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Discovering Patere in Venice

An Augmented Reality
project for Cultural
Heritage

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Discovering Patere in Venice - An Augmented Reality project for Cultural Heritage

Introduction

This dissertation represents a contribution to the ongoing project *Discovering Patere in Venice - An Augmented Reality project for Cultural Heritage* developed in the context of the Master in Digital and Public Humanities at Ca' Foscari University of Venice, under the coordination of Professor Fabio Pittarello and Professor Gloria Vallese.

The technical basis of the project is represented by the Augmented Reality, a technology that has become very popular in the last decades and that has found its application also in the field of Cultural Heritage, as this project demonstrates.
Instead, the historical and cultural basis of this project derives from the research on the patere and their astronomical reading conducted by Professor Gloria Vallese, that led to the exhibitions of 2016 and 2021 *Stelle e Viaggi, a 13th century astronomical cycle of the main portal of St. Mark's Basilica in Venice*[1].

In the next chapters of this dissertation, in the first place an overview of the Augmented Reality technology will be given, explaining its functionalities and its scope of application. The following description will be focused on the Cultural Heritage field since it's the one under which the project *Discovering Patere* falls, and one of the most growing in the branch of the Digital Humanities.

[1] Vallese Gloria (ed.) *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia/Stars and Travels. A 13th century astronomical cycle on the main portal of St. Mark's Basilica in Venice* (Exhibition cat., Accademia di Belle Arti di Venezia, Magazzino del Sale 3, 2016), Crocetta del Montello, Edizioni Antiga, 2017.

The following discussion will focus on the explanation of the research related to the patere and the astronomical theories about them, starting from the portal of the Basilica di San Marco, that will be analysed in its iconography and symbology, essential to understand the astronomical meaning of the patere. [2]

After that, the concept of patera will be discussed further and with it also some fundamental astronomical notions about the celestial navigation. This discussion will be of fundamental importance to understand the concept that lays behind the patere, how their astronomical reading could serve as an orientation means to the passers-by in the Venice of the 13th and 14th century, and how it can be used still today to get their bearings in Venice by looking at the patere up on the walls.

At this point, a number of patere will be fully described. These patere will be grouped according to their location in Venice (e.g. Ca' Boldù, Chiesa dei Carmini etc.), and they are the ones that have been included in the project *Discovering Patere.* For each group, a description of the different patere will be provided, including the description of their meaning, the related iconography, and how to read them as a whole to understand the orientation of the building on which they are in relation to the Rose of the Winds.

Finally, in the last chapter a detailed description of the ongoing project *Discovering Patere in Venice - An Augmented Reality project for Cultural Heritage,* will be given*,* explaining the concept that lays behind it, the research that was led (both technical and historical), the goals of the project and the technical implementations that was carried on in the prototyping phase.

As already said, this is an ongoing project that will see further implementations and research, the steps described in this dissertation represent only the initial phase of it.

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[2] Vallese, G., "Venetian patere and formelle: towards an astronomical reading (part 1)", in *La camera dello scirocco,* Anno V – Ottobre 2021, pp. 7-17.
Vallese, G., "Venetian patere and formelle: towards an astronomical reading (part 2)", in *La camera dello scirocco,* Anno VI – Febbraio 2022, pp. 9-18.
Vallese, G., "Le stelle e i viaggi, Un ciclo astronomico nel portale centrale
della Basilica di San Marco a Venezia (prima parte)" in *Annuario Accademia di Belle Arti di Venezia,* a cura di Alberto Giorgio Cassani, Venezia, 2014.
Vallese, G., "Le stelle e i viaggi, Un ciclo astronomico nel portale centrale
della Basilica di San Marco a Venezia (seconda parte)" in *Annuario Accademia di Belle Arti di Venezia,* a cura di Alberto Giorgio Cassani, Venezia, 2015.
Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference, September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

Chapter 1 Augmented Reality for Digital Humanities and Cultural Heritage

Chapter 1.1 – An introduction to the Augmented Reality and its technical issues

The concept of Augmented Reality (AR) falls under the general field of Mixed Reality (MR) defined by Milgram and Kishino (1994) in their essay *A Taxonomy of Virtual Reality Visual Displays*[3], where they attempted to give a definition to this emerging field, stating that mixed reality can be regarded in terms of a continuum relating purely virtual environments to purely real environments[4]. They refer to augmented reality to indicate a special case of the mixed reality continuum in which an otherwise real environment is "augmented" by means of virtual (computer graphic) objects"[5].

Another definition of Augmented Reality, which is also the most accepted one in this field, is the definition by Azuma (1997), where the author describes it as "a system that combines real and virtual content, provides a real-time interactive environment, and registers in 3D." [6]

Boboc et al. (2022) write that "AR provides a framework for adding information to the real-world environment. AR technology allows users to perceive the world in an enhanced way; it improves the users' experience by overlaying computer-generated information, including graphics, sounds, and sometimes touch feedback, on the real environment."[7]

But why has AR become such an interesting and widespread tool over the last decades? Why is it useful to many and diverse disciplines such as industry, medicine, navigation, cultural heritage,

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[3] Milgram, P. and Kishino, F., "A Taxonomy of Mixed Reality Visual Displays" in *IEICE Transactions on Information and Systems*, Vol E77-D, No.12 December 1994.
[4] Ibidem
[5] Ibidem

[6] Azuma, R. T., "A Survey of Augmented Reality" in *Presence: Teleoperators and Virtual Environments 6*, 4, August 1997, pp. 355-385.

[7] Boboc, R. G., Băutu, E., Gîrbacia, F., Popovici, N., and Popovici, D., "Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications" in *Applied Sciences* 12, no. 19: 9859, 2022, doi https://doi.org/10.3390/app12199859

tourism, and education? It is because, as Ronald Azuma (1997)[8] states, AR achieves goals that human being cannot with its own senses. Augmented Reality an example of what Fred Brooks calls "Intelligence Amplification (IA)" [9], namely a tool that makes it easier for humans to achieve real-world tasks.

In practice, AR is a technology of digital output characterized by an overlaying of virtual object ("Virtual objects are objects that exist in essence or effect, but not formally or actually."[10]) over real objects ("Real objects are any objects that have an actual objective existence."[11]), giving the immersive impression of facing a single object. The virtual objects are viewable through various vision devices: monitors, lenses, helmets, but also personal devices such as tablets and smartphones.

The category of Mixed Realty described by Milgram and Kishino (1994)[12], includes AR and Virtual Reality (VR). Virtual Reality is defined by the two authors as an environment "in which the participant- observer is totally immersed in, and able to interact with, a completely synthetic world. Such a world may mimic the properties of some real-world environments, either existing or fictional", or it can create "a world in which the physical laws ordinarily governing space, time, mechanics, material properties, etc. no longer hold."[13]

An example of Virtual Reality is the CAVE (Cave Automatic Virtual Environment): "a virtual reality (VR) environment consisting of a cube-shaped VR room or a room-scale area in which the walls, floors and ceilings are projection screens."[14], with 3D images floating in mid-air. The virtual scenes from the projectors are synchronized to give the user the illusion of being in a virtual space. The user may wear a VR headset or heads-up display and interacts through input devices such as wands, joysticks, or data gloves.

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[8] Azuma, R. T., "A Survey of Augmented Reality" in *Presence: Teleoperators and Virtual Environments 6*, 4, August 1997, pp. 355-385.

[9] Brooks, F. P. Jr, "The Computer Scientist as Toolsmith II", in *CACM,* Volume *39*,3, March 1996, pp. 61-68, doi https://doi.org/10.1145/227234.227243

[10] Milgram, P. and Kishino, F., "A Taxonomy of Mixed Reality Visual Displays" in *IEICE Transactions on Information and Systems*, Vol E77-D, No.12 December 1994.

