

# Vis-à-vis with Leonardo. Designing Digital Encounters

M. Ceconello<sup>1</sup> and D. Spallazzo<sup>1</sup>

<sup>1</sup>Dipartimento di Design, Politecnico di Milano, Italy

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## ABSTRACT

*The paper describes, frames and analyses the exhibit Leonardo Plays Leonardo. Milan. Life. Nature. at Fondazione Stelline in Milan. This gesture-based interactive installation, located in the cloister of Palazzo delle Stelline, showcases Leonardo da Vinci and his Milanese years. The project is based on the idea of digital encounter and allows visitors to meet a real size simulated hologram of the Renaissance Master who tells several short stories about his life, his years in Milan and his relationship with nature. The article frames the projects in the context of digital encounters in CH field and embodied interaction systems, describes how the system was realized and presents preliminary data about the usage.*

Categories and Subject Descriptors (according to ACM CCS): • **Applied computing~Arts and humanities** • *Information systems~Multimedia content creation* • *Human-centered computing~Gestural input*

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## 1. Introduction

The paper describes, frames and analyses the exhibit *Leonardo Plays Leonardo. Milan. Life. Nature.* (Leonardo Racconta Leonardo. Milano. Vita. Natura.) at Fondazione Stelline in Milan, an interactive installation located in the cloister of Palazzo delle Stelline that presents Leonardo da Vinci and his Milanese years.

The building is located in a crucial place for the Renaissance master: just in front of Santa Maria delle Grazie, whose refectory hosts the renowned Last supper, and close to Casa degli Atellani where the vineyard of Leonardo was – and actually still is, after long restoration work. This district was built by the Sforza family around the complex of the church to host courtiers and dignitaries close to the Sforzesco castle.

Given this unique location, Palazzo delle Stelline, with the support of Fondazione Stelline, Lombardy Region and the Superintendence for Architectural and Landscape Heritage of Milan, has been selected as a cultural hub for the promotion of knowledge about Leonardo da Vinci. *Hub Leonardo* is a technological and multimedia centre aimed at highlighting the *genius loci*, the spirit of the place where Leonardo lived and worked, and to lead citizens and tourists to the discovery of the Master's works.

*Leonardo Plays Leonardo* arises in the context of *Hub Leonardo*, paying homage to the Renaissance genius with three interactive installations dealing with (i) the Milanese years of the Master (ii) his life and (iii) his relationship with nature.

The aim of the permanent installation is to introduce citizens and tourists to the world of Leonardo, by letting them really encounter him in the cloister and listen to what he has to say. Visitors can experience a digital encounter with a human-size Leonardo da Vinci, brought back to life thanks mainly to a professional actor, rear-projected screens, sensors for natural interaction and bespoke software.

This paper frames the project by describing related experiences, presents the methodology used to design the system and finally presents and discusses the results achieved.

## 2. Related projects

Digital encounters with important figures of the past or with real-size characters in general are not new in the Cultural Heritage field and several museums, exhibitions and cultural institutions propose this solution to involve visitors in an engaging experience.

The permanent installation at Palazzo Ducale of Gubbio *An audience with Federico* (In udienza da Federico) by the designer Paolo Buroni is an emblematic example. By using holographic technology, Federico da Montefeltro, Renaissance earl of Montefeltro and duke of Urbino, comes back to life in his palace and dialogues with an angel in front of visitors. A renowned professional actor, resembling the portrait of the duke by Piero della Francesca, wears the role and clothes of the Renaissance lord and, through a 15-minute dialogue, informs bystanders on peculiarities of the palace and about his personal story and that of his family. In the exhibit the technological system is completely hidden in order to provide visitors with a real illusion of having the duke talking and moving just in front of them. The

users are spectators of a movie they cannot interact with: indeed, the installation is thought of as theatrical staging, a short representation to be seen at a distance and separating the stage and the public.

