CODE AND MATERIALITY

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Preface

Welcome to the proceedings of the 20th International Conference on Culture and Computer Science "Code and Materiality" (KUI 2023). It is with great pleasure that we introduce this compilation of research and innovative ideas that emerged from our conference.

In today's rapidly evolving world, the boundaries between the physical and virtual realms are increasingly blurred, as we plunge ever deeper into a technological environment that not only augments our daily lives but also reshapes our understanding of reality itself. At KUI 2023, we explored the intricate interplay between physicality and virtuality, between culture, arts, mathematics, sociology, engineering and other disciplines shedding light on the transformative power of technology in our contemporary society.

Our conference brought together a diverse community of scholars, professionals, and creators from a wide array of countries, universities, and disciplines, spanning from human-computer interaction to art and culture studies, from machine learning to generative and visual arts. This rich tapestry of expertise makes KUI an event where cross-disciplinary dialogue thrives, and new perspectives emerge.

The papers featured in this volume delve into a multitude of topics, reflecting the ever-expanding landscape of culture and computer science. We explore the convergence of physical and virtual spaces, delve into the realms of mixed, extended, augmented, and virtual reality, and discuss the impact of technology on the preservation and presentation of cultural heritage. We examine the symbiotic relationship between art, culture, and technological advancement, and we address critical ethical considerations at the intersection of artificial intelligence, culture and computer science.

Furthermore, our discussions encompass the practical application of technology from 3D tools and digitalization in the cultural and creative industries to interactive multimedia solutions for museums, theatres, and exhibitions. We investigate how computer sciences can enable collaboration in both physical and virtual spaces and how it can enhance storytelling, enriching the cultural experience for audiences worldwide.

Throughout this volume, you will find case studies that showcase the transformative potential of technology within cultural and creative industries. These examples highlight not only the achievements of our conference participants but also the broader impact of their work on society.

As we navigate the ever-changing landscape of technology and culture, it is our hope that the research presented here will inspire further exploration and collaboration across disciplines. We envision a future where the fusion of physical and virtual realms continues to enrich our lives, preserve our heritage, and push the boundaries of artistic expression.

We extend our deepest gratitude to all the contributors, reviewers, and participants who made KUI 2023 a resounding success. We look forward to the continued growth of the Culture and Computer Science community and the exciting innovations that lie ahead.

With warm regards,

Lucas Fabian Olivero
António Bandeira Araújo
Johann Habakuk Israel
Christian Kassung
Jürgen Sieck
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The Earlier Mona Lisa: creating a tactile physical model for transversal sharing and learning during the exhibition

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ABSTRACT

In 2019 the Architecture Models Laboratory from the DiDALabs System at the Dipartimento di Architettura, University of Florence, was called to realise a tactile model of a very special artwork, the "Early Mona Lisa", a masterpiece attributed to Leonardo da Vinci, but still at the centre of certain debate between technical investigations and art historians' evaluations. The occasion was exploited for developing more than a simple touchable reproduction, but to create a complete learning desktop presenting a series of 3D printed models. The desktop was aimed to support the understanding of this masterpiece in parallel with the Louvre's Mona Lisa. The adopted solution was developed creating a common shared experience between blind, partially impaired, and people with normal sight. The whole project was brought on starting from an accurate component design, with well-defined learning experiences. When the whole desktop design was finished, the 3D digital modelling was followed by a complete 3D printing process, stepping through a series of tests with blind people, so to refine and enhance the final result. The exhibition took place in Florence, Italy in April-December 2019, with very positive feedback from the visitors.

CCS CONCEPTS

• **Applied computing** → Arts and humanities; Education; • **Human-centered computing** → Accessibility; Accessibility systems and tools.

KEYWORDS

Monna Lisa, 3D Printing, Digital Museum, Touchable Physical Models, Leonardo Da Vinci, Isleworth Mona Lisa

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1 INTRODUCTION

The contemporary approach to presenting content and artworks in museums and exhibitions has rapidly evolved in recent years.