[11] Ibidem

[12] Ibidem

[13] Ibidem

[14] https://www.techtarget.com/whatis/definition/CAVE-Cave-Automatic-Virtual-Environment

Going back to Augmented Reality, the following discussion will present the technical aspects of it, starting from a basic distinction: Augmented Reality thorough devices that display the scene to the direct look of the user, and AR that uses mobile devices that interpose a camera between the user's look and the real scene. In the first case, the visualization is augmented by using the user's point of view through head-mounted displays (HMD) such has Hololens and Magic Leap. With the second type, the visual components are superimposed to the real scene that is recorded through a webcam or a smartphone camera. Some of the main platforms for this purpose are ARCore, Apple ARKit, Wikitude, and Vuforia.

Microsoft HoloLens is an optical-see-through HMD and a holographic computer, which allows users to interact with virtual content via gaze, gesture, and speech. It gives an immersive experience to the user and therefore conveys emotional involvement that, in some cases, is an important means and prerequisite for learning, understanding and dive into the experience. HoloLens present content in mixed reality and allow users to visualise multimedia content and remain permanently anchored in the real world that becomes an integral part of the user experience.

In the second type of Augmented Reality described above, the augmentation is showed through a device, like a smartphone, and it doesn't appear to the direct look of the user. The point of view can be, but not necessarily, the one of the users.
In recent years, mobile devices such as smartphones and tablets have exponentially grown and with them also their computing power, with the integration of a wide range of sensors (accelerometer, gyroscope, GPS, etc.). This significantly enriched these devices' functionalities and the capacity of connection of smartphones that, thanks to a variety of radios like Wi-Fi, Bluetooth, and NFC make it possible for users to communicate with other devices, connect to the Internet, and exchange their data. As Yang and Cheng (2015) write in their essay *Scalable Augmented Reality on Mobile Devices: Application, Challenges, Methods, and Software,* "These mobile handheld devices equipped with cameras, sensors, low-latency data networks, and powerful multicore application processors (APs) can now run very sophisticate augmented reality (AR) applications."[15]
There are nowadays many mobile AR (MAR) apps for, as an example, interactive books, multimedia-augmented advertising, augmented personal navigation, etc. As a matter of fact,

[15] Yang, X., and Cheng, K. T. T., Chapter 11 in 2nd Edition of "Scalable Augmented Reality on Mobile Devices: Application, Challenges, Methods, and Software" in *Fundamentals of Wearable Computers and Augmented Reality,* edited by Barfielòd, W., Boca Raton: CRC Press, 2015, p. 196.

"a scalable MAR system, which has the ability to identify objects and/or locations from a large database and track the pose of a mobile device with respective to the physical objects, can support a wide range of MAR apps."[16]

According to the techniques they rely on, scalable MAR apps can be categorized into three classes: computer vision-based, sensor-based, and hybrid.

Vision-based MAR apps rely on the image acquisition made by mobile cameras, vision-based recognition, and tracking algorithms to identity the physical object and then link it to the correspondent virtual object. A conventional vision-based MAR pipeline consists of three main steps:

1. Recognition: the app derives a set of features from the image captured by the camera and matches it to a database to recognize the objects;
2. Tracking: the recognized object is tracked from frame to frame by matching features of consecutive frames;
3. Pose estimation: specific coordinate transforms between the image frame and the recognized object in the database are built.

Vision-based MAR apps are becoming more and more popular with the rapid advance in real-time object recognition and tracking. Marketing, education, and tourism are just some of the fields in which these apps are employed, including Cultural Heritage of which I'm going to talk in the next chapter.

Sensor-based MAR apps rely on sensors such as GPS, accelerometer, and gyroscope to identify and track the geographical position of a mobile device and its orientation. Sensors have become more accurate in the new generation of smartphones, so that sensor-based MAR apps are gaining popularity, especially for personal navigation.

[16]Yang, X., and Cheng, K. T. T., Chapter 11 in 2nd Edition of "Scalable Augmented Reality on Mobile Devices: Application, Challenges, Methods, and Software" in *Fundamentals of Wearable Computers and Augmented Reality,* edited by Barfielòd, W., Boca Raton: CRC Press, 2015, p. 196.

As Yang and Cheng (2015)[17] point out, sensor-based and vision-based methods have advantages and disadvantages. Sensor-based methods can obtain the geographical location of a mobile device with few complex calculations, so that any mobile platform can use it, also those with limited computing and memory resources. However, the accuracy of the geographic position is not always high, because of the inertial sensors that are used in the mobile devices. On the other hand, vision-based methods can be more accurate, but they require higher computational and memory complexity. Therefore, to achieve both high accuracy and high efficiency many scalable MAR apps employ hybrid methods, to benefit of the advantages of both approaches.

[17] Yang, X., and Cheng, K. T. T., Chapter 9 in 2nd Edition of "Scalable Augmented Reality on Mobile Devices: Application, Challenges, Methods, and Software" in *Fundamentals of Wearable Computers and Augmented Reality,* edited by Barfielòd, W., Boca Raton: CRC Press, 2015, p. 198.

Chapter 1.2 - Cultural Heritage and Augmented Reality

In the previous chapter it has been attempted to give a definition of Augmented Reality and to briefly introduce the various types of this technology. In this chapter, I'm going to investigate the various fields in which AR is employed, with a particular focus on Cultural Heritage (CH).

As Boboc et al. (2022) write, "The field of AR application began in the 1990s and has continuously increased in importance since then, along with technological advances and the development of information and communication technologies (ICTs)."[18]

AR has been applied to various and very different disciplines, especially medicine, education, automotive industries, healthcare, and tourism. In particular, AR initially focused on professional use such as medical surgery or assembly and maintenance of equipment, application scenarios that needed to be enhanced by 3D technologies. This was due to the fact that in the early days of AR equipment was very specialized and expensive, whereas nowadays the access to it has been democratised by the introduction of less bulky and expensive technologies such as smartphones, tablets, laptops etc., that can support new AR software accessible to anyone. In this way, AR has been employed also to target the mass market for advertising, entertainment, and educational purposes.

A field that has recently gained much importance and recognition is that of Cultural Heritage, since it has been recognised its potential in the management and preservation of it, including also the emotional power this technology can convey. As a matter of fact, Azuma (2015) argues that one of the ultimate uses of AR (and Mixed Reality in general) will be to allow new forms of storytelling "that enable virtual content to be connected in meaningful ways to particular locations, whether those are places, people or objects." [19] He firmly believes that, "in the long run, one of the ultimate

[18] Boboc, R. G., Băutu, E., Gîrbacia, F., Popovici, N., and Popovici, D., "Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications" in *Applied Sciences* 12, no. 19: 9859, 2022, doi https://doi.org/10.3390/app12199859

[19] Azuma, R., "Location-Based Mixed and Augmented Reality Storytelling", Chapter 11 in 2nd Edition of *Fundamentals of Wearable Computers and Augmented Reality*, Woodrow Barfield, (editor), CRC Press, August 2015, pp. 259-276.

uses of MR and AR technologies will be as a new form of location-based media that enables new storytelling experiences."[20]

As a matter of fact, storytelling is widely recognised as a powerful way to increase the engagement of users and spread knowledge.

> Computer-enhanced storytelling represents an evolution of traditional storytelling, for the technical means used for the creation and the delivery of the story, the introduction of new narrative models and the enhancement of the relations between user, narration, and context. [21]

For this reason, in the Cultural Heritage domain many AR projects have been coupled to storytelling, to give a more interactive and compelling experience to the user.

Krogstie and Haugstvedt (2015) give a definition of Cultural Heritage, namely "the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations and maintained in the present for the benefit of current and future generations."[22] These cultural artifacts, as the authors write, need to be preserved and be accessible to the public in short- and long-time period. Augmented Reality, in this way, can help to preserve Cultural Heritage.