A similar approach can be found in the project *Peopling the Palaces at Venaria Reale* by Peter Greenaway, which uses video projections to literally populate the beautiful baroque palace that the Savoy family used in the past as a hunting reserve. Real-size courtiers, dames and gallants, as well as cooks, musicians and scullions appear in period clothes on walls and on screens as soon as visitors approach, recreating the atmosphere of the palace in the baroque era and populating it with voices, music and sounds. The intervention of the British director immerses visitors in another era and sets them in the condition of passive spectators. As a matter of fact, they interact implicitly with the projections, activating them unwittingly with their movements. In comparison with *An audience with Federico*, *Peopling the Palaces at Venaria Reale* provides visitors with a less realistic impression of encounters with actual people but manages to make bystanders feel surrounded by a world that is distant in time but not in space. Peopling different rooms and frequently changing the location of the projection continually stimulates the attentiveness and curiosity of visitors.

Life-size human figures were also proposed by Studio Azzurro at the Italian Pavilion during the Expo 2010 Shanghai China - Better city, better life with the installation *Sensitive City* [Stu10]. In the installation, about 800 citizens of six small Italian cities walk on rear-projected screens and can be stopped by visitors just by raising a hand. Once stopped, they start talking and describe their city, directly addressing the visitor who moved a hand to block them. They tell a vision of their city, fragments of places, and pieces of memory while images and drawings animate the background and enrich the story. In respect to the experiences described above, *Sensitive City* introduces interaction between users and the digital characters on the stage. The digital world lives on the screen also without the intervention of visitors, as every world and people actually do, but is modified by interaction: a natural gesture – raising a hand, as if to really stop people – allows visitors to interact with the citizens of the counter-utopic digital city [Stu10]. This difference gains relevance since it lets visitors interact with digital people, not setting users as passive consumers of multimedia contents.

A novel approach to digital encounters is being carried out also by the *New Dimensions in Testimony* project, stemmed by a collaboration between the USC Shoah Foundation and the USC Institute for Creative Technologies (ICT). Its aim is to let young students talk – now and in the future – with Holocaust survivors about their life experience. In early experimentation, the digital copy of a survivor, sitting on a chair, answers students' questions: the novelty of the project resides mainly in the natural language technology that allows the digital character to “understand” the questions and answer accordingly, greatly increasing the realism of the experience.

The interaction of visitors with digital content is implicit in *An audience with Federico* and in *Peopling the palaces at Venaria Reale*: the presence of users activates videos

that respectively portray an imaginary conversation between the duke and an angel and offer a view on past moments of life. The visitors' bodies act as a switch that, simply by means of presence, implicitly interact with the system-activated contents. Interaction is, instead, made explicit in *Sensitive City*, which returns control of the digital world to users, and is even more explicit in the *New Dimensions in Testimony* project that simulates a real dialogue.

Despite the differences highlighted above, the four projects share the will to simulate realistic encounters with digital characters, making technology disappear in favour of its effects, involving visitors in narrative experiences and taking them to other worlds or other times in a whimsical and fascinating manner.

*Sensitive City*, as well as other projects by Studio Azzurro, proposes a gesture-based interface and thus enters the domain of embodied interaction [Dou01], since it uses the human body and its gestures to control the digital world. Tangible interaction in its multiple interpretations and meanings [HB06] is becoming widespread in the Cultural Heritage field, entering museums, temporary exhibitions and cultural institutions. With the aim of reducing the gap between the physical and the digital worlds, tangible interfaces mainly ask visitors to manipulate objects or to perform bodily gestures to control the digital contents.

Since the first experimentations with Graspable User Interfaces [FIB95] and TUIs – Tangible User Interfaces [IU97] – in the field of Human Computer Interaction, and their early application in the museum field within the SHAPE – Situating Hybrid Assemblies in Public Environments project [BBBH05], tangible interaction returned physicality to the interaction with digital contents, trying to avoid the detachment between the world of atoms and that of bits. This aspect is particularly relevant to the field of Cultural Heritage, where great importance is given to the direct, physical engagement with cultural assets [Dud12]. Current research in the field is being carried out, among others, by the research project *meSch – Material EncounterS with digital Cultural Heritage*, which explores the use of tangible interfaces in the cultural field in order to bridge the gap between digital contents and cultural assets [PDMW\*13].