The possibility offered by digital processing brought to a good opportunity in creating advanced materials for presenting and better understanding elements from Cultural Heritage [6]. These innovations also contain options for extending advanced learning and comprehension to people with limited abilities. But in this, the real challenge is how to create common solutions between normal and partially impaired users and create a common and advanced ground for experiencing Patrimony. Last, but not least, the new setups need proper spaces, they need their own ergonomic dimensioning allowing efficient use and pleasant fruition. In 2019 the Architecture Models Laboratory from the DiDALabs System at the Dipartimento di Architettura, University of Florence, was called to realise a tactile model of a very special artwork, the "Early Mona Lisa", a masterpiece attributed to Leonardo da Vinci, but still at the centre of certain debate between technical investigations and art historians' evaluations.

This portrait, dated at the beginning of the XVI century is extremely similar, but also very different from the masterpiece exhibited at the Louvre since the end of the XVIII century [2]. Operating on such a valuable, but also iconic subject was the occasion to define an advanced and, hopefully, intelligent, set of solutions integrating a correct representation of the subject and defining an experience of learning something more from a worldwide known subject.

When writing "iconic" on the side of Mona Lisa, it is not that clear to almost anyone how Leonardo Da Vinci's masterpiece ascended to be a possible symbol of Cultural Heritage, but its intense story is also comprehensive of the stealing of the artwork happened in the 1911 [8], with one of the first use of contemporary technology during the investigations for verifying the authenticity of the real one in between the many copies. In fact, to check between copies and the original the investigators used photographs of the original to check and match all the details and the cracks. One of the first use of modern technologies at the service of cultural heritage.

2 THE EARLIER MONA LISA IN A GLIMPSE

The earlier Mona Lisa, also known as the "Earlier Version of Mona Lisa" or the "Isleworth Mona Lisa" (Figure 1), is a controversial artwork that numerous researchers claim to be an earlier version or a preliminary study of Leonardo da Vinci's famous painting, the Mona Lisa [1]. The Isleworth Mona Lisa was discovered in 1912 by an English art collector named Hugh Blaker.

It is believed to have been painted by Leonardo da Vinci around 1503-1506, about ten years earlier than the renowned Mona Lisa displayed in the Louvre Museum in Paris. The artwork depicts a

Figure 1: The Isleworth or Early Mona Lisa portrait.

Figure 2: The Mona Lisa and the Isleworth Mona Lisa in parallel (measurement in centimeters).

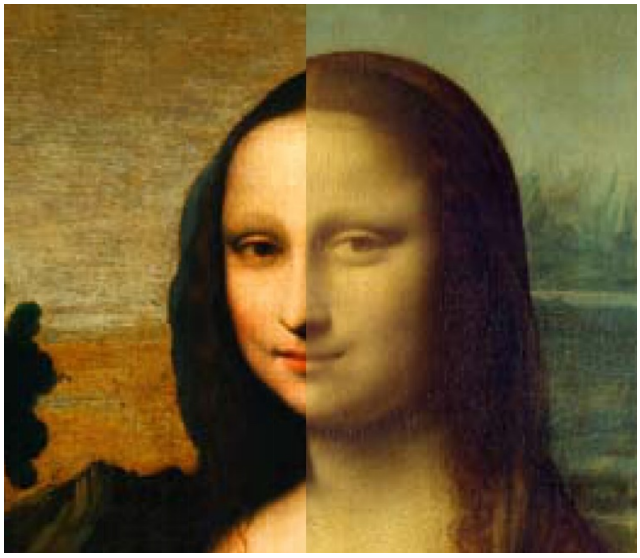

Figure 3: The Mona Lisa and the Isleworth Mona Lisa in parallel, detail on the faces.