AR has been employed by several CH institutions to preserve cultural artifacts, through the development of AR mobile applications. According to Johnson et al. (2010), "Museum educators, arguably, have always been in the business of AR, creating bridges between objects, ideas, and visitors."[23] As a matter of fact, mobile AR applications implement the technology useful to preserve Cultural Heritage, giving better historical information to the user, context of where the user is and when he or she is there. Furthermore, mobile AR technology helps publicise the institutions and therefore attract and reach a new audience.

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[20] Azuma, R., "Location-Based Mixed and Augmented Reality Storytelling", Chapter 11 in 2nd Edition of *Fundamentals of Wearable Computers and Augmented Reality*, Woodrow Barfield, (editor), CRC Press, August 2015, pp. 259-276.

[21] Fenu, C., and Pittarello, F., "Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum" in *International Journal of Human-Computer Studies*, Volume 114, June 2918, pp. 20-35.

[22] Krogstie, J., and Haugstvedt, A., "Use of Mobile Augmented Reality for Cultural Heritage", Chapter 16 in 2nd Edition of *Fundamentals of Wearable Computers and Augmented Reality*, Woodrow Barfield (editor), CRC Press, August 2015, pp. 411-429.

[23] Johnson, L.F., H. Witchey, R. Smith, A. Levine, and k. Haywood, *The 2010 Horizon Report: Museum Edition.* The New Media Consortium, Austin, TX, 2010.

According to Bekele et al (2018)[24], the main purposes for which AR is employed in Cultural Heritage are: improving visitor experience, reconstructing, and exploration. These three goals will be discussed in the rest of this section through the analysis of different case studies related to the application of AR to Cultural Heritage and Digital Humanities.

Concerning the first goal, namely improving visitor experience, also called "reinforcing" by Azuma (2015)[25], the strategy is to identify a real environment that is already meaningful by itself. AR is in this case used to complement the power that the real location, object, or person already have, to give a new experience that is more intense than the real or virtual environment by themselves.

An example of this strategy is given by the project *110 Stories*[26], designed by Brian August in 2011. This experience was designed for mobile phones, so it's easily accessible to many persons. The application, when used around Manhattan, activates the compass and tilt sensors to give out the outline of the Twin Towers in the location where they stood before the terrorists' attack, against the New York City skyline.

This project is a demonstration of the technique often used in the AR storytelling experiences based on the reinforcing strategy, namely connecting the story to the past. It's also the case of another AR project called *Archeoguide*[27], an early attempt to develop a platform to augment archaeological sites.

Archeoguide was developed by Vlahakis et al. in 2002, and the name is the short for Augmented Reality-Based Cultural Heritage On-Site Guide, an avant-garde project intended to "bridge the gap between recreation, education, and scientific research"[28]. The prototype was located at Greece's Olympia archaeological site. The goal was to "provide a personalized electronic guide to outdoor

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[24] Bekele, M., K., Pierdicca, R., Frontoni, E., Malinverni, E., S., and Gain, J., **"**A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage**",** in *Journal on Computing and Cultural Heritage,* Article n. 7, Volume 11,2, June 2018, pp. 1-36, doi https://doi.org/10.1145/3145534

[25] Azuma, R., "Location-Based Mixed and Augmented Reality Storytelling", Chapter 11 in 2nd Edition of *Fundamentals of Wearable Computers and Augmented Reality*, Woodrow Barfield, (editor), CRC Press, August 2015, pp. 259-276. 5

[26] http://www.110stories.com

[27] Vlahakis, V., Ioannidis, M., Karigiannis, J., Tsotros, M., Gounaris, M., Stricker, D., Gleue, T., Daehne, P., and Almeida, L., "Archeoguide: An augmented reality guide for archaeolog sites" in *IEEE Compter Graphics and Applications,* Volume 22,5, October 2002, pp. 52-60, doi 10.1109/MCG.2002.1028726

[28] Ibidem

archaeological sites, help users navigate and make the most of their visit, and enable the collection, exploitation, and updating of archaeological data on any given site"[29].

Archeoguide was built on a client-server architecture formed by the Site Information Server (SIS), mobile units, and the network infrastructure. In this way, the touring user in the archaeological site could carry the mobile units, namely laptop, tablet, and palmtop computer, and get multimedia information from the SIS based on their position calculated by the Global Positioning System (GPS) signals.

However, "the functionality typically provided by AR technology was only available on laptop systems and required the use of a see-through head-mounted display with an external web camera, a digital compass, a backpack with a GPS receiver, a laptop, wireless communication equipment, and a battery."[30] An approximate position of the user was given by the combination of GPS and compass systems; instead, to find the exact user's position and orientation, vision-based tracking techniques based on natural landmarks were used.

The reinforcing method has positive and negative aspects that must be considered. On the positive side, it is a good way to enhance a place that is already meaningful by itself, so that the experience does not rely only on the virtual content. Furthermore, it is easier to build a virtual complement to a meaningful location rather than building an entire virtual project that must be entirely compelling by itself. However, on the negative side, the fact that the experience is strictly tied to a specific location can be limiting because it can be done only in that place. It is for example the case of *110 Stories*, a person who wants to try it must travel to Manhattan. Nevertheless, many different experiences can be built all over the world in different meaningful locations, giving to everyone the possibility to enjoy at least one of them.

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[29] Vlahakis, V., Ioannidis, M., Karigiannis, J., Tsotros, M., Gounaris, M., Stricker, D., Gleue, T., Daehne, P., and Almeida, L., "Archeoguide: An augmented reality guide for archaeolog sites" in *IEEE Compter Graphics and Applications,* Volume 22,5, October 2002, pp. 52-60, doi 10.1109/MCG.2002.1028726

[30] Krogstie, J., and Haugstvedt, A., "Use of Mobile Augmented Reality for Cultural Heritage", Chapter 16 in 2nd Edition of *Fundamentals of Wearable Computers and Augmented Reality*, Woodrow Barfield (editor), CRC Press, August 2015, pp. 411-429.

The second method described by Azuma (2015)[31] in his essay and employed in AR projects for Cultural Heritage is named "reskinning". In reskinning, "the strategy is to remake reality to suit the purposes of the story you wish to tell. Reality is either something that the creators specifically set up and then augment, or the experience is designed to recharacterize whatever real surroundings exist. "[32] In this case the location does not have to be particularly evocative or meaningful, this means that most of the power of the experience relies on the virtual content and the way in which it adapts and exploits the real world.

The third and last AR storytelling strategy taken into analysis is called "remembering". This method is drawn upon memories and stories that, combined with the real location, can result in an experience that is more powerful and meaningful than the real place, or the virtual content, by itself.

Remembering and reinforcing can look similar, but there are some differences. As a matter of fact, the locations used in reinforcing storytelling are commonly recognized as meaningful, and the power of them is agreed by all the participants. Remembering, instead, could possibly be more personal and individual.

An AR storytelling experience that can be taken as an example for the strategy of remembering is the Tiepolo virtual tour[33] built in Augmented Reality for Ca' Dolfin Hall in Ca' Foscari historical central building. The project was cured by Professor Maria Chiara Piva and it was intended to valorise and make available the richness of the University's historical, cultural and artistic heritage.

For this project, a virtual tour in Augmented Reality has been built to make the public experience an actual time travel. As a matter of fact, thanks to Microsoft HoloLens, namely holographic headsets, ten paintings by Gianbattista Tiepolo that are now held by three different foreign museums have been restored as holograms and superimposed on the mirrors in Ca' Dolfin Hall. In this way, the artworks by Tiepolo have virtually returned home, giving the spectator the beautiful overview of Ca' Dolfin as it was in the '700. Furthermore, through the gesture of the hand perceived by the

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[31] Azuma, R., "Location-Based Mixed and Augmented Reality Storytelling", Chapter 11 in 2nd Edition of *Fundamentals of Wearable Computers and Augmented Reality*, Woodrow Barfield, (editor), CRC Press, August 2015, pp. 259-276. 5
[31] http://www.110stories.com
[32] Ibidem
[33] **https://www.unive.it/pag/fileadmin/user_upload/extra/150/documenti/progetti/Tour_virtuale_Tiepolo.pdf** (2018)

headset, the visitors could pose questions to the artworks to know the details of every painting. To every canvas was associated brief audio descriptions and a set of images to investigate the iconographic details and make easier comparisons between the paintings.