If the *meSch project* intends tangible interaction in a more physical way, proposing a co-design approach to build innovative TUIs and thus embedding technology within objects, other projects are focused on using the human body to interact with the digital domain without any device. A relevant example in the field of embodied interaction comes from the project *Etruscanning - Digital Encounters with the Regolini-Galassi Tomb* [RV13] that allows users to explore and navigate a detailed 3D reconstruction of an Etruscan tomb using gestures that are captured by the system. Explicit and codified movements, captured by sensors, let visitors move virtually within the tomb and experience a digital encounter with a highly realistic VII century B.C. construction. In comparison with *Sensitive City* that grounds the interaction on a single natural gesture – raising a hand to stop a digital citizen – the Etruscanning project employs a set of codified movements to control navigation within the 3D reconstruction and thus

declares the technological system, without hiding it. In this case, the human body becomes the input device and the gestures are the inputs given to the system.

In the CH field, embodied interaction, on the one hand, fosters a natural interaction with digital contents, letting the technological system disappear in favour of its effects. On the other hand, it can replace common interaction devices – for example joystick and mouse – with codified body movements.

### 3. Design process and approach

The brief for the project was to realise a technological installation, to be set at Palazzo delle Stelline, able to increase the knowledge of citizens and tourists on specific topics about the figure of Leonardo da Vinci, namely his life, his Milanese years and his relationship with nature. Another aim to be achieved was to convey the *genius loci* of the place, creating something that would allow users to perceive the presence of the Master and his legacy in today's world.

The problem to be solved was quite generic, and several different solutions could be proposed. For this reason, we decided to employ a *design-driven process* that did not start from technological solutions but from an ill-defined and wicked problem [Buc92] and progressively defined it through divergent and convergent thinking.

Leonardo Plays Leonardo was designed following the common double diamond design process, elaborated by The British Design Council, based on four steps of implementation of a design product, service, system or software [Des05]. Considered as a sequence of divergent and convergent thinking, this design process goes through four steps – *discover*, *define*, *develop*, *deliver* – that start from an ill-defined problem and finish with the delivery of a working solution (fig.1).

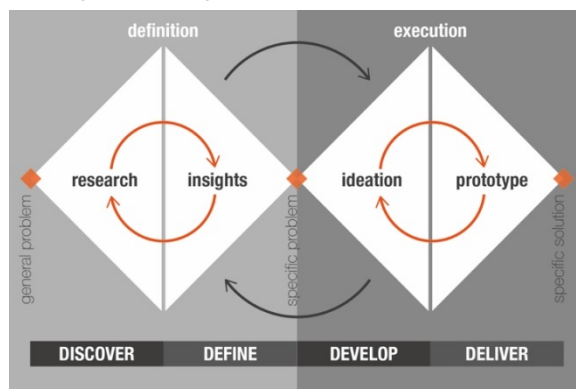


Figure 1: Double diamond design process

The four-step process is made of two main phases: the first is aimed at better defining and specifying the general problem given by the brief, and the second is to translate the specific problem into a specific design solution. Each of the phases is characterised by a sequence of two iterative steps, the first being based on divergent thinking and the second on convergent thinking. The first diamond is made up of a divergent phase – *discover* – based on design research, and by a convergent phase – *define* – that draws insight from the research in order to better define the gen-

eral problem. The second diamond repeats the same structure with a divergent phase – *develop* – that ideates a solution for the specific problem, and by a convergent phase – *deliver* – that translates the ideated concept into a working solution.

This process was used to design *Leonardo Plays Leonardo* as follows. The first divergent phase – *discover* – was devoted to exploring feasible solutions to make the sense of a place recognizable, and to understandable and deal with the three topics proposed in the brief. The subsequent convergent phase – *define* – better defined the general problem, identifying as a specific problem the design of a technological tool that would allow citizens and tourists to experience a digital encounter with Leonardo da Vinci, making him come alive through digital technologies.

Starting from this scenario, a new divergent phase – *develop* – explored several feasible solutions to achieve the stated aim, taking into account the real constraints of the project, such as the location and the budget, as well as the most suitable technology. When the best solution had been identified, the fourth phase – *deliver* – took care of creating the first prototype and, through an iterative process of test and correction that moved back and forth between the third and the fourth phase, it delivered the final product.

A choice made during the design process of *Leonardo Plays Leonardo* was to use open source hardware and software as much as possible, in order to (i) keep the costs of development and implementation low, (ii) exploit the large amount of solutions and suggestions made available by the community and, most importantly, (iii) create an open source system that could be easily reproduced by others. To reinforce the openness of the project, another choice was to use a DIY - Do It Yourself approach, designing and realizing some components of the structure with 3D printers, in particular those related to sensors.