similar subject, a woman with a mysterious smile, but there are some notable differences. The Isleworth Mona Lisa has a similar size to the Louvre version and features a landscape background (Figure 2). Some researchers argue that the Isleworth painting shows a younger and more vibrant-looking Mona Lisa compared to the one in the Louvre (Figure 3). Additionally, the Isleworth Mona Lisa has a different composition and some different details. The authenticity and attribution of the earlier Mona Lisa have been the subject of debate among art experts. Some believe that it could be an original work by Leonardo da Vinci, while others argue that it may be a copy or the work of a different artist. In support of the investigations, it seems to come in help even some deductions from the authors of that time, like the indications from Antonio De Beatis [3] and by Giorgio Vasari, who documents in 1550 an unfinished painting made for Monna Lisa's husband, Francesco del Giocondo, on which Leonardo would work for four years (Leonardo left Florence in 1506) [7]. Given the very detailed description, most experts believe that Vasari must have seen the painting in person. He never saw the Louvre version, however, as he never went to France. His description of the painting may therefore correspond to the "Earlier Mona Lisa".

Scientific examinations, such as infrared reflectography and multispectral imaging, have been conducted on the earlier Mona Lisa to analyze its layers, pigments, and techniques used. These studies have provided some insights into the process of the painting creation process but have not definitively settled the debate.

The earlier Mona Lisa remains a fascinating piece in the art world, raising questions about its origins and Leonardo da Vinci's artistic process [4]. While some consider it a possible earlier version of the iconic painting, its attribution and significance remain controversial, and the Louvre Mona Lisa remains the definitive representation of Leonardo's masterpiece. Despite this complex condition of the attribution, the Isleworth Mona Lisa is a brilliant case study about the complexity of cultural patrimony and the difficulties in giving complete and accurate definitions of the events from the past. It is also a fascinating investigation, where all the clues found and connected by the human ingenious built a valorization of the artwork and create the occasion for extended learning about artists, figures, events, and commitments from the Renaissance.

3 FROM A SIMPLE TACTILE MODEL TO A TRANSVERSAL SHARED EXPERIENCE

In September 2018 the Florentine board of the UIC (the Italian Union of Blind People) took contact with the DiDALabs System asking for the creation of a tactile model from the Isleworth Mona Lisa on the occasion of a specific exhibition to be held in the following spring in Florence. The interesting proposal was soon turned into a more extended tactile proposal, in a try of realising a whole touchable desktop to integrate the public presentation of such a significant artwork and to offer a common experience to both normal users and blind and partially sight-impaired users. The whole design process was based on a 3D printing system, so to allow an easy and inexpensive model production, with the option of easy replacing of the components in case of possible damages during the exhibition. The logic of the desktop was planned with various passages from the scale of the picture to the scale of the details present in the paintings.

4 DESIGNING THE LEARNING DESKTOP

The design of the learning desktop was planned to provide a clear understanding of the differences between the two Mona Lisa portraits and a learning opportunity to acquire new and specific information about these important artworks as well. The organisation of the experience considered the needs of blind and partially sight-impaired people, but also created an inclusive solution; that would allow access to all users, providing a "transversal" opportunity. The aspect of creating something with options for blind and partially impaired people, but fully open to a logic of "learning by touch" for everyone, was a compelling intention from the beginning of the development of this learning desktop (Figure 4). The objective of the research was then producing not a simple "3D" version of the painting, defining a volume for the portrait and some reliefs for the background, but creating a full set of elements aimed to a better comprehension of both the artworks and of the space framed in their representation. The tactile models were then a challenge in representing the space of these masterpieces, becoming fully interesting and attractive for any kind of users.

In the exhibition, the desktop was planned to be located near the exhibited "Early Mona Lisa" so that the reference to the real object could be seen immediately from the system of models. The organization of the various models was structured to allow the access to the models to more people at the same time, with no risk of waiting times and invasion between the fruition spaces, the subjects were divided accordingly to topics that allowed the fruition of the whole set in any order: 1) The two Mona Lisa side by side, representing the two figures as a complete three-dimensional body, scaled to the original size they have in the picture, cut at the same height where the frame completes the portrait. The goal of these two models was to put in evidence the differences in size and in detail. The skin and the features were expressly treated to allow a perceptible difference when touched, illustrating the different ages. In these two models, the scenarios were realised as classical bass reliefs describing the elements of the backgrounds with shapes taken directly from the paints and maintained in the same size and position. The material used for these two models was PLA. 2) Two side-by-side models showing the spatial evolution of what was