The choice of Augmented Reality was made to keep visually perceivable the real environment of Ca' Dolfin Hall. In this way the elements from the past fit within the place where they were placed, establishing a dialogue with everything that belongs to the present. Furthermore, the peculiarity of the experience proposed by the project, and suggested by the potential of the tool itself, is the possibility of fruition of the content in a free and personalized way.

Another important example of application of Augmented Reality to Cultural Heritage that needs to be cited is the *Svevo Tour*, since it has been the first example of the application of AR techniques to a literary museum, namely the Svevo Museum in Trieste.

This project started from the museum's management to virtually augment the physical exhibit, "to make the collection more accessible to the visitors, and to enhance the attractiveness of the museum and of the literary tourism experience in Trieste".[34] The goal was, in fact, to give wider and richer information to the visitors, enhance the user engagement and widen the categories of users.

To reach this goal, it was chosen to use smartphones and tablets as supporting hardware, a choice that has been made for many recent AR experiences. As a matter of fact, the use of widely diffused mobile platforms such as iOS and Android is a great way to include the users' mobile devices in the AR experience, "lowering the hardware costs and therefore allowing even small museums to design interesting experiences within a limited budget."[35] In particular, the project takes advantage of Wikitude Studio[36], a commercial AR platform that is available for the most common operating systems such as iOS and Android. The starting point to create an AR experience is a set of 2D target images that are augmented through different types of media like images, video, 3D shapes and hypermedia. The AR result can be experienced by the user through the Wikitude app, that uses camera and sensors of mobile devices to give out the augmented visualization on their screens.

The *Svevo Tour* was not intended as a solely indoor AR experience, but it was built as a tour through the Svevo Museum and different urban locations, conceived as a free wandering tour

[34] Fenu, C., and Pittarello, F., "Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum" in *International Journal of Human-Computer Studies*, Volume 114, June 2918, pp. 20-35.
[35] Ibidem, p. 23
[36] https://www.wikitude.com

through the set of augmented locations around the city. For each location it was selected a relevant target image, part of the urban environment or the museum layout, connected to a single aspect of the writer's life. Storytelling was built through a self-contained audio narrative and videos for each target image, the augmentations were automatically played after the target image recognition or activated by an icon of the app navigation bar.

The final evaluation of the *Svevo Tour* project showed that "the combined introduction of AR and storytelling in the visitors' experience, identified by Azuma as one of the directions for the creation of a new media, proved to be successful"[37]. As a matter of fact, the use of AR techniques proved to be capable of transforming the usually contemplative experience of a literary museum to a more interactive and engaging one, facilitating the sensory and emotional engagement of the visitors.

Boboc et al. (2022)[38] write in their article about the *Svevo Tour* and state that "The target group for the learning process consists of adults, in the context of a literature museum. An AR web application augments a literary museum, together with storytelling techniques, in an attempt to immerse visitors into the virtual universe of Svevo's literary work, proving that even senior citizens can benefit from specially designed AR applications."

To conclude, it has been demonstrated by the previous examples and by the various Augmented Reality projects for Cultural Heritage conducted in these years that "AR can improve several tasks in digital heritage, namely visualization of reconstructed artifacts, documentation, and contextual understanding."[39], enhancing the visitor experience and providing a more interactive and involving way of learning, understanding, and remembering.

[37] Fenu, C., and Pittarello, F., "Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum" in *International Journal of Human-Computer Studies*, Volume 114, June 2918, pp. 20-35.
[38] Boboc, R. G., Băutu, E., Gîrbacia, F., Popovici, N., and Popovici, D., "Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications" in *Applied Sciences* 12, no. 19: 9859, 2022, doi https://doi.org/10.3390/app12199859
[39] Ibidem

Chapter 1.3 - Open air museums, outdoor AR in the urban context

The last given example of AR application in Cultural Heritage, namely the *Svevo Tour,* opens to the following discussion about open air museums and, in general, outdoor AR experiences.

AR soon found applications also and above all in mobile outdoor cultural fruition and it became, among the technologies for the communication and fruition of Cultural Heritage, the one that has probably most transformed the idea of fruition into an experience. Thanks to the diffusion and technological level of the most recent mobile communication devices, AR is now within everyone's reach. As a matter of fact, the research conducted by the Joint Information Systems Committee showed that the «[...] augmented reality enables an enriched perspective by superimposing virtual objects on the real world in a way that persuades the viewer that the virtual object is part of the real environment»[40], giving the user a user a more immersive and interactive experience.

The potential of augmented reality in outdoor solutions soon proved to be considerable, as early as 2005, when Doshysha University in Kyoto presented a project of a time machine navigation system, namely a software application for smartphones based on GPS technology, capable of showing, through the webcam on its screen, the transition from the modern reality of an urban place to its virtual historical reconstruction.[41]

Gerardo Maria Cennamo (2021) writes in his essay that "Museum fruition was confined to places of conservation and contemplation until a few years ago, but now exportable to whole urban sites (open-air museums) thanks to the support of virtuality that introduce to immersive learning paths."[42] The open-air museumization experiments succeeded in transforming the visitor experience from an external and contemplative dimension to a participatory one. In this digital system the user is no longer following predefined mental, visual, exploratory, or perceptive paths, but he freely chooses, creating an active interaction with the virtual environment. As Cimatti (2000) states, "the human animal, by interposing a semiotic screen between the mind and the external environment,

[40] Butchart, B., *Augmented Reality for Smartphones,* UKOLN, University of Bath, 2011, p. 2.

[41] Sukigara T., 'The history information disclosure system by a cellular phone', in *Smart Environments and their Applications to Cultural Heritage*, Tokyo, 11 September 2005, pp. 57-60.

[42] Cennamo, G. M., "Advanced Practices of Augmented Reality: the Open Air Museum Systems for the Valorisation and Dissemination of Cultural Heritage" in *REPRESENTATION CHALLENGES Augmented Reality and Artificial Intelligence in Cultural Heritage and Innovative Design Domain*, FrancoAngeli, Roma, 2021.

can [...] guide perception from within, freeing itself from the direct influence of the external environment".[43] This means that the interactions during the experience can be multiple and unpredictable, and they can trigger different behaviours, precisely because they include a participatory role of the user in the process of learning and fruition, that therefore becomes more personal and remarkable. In this way the open-air museum becomes a great opportunity to disseminate and deepen Cultural Heritage that can now be experienced outside of physical building and with new perceptive tools.

As Elisa Bonacini (2014) writes in her article[44], the potential of this technology was soon understood and it has been applied both for culture and tourism, especially in urban areas and archaeological sites, enabling visitors to admire, with their "time machine" in the palm of their hand, the transformations that have taken them from an ancient landscape to a contemporary one, and to obtain any additional information. As a matter of fact, with the new generation of portable computers, it has soon become possible to take advantage of an inexpensive hardware device for applying augmented reality to Cultural Heritage sites, building what are called "open air museums".

The first case study that will be outlined is the *Streetmuseum* project. It is one of the most significant and earliest examples of AR apps in the museum field and it was created by the Museum of London in 2009. *Streetmuseum* is an application for iPhones thanks to which it was possible to walk around the city and admire in AR its urban views as they appeared in paintings, lithographs, and old photos (the period covered ranges from the fire of 1666 to the 1960s). The user is shown a map of London based on Google Maps technology, in which his or her location is georeferenced and a series of points of interest in the city are indicated with tags, of which the application provides historical images. The users can click on a tag to see a historical image of London appear or, once they have gone to the exact location, view the historical image through the iPhone screen. By clicking on the device and choosing the 3D view option, the viewer can admire in exact superimposition the historical photograph to the real environment.