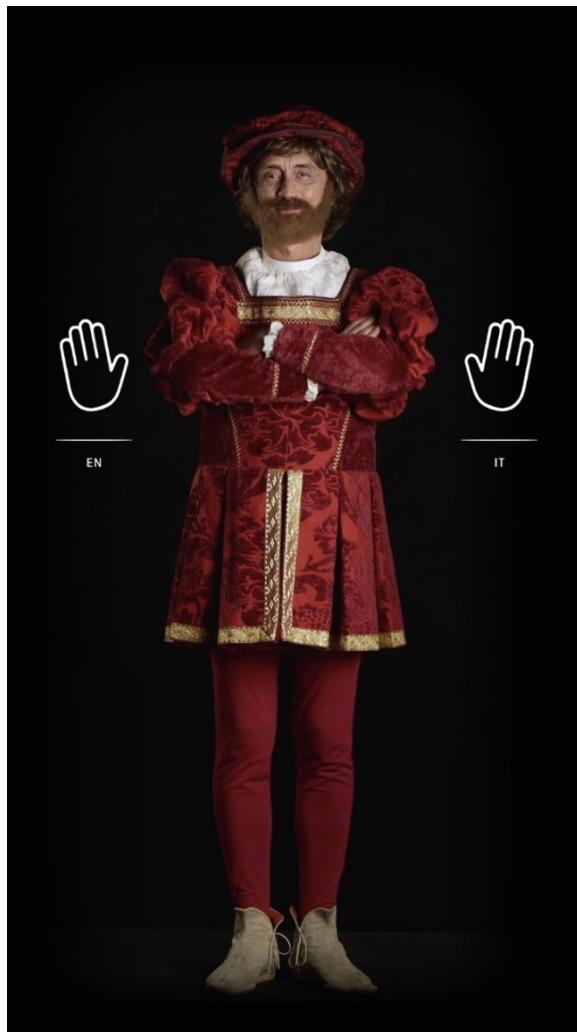
The entire process – from the brief to the delivery of a stable product – lasted about two and a half months, and the exhibition was inaugurated on December 20<sup>th</sup> 2015; in January 2016 additional adjustments and code upgrades were made in order to improve system stability and include a tool that could trace every interaction that users made with the system. While writing, *Leonardo Plays Leonardo* has been running for little more than a month, but not in temporal continuity: the installation is located in the cloister, where several activities, including other exhibitions and events, take place. As a consequence, it has been moved several times.

Such a short time of activity did not permit the organisation of relevant tests with users, something that will be conducted in the follow-up to the project, but significant data about its usage can already be analysed. The software that runs the system was designed to save the memory of each interaction made by people with Leonardo, thus the paper reports on the usage of the system for the 37 days of activity, analysing the data collected in order to draw some preliminary considerations.

#### 4. Leonardo Plays Leonardo: structure, technology, production and use

A user enters the cloister of Palazzo delle Stelline and, guided by the signs, heads towards the Leonardo Plays Leonardo exhibition. From a distance the user notices three installations: a man dressed in Renaissance-style clothes who enters and exits three large screens. Sometimes he wears luxury clothes and seems thoughtful, other times he wears work clothes and moves an easel looking for the right light, other times he seems in a hurry or looks at the user and invites her to approach.

The visitor decides to get close and, as soon as she is a few steps from the first installation, Leonardo appears in front of her in a whimsical way, speaking Italian and asking the user to make a choice between English and Italian subtitles. A motion sensor has indeed detected the movement of the user and the software prompts a video for the choice of the language.



**Figure 2:** Graphic on the screen for the choice of the subtitles

A graphic on the screen asks the user to approach her right hand for Italian subtitles and her left hand for English subtitles (fig. 2). She is Italian, and when she raises her right hand near to the screen, a first video starts (a proximity sensor has indeed detected the hand), chosen randomly by the system from among the five that each installation contains.

After a short introduction showing the title of the short story, Leonardo appears again and starts talking. He talks for about two minutes and once the story ends the user can decide to listen to another story by raising her right hand or to quit by raising her left hand. She decides to go on listening to all the five videos and, once finished, Leonardo kindly says goodbye and then starts entering and exiting the screen. At this point the user can decide to approach another thematic installation that uses the same interaction system.