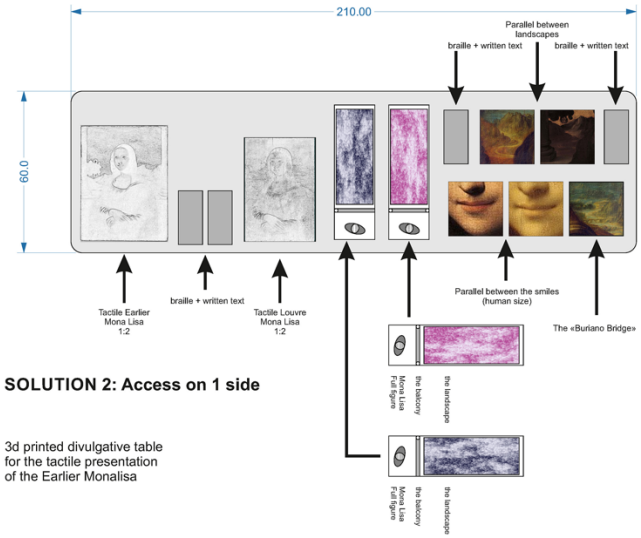

Figure 4: Early draft proposal for the tactile desktop.

represented in the paintings: the woman, the balcony, the landscape, and its elements are here brought to a depth more similar to reality, offering the opportunity to understand the spatial extension of the scene framed in the artworks and to become aware of certain differences in the two scenarios. The material used for these two models was chalk and resin. 3) An enlarged portion of one of the hills from the landscape, is useful to understand the smoothness and the relationship between the green parts, the terrain, emphasizing this highly characteristic element. The material used for these two models was chalk and resin. 4) An enlargement of the "Buriano Bridge", this specific architectural part is located in the Louvre Mona Lisa, being widely recognized for being this old bridge nearby Arezzo, in Tuscany. It was easy to create the model using a previous digital survey with a 3d laser scanner taken in 2007. The material used for this model was chalk and resin. 5) The two smiles of the two Mona Lisa, this extremely well-known element of portraiture that is the subject of wide debate in various disciplines were presented side by side, with minimal differences in surface and scaled to the real size of a woman's mouth. The original portraits do not correspond to the real size of a human being. So, to define a possible measurement between the various possibilities it was decided to derive it from an online request "Ladies, please send us the measurements of your smile" (Figure 5).

The request was posted on Instagram and brought in about 30 responses, then all the measures were summed, and the resulting medium value was used to scale the model of the lips. The material used for these two models was PLA. 6) To complete the desktop a series of captions and texts were provided in Braille and supplemented with QR codes that allow access to the audio files of each text and subtitle.

5 MODELLING AND 3D PRINTING PHASES

To allow the creation of all the models taking part in the learning desktop the choice was done for 3D FDM (Fused Deposition Modeling) printing, based on the use of PLA filament. This is a popular

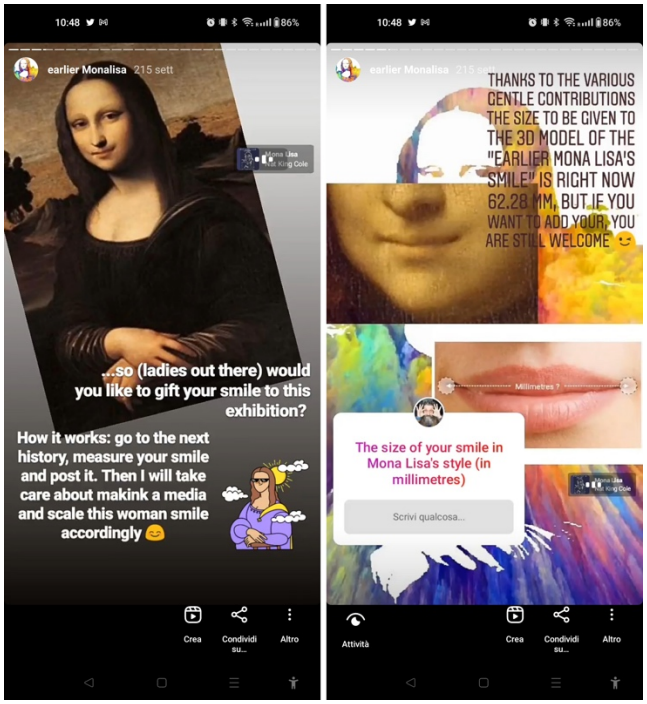

Figure 5: Two screens from the Instagram questionnaire.