[43]"L'animale umano, grazie al fatto che interpone uno schermo semiotico fra la mente e l'ambiente esterno, può [...] guidare dall'interno la percezione, liberandosi dall'influsso diretto dell'ambiente esterno". – Cimatti, F., *La scimmia che parla. Linguaggio, autocoscienza e libertà nell'animale umano,* Bollati Boringhieri, Torino, 2000.

[44] Bonacini, E., "La realtà aumentata e le *app* culturali in Italia: storie da un matrimonio in mobilità" in IL CAPITALE CULTURALE Studies on the Value of Cultural Heritage, N. 9, 2014, doi http://dx.doi.org/10.13138/2039-2362/740

The second example of mobile AR application developed outdoor in an urban context is called *Remembering the city: Stumbling Stones, Memory Sites and Augmented Reality*, an AR project developed in the context of the Master in Digital Humanities of the Ca' Foscari University of Venice, with a focus on public history.

The project by the German artist Gunter Demnig[45] was built around the stumbling stones that can be found in the city of Venice. "The idea for the Stumbling stones was first conceived in Cologne in 1992, as part of an initiative to commemorate Roma and Sinti victims of the Holocaust. Each stone commemorates a victim outside their last-known freely-chosen residence."[46] It is the first AR application that gives contextual access to these urban artifacts. The choice of using AR technology was made not only because of its great technological potential, but also to make the project more accessible to a younger audience and therefore spread the awareness of these tragical past events.

Remembering the city is a great example of a Digital Humanities project for Cultural Heritage, since it involved many fields and phases from historical research to content creation and design, to the implementation of the AR experience.
As the authors explain in the article *Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality*[47], the project was conceived as a mobile AR application for a user moving in the urban scenario. This entailed the choice of an intuitive, engaging, and informative interface, based on audio narration triggered by the target image recognition.
Aside of audio explanations there is the AR view, that is the most important part of this project, because it activates the augmentation of the urban objects that the camera of the user's smartphone frames. The types of augmentation triggered are different: a historical picture of the person that the stumbling stone recalls, a menu with different functionalities, and coloured markers indicating the other stumbling stones.

These augmentations were achieved using the Wikitude AR platform, that gives the possibility to implement different technical solutions before the final app version, and to test the AR project and the web resources database in a single mobile environment.

[45] https://www.stolpersteine.eu
[46] Pittarello, F., Carrieri, A., Pellegrini, T., and Volo, A., "Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality" In *Proceedings of the 2022 International Conference on Advanced Visual Interfaces (AVI 2022), June 6–10, 2022, Frascati, Rome, Italy.* ACM, New York, NY, USA 9 Pages. **https://doi.org/10.1145/3531073.3531103**

[47] Ibidem

Because of the characteristic of the project, namely the outdoor setting in an urban landscape that is inherently very particular, namely Venice, some technical challenges were faced during the development of the application. These are due to the ever-changing outdoor light conditions and the varying weather, that make it difficult for the technology to always recognise the target image and activate the related augmentations. These are technical issues that happen in many AR outdoor projects, but in this project there are some novel design solutions that can be adopted to overcome these problems.

In the case of the *Remembering the city* project, a complementary access to the information based on GPS localization was designed and implemented. As a matter of fact, if the augmentation fails to activate, the user can still access the information through a widget on the screen, a miniature of the stumbling stone located near to the user position.

Furthermore, because of the narrow streets of Venice, the GPS localization can be imprecise. For this reason, the app displays a carousel of miniatures, corresponding to the nearest stones available in that urban area, so that the user can select the proper one by visually comparing the miniature with the real artifact.

"The idea of viewing history through an urban context is extremely important to keep its memory alive and to make it more deeply felt."[48] AR technologies, in fact, have great potential for improving historical engagement through the urban environment, but they can also be applied to education strategies, facilitating more effective and engaging ways of teaching. In this regard, Boboc et al. (2022) write that "Digital heritage benefits extensively from AR technologies, whose recent widespread adoption makes them a major challenge to the way we understand and study the past."[49]

[48] Pittarello, F., Carrieri, A., Pellegrini, T., and Volo, A., "Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality" In *Proceedings of the 2022 International Conference on Advanced Visual Interfaces (AVI 2022), June 6–10, 2022, Frascati, Rome, Italy.* ACM, New York, NY, USA 9 Pages. **https://doi.org/10.1145/3531073.3531103**

[49] Boboc, R. G., Băutu, E., Gîrbacia, F., Popovici, N., and Popovici, D., "Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications" in *Applied Sciences* 12, no. 19: 9859, 2022, doi https://doi.org/10.3390/app12199859

Chapter 2 Patere in Venice

Chapter 2.1 - San Marco's portal

> "We find ourselves in a paved street, about seven feet wide, full of people and resounding with the cries of the peddlers; [...] Then we pass the Bridge and Campo S. Moisè, and here at the entrance to San Marco's Square, known as the Bocca di Piazza [...] we approach the square and the lazy groups of English and Austrians [...]. We cross these groups without stopping to reach the shadow of the pillars where the Bocca della Piazza ends and then we will forget everything, because between these pillars a great light opens up and in the midst of it, as we slowly advance, we see the grandiose bell tower rise as if from a field of inlaid stones, while on each side the innumerable arches extend symmetrically [...]. And at the end of this row of well-arranged arches a vision rises from the earth, and the whole great square seems to open up in an attitude of respect so that we may better enjoy it."[50]

This is how John Ruskin describes the appearance of the Basilica di San Marco to the visitor's eye, in all its magnificence, in his classical book *The Stones of Venice.*[51]

He further proceeds to give an accurate description of the façade, describing the five big arches beautifully decorated with mosaics in the upper part, and in the lower part enriched with sculptures made of, he says, "alabaster as clear as amber and as delicate as ivory"[52]. These sculptures represent "palm leaves and lilies, bunches of grapes and garnets, birds at rest and fluttering among the branches, all tied together in a web of feathers and sprouts, and in the middle solemn forms of sceptred angels in foot-length robes."[53]

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[50] Ruskin, J., *Le pietre di Venezia* (1851-53), ed. it., Rizzoli, Milano, 1987, p. 74

[51] Ibidem

[52] Ibidem

[53] Ibidem.

It is particularly on this, namely the decorations on San Marco's portal, that Professor Gloria Vallese focused her research that led to the exhibition *Stelle e Viaggi*[54]*, a 13th century astronomical cycle of the main portal of St. Mark's Basilica in Venice*, also explained on the website.[55]

The bas-reliefs on the lesser arch of the main portal of San Marco have always been under the eye of everyone, and have always been interpreted as decorative and ornamental, or having the allegorical meaning of a fight between Good and Evil[56]; but there's reason to believe that this collection of figures actually represents an astronomical cycle. Professor Vallese in her articles *Le stelle e i viaggi*[57] firstly advanced, some ten years ago, the innovative hypothesis of an astronomical reading of these decorations. This is also the core point of the project *Discovering Patere* exposed in this dissertation, of which I am going to discuss in detail in the next chapter.

But what is a portal? From a symbolical point of view, as Vallese writes, it is "The element by which a church communicates with the outside world."[58], and in fact the San Marco's one was conceived to appeal and amaze the visitors from all around the world, making them look up and making them feel a sense of familiarity and inclusion. To achieve this, the artist and his collaborators chose to use a universal language, namely that of the celestial navigation.

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[54] Vallese Gloria (ed.) *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia/Stars and Travels. A 13th century astronomical cycle on the main portal of St. Mark's Basilica in Venice* (Exhibition cat., Accademia di Belle Arti di Venezia, Magazzino del Sale 3, 2016), Crocetta del Montello, Edizioni Antiga, 2017.