The brief user journey described above highlights how users can interact with the system, using body movements to activate the device and to interact with it. In particular, it is worth noting that the system enables mainly two kind of interactions.

The first one happens out of the control of the user, since it is based on motion detection: the user walks in front of the device and the PIR sensor detects her. It is an implicit interaction that aims at surprising the visitors, letting them think that Leonardo was waiting for them.

The other interactions – choice of the subtitle language and choice to continue or to quit – are instead explicit, since they require users to approach their right or left hand to the screen to make a choice, following the instructions given by the graphic and by Leonardo himself.

#### 4.1 Structure



**Figure 3:** Users in front of the interactive installations

The concept behind Leonardo Plays Leonardo, as already stated, is to allow citizens and tourists to have a digital encounter with Leonardo da Vinci, giving them the impression of having the Renaissance Master right in front of them, in real size, telling stories (fig. 3). As seen in chapter 2, other projects that provide users with digital encounters usually hide the technological system in the exhibition settings, with the help of darkness, in order to provide the best possible impression of having a real character from another time or another place, talking and acting just in front.

In our case, this choice was precluded because of the location in a cloister and the resulting light conditions. The location was indeed an issue: Palazzo delle Stelline is a major hub for exhibitions, conferences and meetings, and for this reason it was not possible to identify a room to locate the permanent exhibition and arrange the setting to foster the sense of realism usually pursued. The only feasible solution was the Chiostro della Magnolia; the cloister in fact provides a great amount of space surrounding the central court with wide corridors closed by windows.

The perimeter of the corridors facing the internal garden with an old magnolia is a windowed space with a great amount of light at almost every hour of the day. Given the impossibility to hide the technological system, the choice was to make it evident by creating a sort of portal, a timeless space where visitors could meet Leonardo. Rear projected panels seemed therefore to be the best choice to suggest this idea but, if heavy ambient light is a problem when projecting videos, it becomes even more so with rear projection.

For this reason, we decided to use holographic screens: this particular kind of screen is provided with profiled surfaces serving as a pattern of minute lenses resulting in increased brightness and higher resolution even with bright ambient light. Despite this choice, we had to choose a projector capable of high brightness and contrast ratio according to the best trade-off between performance, dimensions and cost.

The height of the ceilings as well as the very old structures prevented us from hanging any kind of equipment, so the only feasible solution was to build a stand-alone structure embedding all the technical devices needed.

Following these restrictions, we decided to split the installation into two parts (fig.4): the first concealing the computer and the video projector – *back-end* – and the second – *front-end* – holding the screen with the interaction and audio equipment.



**Figure 4:** Back-end (left) and front-end (right) structures. Visible on the front-end structure the three sensors on the top (dark grey) and the two boxes hosting the loudspeaker.

The front-end structure, in brushed stainless steel, was designed with multiple functions: holding up the screen and at the same time capable of embedding sensors and cables, the Arduino board and the loudspeakers. In more detail, the installation consists of a heavy iron base, cov-

ered with a stainless steel shaped tinplate that gives stability to the whole structure, with two boxes on the left and the right side to accommodate and hide the two loudspeakers and the Arduino board. A square section stainless steel frame holds the screen through four tie rods and bushes to easily adjust the screen position. The holographic screen was large (200 cm high x 90 cm wide) in order to show a standing person entirely.

On the top of the frame a slot hosts a motion sensor while on the left and right sides there are two proximity sensors that allow interaction with the system. The motion sensor, a pyroelectric infrared sensor covered with a lens to broaden the range, detects a human passing by the screen and activates the interaction through the two IR distance sensors. The three sensors are kept in the right position thanks to bespoke holders, designed and realized with a 3D printer.

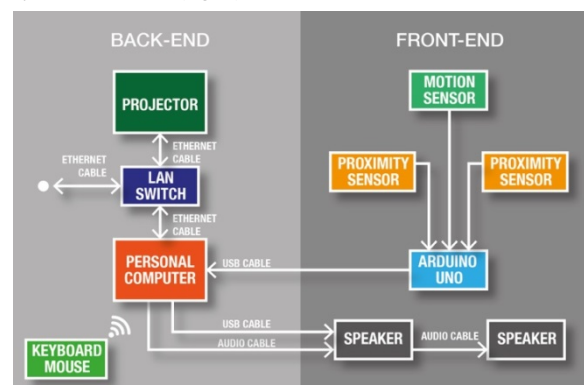
The back-end structure was designed to hold, protect and conceal the PC, the video equipment and an internal switch that allows the connection of all the equipment to the local LAN for remote control access. It was realized as a painted wooden box to keep the costs low and to make it massive enough to prevent possible theft.