Figure 6: The head of the Earlier Monalisa in 3D print.

Figure 7: Components of the tactile desktop at the end of the 3D printing process.

additive manufacturing technology that involves the creation of three-dimensional objects by melting and extruding thermoplastic filament layer by layer [5]. For the smaller models, in need of a higher level of details and which may benefit from surface with a "grainier" effect, the choice was done for printing with chalk and resin, once again using a printing system based on the deployment of consecutive layers of material. FDM printers are quite common and are widely used due to their affordability, ease of use, and versatility.

In this specific case it was decided to use three different printers, a 3D System ProJet 660 Pro for the chalk and resin printing, a Raise 3D Pro for the larger parts (like the two Mona Lisa models for the side-by-side match), while for all the smaller parts the FDM printer in use was an Ultimaker 3 model (Figure 6). The process applied for the development of each model was classic and oriented to the production of well-efficient components. During the design of the model each part was created using CAD/modelling software, most of the models were developed modelling free shapes using the portrait of the Isleworth or the Louvre Mona Lisa for reference. The full figures of the two Mona Lisa were derived from a 3D Model previously developed and freely available online. In the case of the Buriano Bridge the model was obtained from 3D scanner data gathered years before for a master's degree thesis. The two software in use for drawing and modelling were mainly McNeel Rhinoceros 3D and Maxon Cinema 4D. The models were then saved in a standard file format like STL or OBJ to pass them to the 3d printing process.

The process of setting up the 3D printer was oriented to obtain smooth surfaces, pleasant to the touch, so the slicing was set to high quality, with layers of about 0,15 millimetres. The 3D model was imported into slicing software and prepared for printing. For the larger portraits and the reconstruction of the scenario in "real" proportions, the models were divided into parts and then glued at the end of the printing process. The infill density of each model was set in a range between 50 and 70 per cent to obtain very resistant models, with no risk of cracks or damage even after a long use by the public, but also to make them appear more solid to the touch. The setting up of the printer was aimed at obtaining smooth

Figure 8: The Mona Lisa assembled and ready for the last finishing before the exhibition.

surfaces pleasant to the touch. During the creation process, some tactile tests were done with volunteers from the UIC, using a scaled version of the Mona Lisa model and some parts in the effective size. These tests were extremely useful for understanding the level of accuracy and the finishing of the surfaces to make them more pleasant at touch, more recognizable and more appropriate for the represented parts. The printer heated the thermoplastic filament to its melting point and extruded it through its nozzle. In both the FDM printers the movement of the nozzle was controlled along the X, Y, and Z axes using orthogonal arms to support and move the printing head, depositing the molten material layer by layer onto the print bed or on previously printed layers. Each layer solidifies quickly after being deposited, bonding to the previous layers. This simple and quite well-known process was not free of potential problems, but in the specific case of the Mona Lisa's models, it was extremely peaceful except for an error in printing one of the full-length portrait models. Nothing difficult that can be solved by a new print. Since each printer has its own volumetric limits, the full-portrait models had to be split into three blocks (Figure 7, Figure 8). The process, was not entirely painless, while it would have been highly desirable to have a single block with no visible (or touchable) connections, even though the laboratory was not equipped with a printer for such a size and while there was the possibility of quickly printing a new copy if a replacement was needed during the exhibition, it was preferred to handle the whole situation using what was available in the laboratory.

Figure 9: The tactile desktop during the exhibition.

Specific attention was reserved for the presence of support structures in the FDM printing. If the model has overhangs or intricate geometries that require additional support, the printer can generate temporary support structures using a different material or the same filament.