[55] www.stelleeviaggi.org

[56] Otto Demus, ed., Lorenzo Lazzarini, Mario Piana, Guido Tigler, *Le sculture esterne di San Marco*, Milano, Electa, 1995; Tigler Guido, *Il portale maggiore di San Marco a Venezia/Aspetti iconografici e stilistici dei rilievi duecenteschi*, Venezia, Istituto Veneto di Scienze, Lettere ed Arti, 1995

[57] Vallese, G., "Le stelle e i viaggi, Un ciclo astronomico nel portale centrale della Basilica di San Marco a Venezia (prima parte)" in *Annuario Accademia di Belle Arti di Venezia,* a cura di Alberto Giorgio Cassani, Venezia, 2014. Vallese, G., "Le stelle e i viaggi, Un ciclo astronomico nel portale centrale della Basilica di San Marco a Venezia (seconda parte)" in *Annuario Accademia di Belle Arti di Venezia,* a cura di Alberto Giorgio Cassani, Venezia, 2015.

[58] Vallese Gloria (ed.) *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia/Stars and Travels. A 13th century astronomical cycle on the main portal of St. Mark's Basilica in Venice* (Exhibition cat., Accademia di Belle Arti di Venezia, Magazzino del Sale 3, 2016), Crocetta del Montello, Edizioni Antiga, 2017, p. 56.

The main portal of San Marco is the middle of five portals of the main facade of the Basilica. It was built between the 13th and 14th century, and "marks the development from an early Romanic to a fully developed Gothic sculptural language."[59] The portal is made of three concentric arches decorated with bas-reliefs in marble that once were polychromed[60]; which enhanced not only their splendour, but also the readability of the figures and of their tiny details from below (Fig. 1).

Fig. 1 Venice, San Marco. Detail of the main portal, lower arch.

Among these arches, the lesser one, built and decorated around the 1240/60, has been for long less known and debated, also because the difficulties in identifying for it a unifying iconographic theme.

[59] Vallese Gloria (ed.) *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia/Stars and Travels. A 13th century astronomical cycle on the main portal of St. Mark's Basilica in Venice* (Exhibition cat., Accademia di Belle Arti di Venezia, Magazzino del Sale 3, 2016), Crocetta del Montello, Edizioni Antiga, 2017, p. 56.

[60] Lazzarini Lorenzo, 'Nuovi studi tecnico-scientifici sui rilievi degli arconi della basilica marciana', in Otto Demus, ed., Lorenzo Lazzarini, Mario Piana, Guido Tigler, *Le sculture esterne di San Marco*, Milano, Electa, 1995

As Ruskin wrote, it represents a sequence of fighting animals, hunters, and hybrid monsters among vegetal volutes. The latter seems to originate from the hands of two human figures, one female and one male, who are riding a double-headed snake at the basis of the subarch (Fig. 2).
This couple has for long been interpreted in a Christian iconographic key, people saw in them the Church and the sin, or the Devil and the Lust; so that the other representation of hybrid animals, monsters, and battles, developed in the arch itself, would represent the fight between good and bad, virtues and vices. [61]

Fig. 2 Main portal, right side, subarch. Female figure on a double-headed snake.

[61] Tigler Guido, *Il portale maggiore di San Marco a Venezia/Aspetti iconografici e stilistici dei rilievi duecenteschi*, Venezia, Istituto Veneto di Scienze, Lettere ed Arti, 1995, pp 61-116

The articles by Professor Vallese propose a radically different interpretation, that will also be the basis for the project *Discovering Patere,* that identifies in the lower arch a series of astronomical references. In this view, the fighting animals and hybrids are to be read as constellations or single stars, disposed as to create a double annual calendar cycle, solar and lunar.

According to Vallese, many of these representations do not follow the Greek-Latin tradition, but are depicted according to oriental (Arab-folkloric, i.e. Bedouin, Persian, and even Indian traditions) iconographies. These became to be more and more present in the so called "marginal" sculpture in the religious and civil buildings of Venice because, after the first millennium A.D., the relationships between Europe and Near and Far East tightened, so that the images of the Eastern and Western traditions came into closer contact.

As Vallese remarks, "the lower arch of San Marco's main portal, a work full of symbols of this kind, has become over time entirely obscure. But in origin it was no meant to be so. On the contrary, the Venetians who conceived this representation must have been deeply familiar with the characters, objects and animals, that allowed to identify the groups of stars and their movement in the heavens."[62]

As a matter of fact, back in the day, the stars were the main instrument to for navigation, both by land and by sea, and not only for the long-distance journeys of the great venetian merchant-explorers of this age, but also for the short displacements of everyday life. A basic knowledge of the starry sky seems to have been more widespread among the general population than nowadays, being useful not only for navigation, but also for agricultural purposes, for fishing and hunting.

Given the enormous distance, the starry sky looks almost the same from every part of the world; the main constellations, though the legends attached to them may differ slightly, are familiar in every part of the earth. This is why the Venetian choose the celestial navigation as reference, when conceiving the decoration of their Basilica, the main church of the town.

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[62] Vallese Gloria (ed.) *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia/Stars and Travels. A 13th century astronomical cycle on the main portal of St. Mark's Basilica in Venice* (Exhibition cat., Accademia di Belle Arti di Venezia, Magazzino del Sale 3, 2016), Crocetta del Montello, Edizioni Antiga, 2017

A Biblical reference to Psalm 18, 1, which praises the wonder of the ‘language without words’ of the starry sky, and of the race of the sun across it, as a manifestation of the wisdom, benevolence, and greatness of God, makes this astronomical representation relate to the Christian content of the main representation of the portal, the mosaic in the lunette above[63]. The present one is not original, having been redone in the XVIII century, but in origin it likely represented the Christ Pantocrator, or his Second Coming in glory, between angels, as Judge of the world.

I am now going to expose more in detail some of the symbols, possibly connected to an astronomical meaning, that can be seen in the portal. This will be fundamental also for the interpretation and understanding of the patere and the concept of *Discovering Patere,* that will be further outlined, as the iconographical repertory is mainly the same.

The first couple of animals that will be described can be defined in Italian, from the name of the corresponding winds, “Aquiloni”. They can be seen in the upper central section of the subarch, and they represent two symmetrical eagles, facing each other, but in slightly different posture. The one on the left is flying away with a hare in its claws, while the one on the right is swooping down on its prey (Fig. 3).

The two eagles can be associated, as Vallese points out, to two classical names: 'Vultur Volans' and 'Vultur Cadens', given respectively to Altair and Vega, two of the brightest stars in the night sky in the northern hemisphere. They are part of the so called 'Summer triangle', an asterism very important for travellers, as by it they could get their bearings and tell, roughly, the hour of the night. Altair and Vega, two names still in use in present-day astronomy, are of Arab derivation, and they mean, respectively “the Rising Eagle”, and “the Plunging Eagle”, with reference to two different

[63] Vallese, G., “Le stelle e i viaggi, Un ciclo astronomico nel portale centrale della Basilica di San Marco a Venezia (prima parte)” in *Annuario Accademia di Belle Arti di Venezia,* a cura di Alberto Giorgio Cassani, Venezia, 2014.

attitudes of the bird when catching a prey. Altair lifts its head and spreads its wings, Vega has closed wings and lowered head.[64]

Fig. 3 Main portal, subarch, in the middle on top: the two Eagles ("Aquiloni"), left side rising Eagle (Altair/Aquila), right side swooping Eagle (Vega/*Lyra*).

Vultur Volans and Vultur Cadens are among the most common subjects in the Venetian patere (see below, Chapter 2.2.)