#### 4.2 Technological setup and software

From the technological point of view, each interactive installation was assembled using the following hardware components:

- 1 personal computer with wireless keyboard and mouse
- 1 LAN projector NEC PA622U
- 1 LAN switch
- 1 Arduino Uno R3 board
- 1 PIR - motion sensor
- 2 infrared proximity sensors
- 2 stereo loudspeakers
- 1 additional fan
- connection cables.

The schema summarises the connections between all the system elements (fig. 5).



**Figure 5:** Schema of the setup of front-end and back-end structures

The three sensors (1 PIR and 2 proximity sensors) are connected to the Arduino UNO board through cables that run inside the steel frame and are fixed to it through bespoke holders, printed with a 3D printing machine. Inside the frame there is also an audio cable that connects the two loudspeakers placed at the base of the structure.

Two long USB cables connect the Arduino board and the loudspeakers to the PC, providing, respectively, power supply plus data exchange for the board and power supply for the loudspeaker. A long audio cable transmits the audio signal from the PC to the loudspeakers.

Inside the wooden box, a switch allows the PC to be connected via Ethernet cable to the projector and to the Palazzo delle Stelline network, to grant the remote control of the system. An additional fan, external to the PC, was also positioned, in order to avoid PC and projector overheating. For on-site settings, a wireless keyboard and mouse were provided, to avoid opening the screwed side cover.

The PC, running the Windows 10 operating system, was programmed to wake up automatically in the morning and contextually to turn the projector on, and start the software that (i) reads the signals coming from Arduino and (ii) translates them into actions on the videos projected and (iii) keeps trace of each interaction.

The inputs coming from the sensors are read by the Arduino firmware installed on the board, that in turn sends codes to the software; the software then interprets them to control the interaction. The Arduino firmware was written with a bespoke code in order to obtain reliable inputs from the sensors, setting their responsiveness and sensitivity to clean false inputs and avoid consequent fails in the user experience. The software that controls the interaction system, relying on the codes sent by Arduino, was written with bespoke code in *Processing 3* and exported as an executable file, allowing auto run and easy management by the exhibit personnel in case of trouble. The writing of the code was the most delicate phase, since it required several iterations of test and correction in order to fix all the problems and bugs that emerged during the testing. As already stated, the code was upgraded several times after the start of the exhibit, in order to fix minor bugs and to include a tool that could register each interaction that users made with the system.

#### 4.3 Making of

The design and development of the structure and of the technological part of the exhibition are only a part of the *Leonardo Plays Leonardo* project. As we were also in charge of all the tasks, we placed great effort into organising and coordinating all the activities from the script to the shoot of the videos that run in the three installations of the exhibit.

The project indeed required the cooperation of different professionals, in addition to designers and coders: an art historian, a screenwriter, a translator, an actor, a costume designer, a makeup artist, a director, a cameraman and a video editor.

The scripts of each video were written by a screenwriter, relying on the notes of an art historian, and then translated from Italian to English in order to have bi-lingual subtitles. The narrative approach chosen, with Leonardo staging in front of the visitors and addressing them directly, required the contribution of a professional who was able to translate historic texts by an art historian into vivid and captivating monologues.

A costume designer selected two outfits for Leonardo – a working clothes and a suit for special occasions – made up of several garments and details that could be slightly modified in each scene by adding or removing them. A makeup artist chose a wig and a fake beard to make the actor resemble a fifty-years old Renaissance man and equipped him accordingly.

The shooting took 2 days in a photographic studio (fig. 6) involving a director and cameraman and the video editing lasted about 10 working days.

The result is a set of 15 short stories, 15 very short videos to be used as screensavers, a video for the language selection, 4 videos to continue with the interaction and 1 video of greetings.