These supports provide stability during printing and are removed after the print is complete. But even if they are mandatory to allow a correct result and avoid any mess and failure during the print, they may cause irregular marks on the final model and require complex cleaning/retouching operations to refine the final model. The support structures were then reduced to the minimum, the division in parts contributed in a significant way to this optimization. The shape of the models helped a lot in this, while just minimal parts were really in need for generating support during the printing

Figure 10: The tactile desktop in front of the Earlier Mona Lisa.

process. This "lucky" condition helped a lot in the production of the models, reducing the after-print processing.

This last post-processing was obviously aimed at the removal of any support structures, this was operated manually and using tools for getting sharper detachments and refining the detach points. The separated components for the models divided in parts were accurately glued together. The models in PLA did not require significant further post-processing steps like sanding, painting, or additional treatments. The models released in resin and chalk were painted with a thin layer of resin to make them more pleasant to the touch and more resistant to consumption and dirtiness.

6 THE EXHIBITION

The exhibition took place from 10th of June 2019 and closed on the following 30th July at Palazzo Bastogi, in Florence (Figure 9, Figure 10). The Isleworth Mona Lisa was the focus of an extensive system of panels describing all historical, technical, and artistic aspects of the artwork. Since its opening, the tactile desktop generated great interest and functioned efficiently for all kinds of users. All the physical models resisted well to the users and did not need to be repaired or replaced at the end of the exhibition. The exhibition was originally intended to be a travelling exhibition, and the next event was to be held in Beijing in the spring of 2020, but the impending pandemic scuttled that intention. At the time of writing no new exhibitions are in the program, any possible future options for a new edition can be reviewed on the Mona Lisa Foundation website (www.Mona Lisa.org).

Figure 11: The "Older Mona Lisa", just a simple divertissement created using MidJourney AI for image generation (June 2023).

7 WHAT ELSE CAN BE ADDED FOUR YEARS LATER?

At the time of the exhibition, the great result was obtaining a completely transversal learning desktop. After four years, it can be said that the parallel between the younger and the older Mona Lisa was capturing all the attention and stimulated the visitors into complex reflections. Nowadays, with the robust presence of numerous AI tools for image generation, it becomes interesting to play with the subject and imagine a third portrait, by simply inventing an imaginative "older Mona Lisa " depicting the woman when elderly. A fully impossible experiment, knowing that Lisa Gherardini died in 1542 at the age of only 63. But the possibility offered by the AI platform is too challenging, and so, using Midjourney, such an iconic subject, instantly produces a convincing result with just a few words in a very simple prompt. The use of "Leonardo Da Vinci's Mona Lisa, but Mona Lisa is now much older than the character in the portrait, she is an old woman, with white/grey hair" produced creative and surprising images, keeping the main structure of the artwork, and adding a layer of "age" to the main subject (Figure 11). Increasing the complexity of the prompt and adding "she is portrayed in a picture as the real person of Mona Lisa, but when older" brings out a stunning portrait of an imaginative old Gioconda (Figure 12). What do these two graphic products add to previous research and activity? Probably nothing, but they show, once again, the powerful iconic value of the subject, so frequently used to achieve good results extremely easily with very basic and simple use of AI software.

Figure 12: Photographic portrait of the "Older Mona Lisa", just a simple divertissement created using MidJourney AI for image generation (June 2023).

8 CONCLUSIONS

The research and activity presented here do not contribute to the direct definition of the authenticity or artistic value and story of the Isleworth Mona Lisa, but it results in an accurate use of digital tools to focus on a subject using appropriate and specific solutions. It was an attempt to combine and bring to a happy end the various aspects of communication, design, and technical solution of all the components related to this tactile desktop. The fascinating and exceptional occasion to work on a subject of such importance was the occasion to try to elaborate something very specific and innovative in the approach to the artwork, defining rules that can be used in other institutions in the future, but here an extremely specific solution was defined, worthy of attention and able to create a bridge between the two distant artworks, between visitors and the masterpieces and between experiences based on sight and experiences based on touch.

ACKNOWLEDGMENTS

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