Going down from the Aquiloni, the visitor who enters San Marco can find on the left *Vulpecula,* the representation of a hyena or jackal that, instead of being the predator, looks like it's the prey of a rooster above it (Fig. 4).
Vulpecula is a constellation located in the northern side of the heaven, in proximity of the Eagle-Altair. This constellation can be traced back in time to the Egyptian map of the northern celestial vault known as the "Dendera Zodiac" (II century B.C.). (Fig. 5)

[64] On the Two Eagles, see also: Ridpath, I., 'Aquila', in *Star Tales: Revised and Expanded Edition*, Cambridge, James Clarke & Co Ltd, 1989 http://www.ianridpath.com/startales/ aquila.html [accessed 3 november 2022]

Ridpath, I., 'Lyra', in *Star Tales: Revised and Expanded Edition*, Cambridge, James Clarke & Co Ltd, 1989, http://www.ianridpath.com/startales/lyra.html [accessed 3 november 2022]

Ridpath, I., 'Vega and Altair, the flying eagles', in *Star Tales: Revised and Expanded Edition*, Cambridge, James Clarke & Co Ltd, 1989, http://www.ianridpath.com/startales/vega-altair.html [accessed 3 november 2022]

Fig. 4 Main portal, left side, subarch: Fox and Rooster

Fig. 5 Celestial North Pole: Egyptian relief of the II century B.C. (“Dendera Zodiac”), Paris, Louvre.

The figure corresponding to the *Vulpecula* on the opposite side of the subarch, namely on the right of the two eagles facing the building, represents a wolf that grabs a sheep at the throat (Fig. 6). It is a singular representation because the two animals are disposed back-to-back, a configuration that again has its analog in the Dendera Zodiac. These two were identified as the couple of stars that are the “back” of the Ursa Major, two stars very important for the celestial navigation.

Fig. 6 Main portal, right side, subarch: couple of animals back-to-back among the constellations, Wolf and Lamb.

In the left half of the subarch we can see two dromedaries that look like they're crossing their paths, they are characteristic because they are a clear recall of the East (Fig. 7). As a matter of fact, in the Islamic Bedouin myths of the stars, the camel going and then coming back represents Aldebaran and a group of lesser stars that form what for the Western tradition is the constellation Taurus. For the Greek-Latins, the little white stars near Aldebaran were the Hyades, a group of sisters crying for the loss of Hyas, their brother; this because their rising and setting, in spring and autumn, characteristic of introducing a season of the downpours.[65]

In a city of sailors like Venice, information about winds and weather were very important, therefore the entire cycle of the San Marco's portal is full of them.

[65] Allen, R. H., 'Taurus-Hyades' in *Star Names. Their Lore and Meaning*, New York, Dover publications, (prima ed.: NewYork - Leipzig - London - Paris, G.E. Stechert,1899, p. 59. Online at: Bill Thayer (ed.), (https://penelope.uchicago.edu/Thayer/E/Gazetteer/Topics/astronomy/ _Texts/secondary/ALLSTA/Taurus*.html).

Fig. 7 Main portal, left side, subarch: two Dromedaries

On the opposite side of the portal, correspondent to the dromedaries, there is another couple of animals, namely the two cranes or storks that intertwine their necks, as these animals do when performing their wedding dance (Fig. 8). *Grus* the Crane is part of a group of constellations, the so-called *Southern Birds,* mostly aviform (hence the name), located in the Southern skies, around and below the tropic of Capricorn. Some of them were barely or not at all visible in the European skies, especially in the Northern countries; yet the travellers and sailors of Venice knew well these constellations, and they used them for their long-distance travels by sea across the Indian Ocean, or, by land, across Asia. The two Cranes intertwining their necks in their wedding dance are also a very common subject in the patere iconography.

Fig. 8 Main portal, right side, subarch: two Trampoliers with entwined necks.

Going back to the opposite side (on the left of the portal for the visitor who enters the Basilica), below the Dromedaries appears the figure of a Deer, bitten at the shoulder by a Lion, who seems to turn on himself with a fierce leap. This is a possible representation of the rebirth of the Sun after the Winter Solstice. As a matter of fact, the Deer is one of the many representations of the winter demon that holds the sun captive.

On the other side we see a scene of opposite meaning, namely, the Sun/ Lion overturned and lying on its back in a moment of extreme weakness, defeated by a little boy, who sits on him and smashes his jaw (Fig. 9). The latter can be identified as the star Sirius, the brightest of the night sky, which culminates at midnight at the time of the Winter Solstice, when the Sun is at its lowest; for the Egyptians, this event marked the beginning of the good season of wellness and fertility.

Fig. 9 Main portal, right side, subarch: Lion defeated by Sirius.

We have now arrived at the base of the subarch, where we find the already mentioned two figures, one female and one male, riding a double-headed snake (Fig. 10 and 11). The snake is characterised by two heads that are unequal, one bigger than the other, which is typical of the iconography of the lunar dragon. Leaves and branches appear to sprout from the hands of the man, as well as from the hands of his female counterpart on the other opposite side of the portal. These two figures represent the two extremes of the annual cycle of the sun. The couple of animals described before, and located along the branch in the rhythmical curves of the vegetal volutes, are the “doors of the Sun”, i.e. the constellation in correspondence of which the Sun sets, month after month, along its annual path; they are relevant for us, because the same iconographies are to be found in the patere, to represent different points at the horizon.

Fig. 10 Main portal, left side, subarch: man sitting on a snake or dreagon with one large and one lesser head.

Fig. 11 Main portal, right side, woman sitting on a snake or dreagon with one large and one lesser head.

At the base of the extrados there is another couple of figures, the female on the left is riding a lion and she's moving away with an upside-down omega in her hands; the male on the right, instead, is moving away on a bovine, holding the reverse symbol, an omega (fig. 12 and 13). From these figures another vegetal raceme develops, rising along the external arch, and again hosting in its volutes stars and constellations. This part represents the monthly "houses" in the annual cycle of the Moon.

Fig. 12 Main portal, left side, subarch: female figure riding a lion.

Fig. 13 Main portal, right side, subarch: male figure riding a bull.

Chapter 2.2 – What is a patera?

The previous chapter and the astronomical explanation of the elements of the lower arch in the San Marco's portal was fundamental to introduce the patere, focus of the project *Discovering Patere.* As a matter of fact, many representations of animals that appear in the portal of San Marco can be found also in the patere on the buildings and about the city of Venice.

It is now necessary to clarify what is a patera, its meaning and its role in the Venice of the 13th and 14th century.

The term *patera* is commonly used in Venice and has a diffusion in the neighbouring territories like Veneto, Friuli and Istria. As Alberto Rizzi writes in the book *Scultura esterna a Venezia*[66], the term is not employed in the sense given to it in classical archaeology, where the patera (πατέρα) is the round vessel, low and wide, used for the sacrificial libations. It instead indicates the Veneto-Byzantines circular bas-reliefs on the facades of the most antique Venetian palaces and also in church architectures, like the Basilica di San Marco (Fig. 14).
Mostly, they date from the end of 12th century to the 13th century and fell into disuse at the end of '400. Many imitations were later produced in the 19th and 20th century. As Ruskin writes: "The number of these sculptures [...] is truly enormous, but although they are scattered all over Venice, it is rare to find them in their original location. When Byzantine palaces were destroyed, sculptures were preserved and inserted into the walls of new buildings with a more or less careful eye for symmetry."[67]
According to Rizzi and Swiekowsky, for the Venetians it was a common usage to remove and re-employ patere when buildings were renovated or modified (which gave these material the name of *sculture erratiche,* "erratical sculptures "); but the more drastic displacements occurred more near our age, from mid-19th to mid 20th century, when the eclectic architecture came into fashion. To decorate new buildings in "Veneto-byzantine" or "Moresque style", the imitations flowered, and so did the relocation and free redistribution of these old materials, under merely decorative criteria; as the idea of they having a possible astronomical meaning was entirely lost.
So, a number of original dispositions (which also, as we are going to see further, had a geolocal meaning), were disregarded or destroyed; and this need to be kept into account when studying them.