The 15 stories are organized in three thematic groups, one for each interactive installation:

- *Milan* (In the court of Ludovico il Moro, 1498, The portraits, Salai, The equestrian statue)
- *Life* (The early years, In Verrocchio's workshop, In Milan, The Leonardo da Vinci codes, The last years)
- *Nature* (Nature, teacher of all teachers, Water and the Navigli, Leonardo's Vineyard, Studies on flight, Studies on anatomy).

Each short video lasts about two minutes and portrays a sitting or standing Leonardo, with different outfits (variations of the two garments) and scene objects, directly addressing the user in front of the screen. Italian is the language spoken by Leonardo, but users can select subtitles in Italian – useful in particular for hearing impaired people – and in English for foreigners.



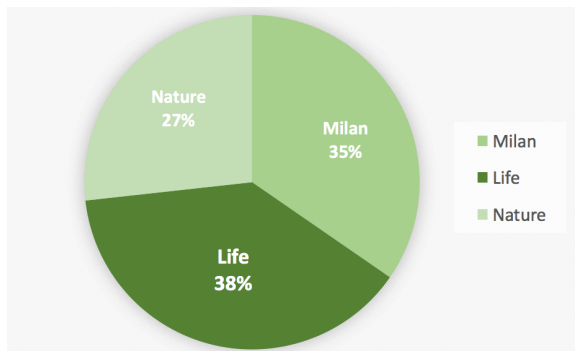
Figure 6: Backstage. Setting for the shooting

## 5. Usage

The software that runs the interactive system was designed to keep track of each interaction between visitors and the three installations, registering the inputs and the videos projected. This improvement in the code was a later introduction and, while writing, we hold quantitative data relative to 37 non-consecutive days covering 2 solar months, from 9 am to 8 pm, for a total amount of about 400 hours.

The system registered 2157 visitors, summing those of the three screens – 747 visitors for Milan, 833 for Life and 577 for Nature – with an average of about 58 users per day and about 5 users per hour. The system registers the interaction of each single installation and, as a consequence, we cannot understand if the 2157 visitors are unique users or if a visitor used more than one installation.

A great percentage of users (82%) chose Italian subtitles, and presumably are Italians, while the remaining 18% selected English subtitles. The data on language are still difficult to interpret, since the low percentage of English videos could be, on the one hand, a confirmation of the choice to make Leonardo speak only in Italian with English subtitles and, on the other, a consequence of this choice. The tests with users will shed light on this issue.



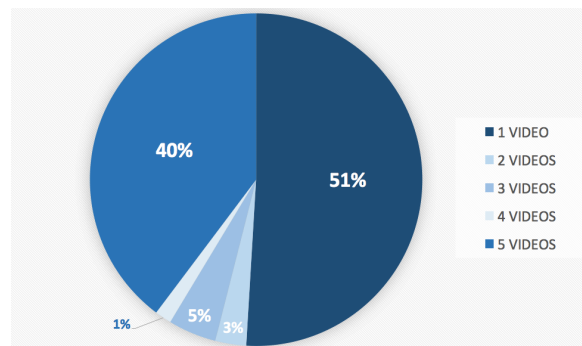
**Figure 7:** Distribution of users across the thematic installations.

Other considerations about the usage data can be drawn by analysing the differences among the three installations and the layout of the exhibit. The second installation met by visitors following the exhibition signals was *Life*, and it resulted as being the most used one, with 833 users. After this came the first installation to be met – *Milan* – with 747 users and then the third one – *Nature* – with 577 users (fig. 7). The expectation to have more users in the first installation and progressively less going towards the end of the exhibit was therefore betrayed. An explanation of this condition could be the proximity of the second booth to a café. This assumption can be partially confirmed by the preference of visitors to listen to a single video (604 out of 833) during the interaction: probably passers-by caught by Leonardo interacted briefly with the system. The first booth, Milan, counted less visitors than the second one but, on the contrary, the interactions performed

had longer durations: 532 visitors out of 747 listened to all the five short stories of the booth. The last booth, Nature, confirms the theory, since it counts considerably less interaction in respect to the first two.

Regarding the number of stories activated by users at the three booths, the majority of them listened to only one video (1099) or to all the five videos (857), while the activation of 2 videos (65), of 3 videos (101) and of 4 videos (35) (fig. 8) were less common.

