.2 Discussion

This research is primarily aimed to improve the visitors' museum experience. By improving this experience is possible to better understand the relationship between museum and public, between artefacts and visitors. The museum machines are complex organisms and therefore it's not surprising that the success of the visit as an experience can be entrusted on many variables that can come into play during the visit. Above all it is necessary a joint effort between different areas and institutions. In this paper we have proceeded to the analysis of the operation of the museum complex machine, accepting the challenge of an often obscure and difficult use of large-scale museum collections. In this research we tried to combine some variables, such as environmental factors, psychological, ethnological and technological aspects in order to improve the navigation of people inside the museum spaces. The challenge is given by the implementation of a technology that can be a hybridization of museological, architectural and engineering aspects capable of mixing the museum audience as, conceiving a practical possibility of an accessible and inclusive culture.

Also the key point of this sensor system is the double peculiarity to act as an analysing and mapping tool, and as a visitor's navigation tool to help the customers. As we underlined before in this paper other large scale museums and institutions have tried before us to take into consideration some issues of visitors' navigation or to define new pathways, but rarely together, and not with the same ICT technology we aim to implement. The main contribution of this paper is the implementation of a non invasive sensor system that aims to track visitor's behaviour, and suggests new museum trails. The results of this project have useful implications in the improvement of the Museum Visit Experience and on the key issue of the collection display: learning through the artefacts.

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