These results suggest that Leonardo Plays Leonardo, during its first month of activity, attracted mainly two different kinds of user: firstly, passers-by captured by Leonardo to interact with the system but maybe not really concerned about the topics and, on the other, users interested in listening to all the stories.



**Figure 8:** Percentage distribution of the number of videos seen in each session.

Quantitative data can therefore shed some light on the usage of the system in the first month of exercise but only a qualitative analysis will help us to fully interpret and contextualise them.

## 6. Discussion and future works

The paper describes the interactive exhibit *Leonardo Plays Leonardo*, delineating the process and the approach used to design the system, the user experience provided, the hardware and the software employed and the professionals involved. Quantitative data on system usage during a period of one month are finally presented.

The project is set in the field of HCI, looking, on the one hand, at previous experiences of digital encounters and, on the other, an interactive system based upon tangible interaction and embodied interaction in particular. As discussed at the beginning of the paper, *Leonardo Plays Leonardo* differentiates from previous experiences of digital encounters since it does not hide technology and the structure to simulate an astonishing meeting with personalities of the past. Due to conditions of strong illumination and to the peculiar setting of an open cloister, the choice was indeed to make both the structure and the technological system evident. In so doing we introduced a novel way of proposing digital encounters in CH field, facing the difficulties of setting up the system outside of a closed room and in daylight.

Another aspect that differentiates *Leonardo Plays Leonardo* from previous experiences is the open source approach: the projects described at the beginning of the paper were mostly designed and realized by interaction design agencies, artists, and professionals as commercial products and systems. The choice of using open source hardware and software to create a gesture-based system for digital encounters, and to share it, is ground-breaking for CH field since it could allow museums and cultural institutions to reproduce the experience with consistently less effort in terms of time and costs for system setting and coding.

Furthermore, the DIY-Do It Yourself approach, with components realized through digital fabrication machines, contributes to keeping the project as open as possible for further development by other groups interested in using the system developed.

*Leonardo Plays Leonardo*, in terms of kind of interaction enabled, proposes a gesture-based system that makes it possible to modify the state of the system, exploiting both implicit and explicit interaction. The user's body is the controller of the system: just by walking in front of the booths she unwittingly stops the hectic walk of Leonardo, activating the interaction, and voluntarily uses her right or left hand to control the system once started.

The analysed experiences of digital encounter in CH field usually chose one of the two ways of interacting with the system, just using motion sensors to start the projection, or proposing gesture-based or voice-based interaction. The idea of mixing implicit and explicit interaction is an effort to find a balance between the whimsical, unexpected and movie-like appearance of Leonardo and the freedom for users to play an active role in the interaction with the system.

*Leonardo Plays Leonardo* was developed following the *double diamond* design process, going through four phases of development – *discover, define, develop, deliver* – from a generic brief to a working product. The double sequence of divergent-convergent thinking proposed by the process resulted to be very efficient in favouring fast system development without losing both a broad and a narrow view of the project. The design-driven approach chosen for the project did, in fact, make it possible to start from the requirements of the cultural institution and to get to a concept, progressively defined till the definition of its details. The choice of the best suitable technology came only after several steps of development, in order to avoid any possible restriction in the design project due to limitations of the selected tools.

As already stated, *Leonardo Plays Leonardo* is a working, free interactive exhibit, active in all its functionalities for only little more than one month, at Palazzo delle Stelline in Milan. Such a short period of time allowed us to collect quantitative data about the usage of the system for 37 days, discussed in chapter 5, but not to organize sufficient tests with users in order to better understand the quantitative data and to gather pertinent feedback.

Albeit these limitations, the preliminary analysis of data highlights a significant number of visitors at the three booths with an average of about 58 visitors per day and 5 visitors per hour. As the installation is a permanent exhibit

set in a cloister where people usually pass during their daily activity and not in a dedicated room, these results seem encouraging.

Another positive point that emerges from data analysis is the high percentage of users that watched more than one single story (49%), with a high percentage of visitors (40%) enjoying the totality of videos available at each booth.

The next steps in the project are the collection of other quantitative data about usage, and the arrangements of structured tests with users. Participants' observation through think-aloud protocol, structured questionnaires and informal interviews are the research tools that will be employed to conduct tests with a sample of users, in order to shed light on usability issues and on the appreciation of the system, and to receive suggestions for improvements.

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