[66] Rizzi, A., *Scultura esterna a Venezia. Corpus delle sculture erratiche all'aperto di Venezia e della sua laguna*, Venezia, Stamperia di Venezia editrice, s.d. [ma 1987].
[67] Ruskin, J., *Le pietre di Venezia* (1851-53), ed. it., Rizzoli, Milano, 1987, p. 132.

Patere, especially the ones at the corners of the streets and water routes, were merely utilitarian, and so their quality and style may vary from very rough to very elegant; and this is also why it's not easy to give a precise dating to each patera, the chronological assumptions are based on material and style. Regarding the material, Brendan Cassidy in *The Burlington Magazine* writes that "The medieval roundels are carved from the greyish Macedonian marble which was the preferred material for this kind of sculpture. The marble probably reached Venice from Greece as ballast in the holds of merchant ships."[68], citing Swiechowski and Rizzi, *Romanische Reliefs von venezianischen Fassaden: "patere e formelle"*[69]*,* that is the most complete study on the patere that we have.

Furthermore, "In origin, all the reliefs, both on St Mark's archivolts and on the patere and formelle, were polychrome, with figures often partly gilded on a dark background, so that they were better readable in distance than nowadays."[70]

Fig. 14 An example of patera: Grus with *Piscis Austrinus* on the side of the porch of Chiesa dei Carmini.

[68] Cassidy, B., 'Some Venetian Romanesque Reliefs in Nottingham', in *The Burlington Magazine,* Vol. 128, No. 1005 (Dec., 1986), pp. 889-891, Stable URL: https://www.jstor.org/stable/882852

[69] Rizzi, A., and Swiechowski, Z., *Romanische Reliefs von venezianischen Fassaden: "patere e formelle",* Wiesbaden, Steiner, 1982.

[70] Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference*,* September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

The recurring subjects of these artifacts are "groups of birds or animals, now depicted facing each other, separated by an arborean trunk or a column, now in the act of tearing or devouring each other."[71] The attempts to interpret this iconography in the past had not been entirely satisfactory; as a matter of fact, there are barely any sources that can assist the iconographic interpretation of the patere and up to now they have been considered merely decorative or with a conventional allegorical meaning, often deemed to be the fight between virtues and vices. In this regard, Cassidy states that "The theme of fighting animals was a favourite subject in Byzantine art from the seventh century onwards, and it was from Byzantium that the imagery of the patere reached Venice, probably in the eleventh century. Like eastern scenes of animal conflict, the function of the patera on the Venetian palace would seem to have been apotropaic."[72] As Rizzi[73] writes, venetian patere are considered one of the richest sculptural bestiaries *en plein air* from the medieval age.

And here is where the lower arch of San Marco's portal comes in our help. In fact, its articulated content can offer contextual clarification and an important contribution to the interpretation of the patere.
As already said, the project of 2016 *Stelle e Viaggi*[74] gave a different interpretation, an astronomical one, to these artifacts that share the same symbols of the bas-reliefs in San Marco's portal.
More recently, Professor Vallese shares her opinion in the article *Venetian Patere and Formelle: Towards an Astronomical Reading (part 1),* where she states that these devices were possibly meant to "help the by-goers to get their bearings; their elusive imagery likely represent stars and constellations, denominated not according to the classic Greek-Latin tradition, but according to the folkloric star lore found in the Near East, or even farther, along the caravan routes which extended to Asia." [75] In this way, since the subject of patere were widespread in a vast area, from the Mediterranean to Asia, they were accessible to a wide and multicultural audience.

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[71] Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference, September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

[72] Cassidy, B., 'Some Venetian Romanesque Reliefs in Nottingham', in *The Burlington Magazine,* Vol. 128, No. 1005 (Dec., 1986), pp. 889-891, Stable URL: https://www.jstor.org/stable/882852

[73] Rizzi, A., *Scultura esterna a Venezia. Corpus delle sculture erratiche all'aperto di Venezia e della sua laguna*, Venezia, Stamperia di Venezia editrice, s.d. [ma 1987].

[74] Vallese, G., *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia*, Antiga Edizioni, 2017, p. 26-27.

[75] Vallese, G., "Venetian patere and formelle: towards an astronomical reading (part 1)", in *La camera dello scirocco,* Anno V – Ottobre 2021, pp. 7.

As a matter of fact, the patere are rarely isolated, but in most cases are in combination of two or more; so that their symbols, but also their disposition on the façade of the building could tell the travellers which cardinal point they were facing.
Furthermore, since they are placed also on the facades of private buildings, they could indicate, by means of the different iconographies that were employed, possible routes and geographical areas explored by the families. It is important to note that these artifacts and their representations talks to an audience far more accustomed than today to read the night sky and use the cardinal points, stars, and constellations for orientation. To give a hint of how passers-by used the animals represented in the patere to understand what point of the Rose of the Winds they were facing and therefore decide the route to undertake, I am now going to quote the words of Professor Gloria Vallese in her article *Venetian Patere and Formelle: Towards an Astronomical Reading (part 2):*

> Stars and constellations are represented as they reach some point of reference (rising, declining, or culminating), by mean of visual conventions. For exemple, two symmetrical figures of eagles or two lions back to back mean that the corresponding constellation is at its lower culmination, which happens, invariably, at the cardinal point North, at midnight. If, instead, the two eagles, or lions, appear face to face, disposed symmetrically, in the middle of the composition, this means "upper culmination": a celestial event which happens South, at midday for the Sun, at midnight for every other celestial body. At times, a star at its culmination is represented not by a symmetrical, converging couple, but by a single figure, frontal, with a particular accent on an idea of triumph, happiness, according to the animal species; a Peacock, for example, displays its tail in a fan.[76]

[76] Vallese, G., "Venetian patere and formelle: towards an astronomical reading (part 2)", in *La camera dello scirocco,* Anno VI – Febbraio 2022, pp. 7.

Chapter 2.3 – Venice's patere and their astronomical interpretation

For the purpose of this dissertation, I am now going to talk about the patere involved in the project *Discovering Patere* and their iconography, that has already been discussed in the previous chapter about San Marco's portal. As a matter of fact, the representations and iconography that can be found in the lower arch of the portal occur also in the patere, that therefore acquire a geolocal meaning.
As Vallese writes:

> At the corners of the streets (and also, even more often, of the waterways), patere and formelle seem to have had a mainly utilitarian function, not unlike that of the road signs in today's cities; but on the houses of the great merchant-explorers of the 13th century (such as the Polo, or the Da Mosto), patere and formelle form groups and alignments which tell the orientation of the façade with the surprising approximation of a few degrees, showcasing the astronomical and geographical knowledge of each family.[77]

To better understand the patere, their astronomical interpretation and how they could work to indicate geographical directions, it is important to bear some fundamental basic astronomical concepts in mind.
First, our working hypothesis is that the animals represented in the patere stand, in general, for the correspondent constellation, e.g. a crane stands for *Grus*, a hare for *Lepus*, and so on. A remarkable exception is the figure of the Lion, which, as in San Marco's lesser archivolt, doesn't represent the *Leo* constellation, but the Sun.

In the ancient times, travellers identified some spots at the horizon as the "houses of the stars": every star has a "house", and therefore a place along the horizon, where it rises and sets, and which never changes (except for the very slow shift along the millennia, caused by the precession). (Fig. 15)

All the celestial animals have their own "house", that is visited by the Sun during its annual (apparent) travel back and forth on the horizon; therefore, a combination of the Sun/Lion and

[77] Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference, September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

various animals in different attitudes as his prey can indicates several points on the Rose of the Winds.

But the Lion is not the only predator that can be found on the patere, as his travel along the horizon is not enough to indicate all the points on the Rose of the Winds; therefore, we find other predators, such as the Griffin (the constellation *Pegasus*) and the two Eagles, also in combination with various other celestial animals as their prey. This allows to designate the complete circle of the horizon.

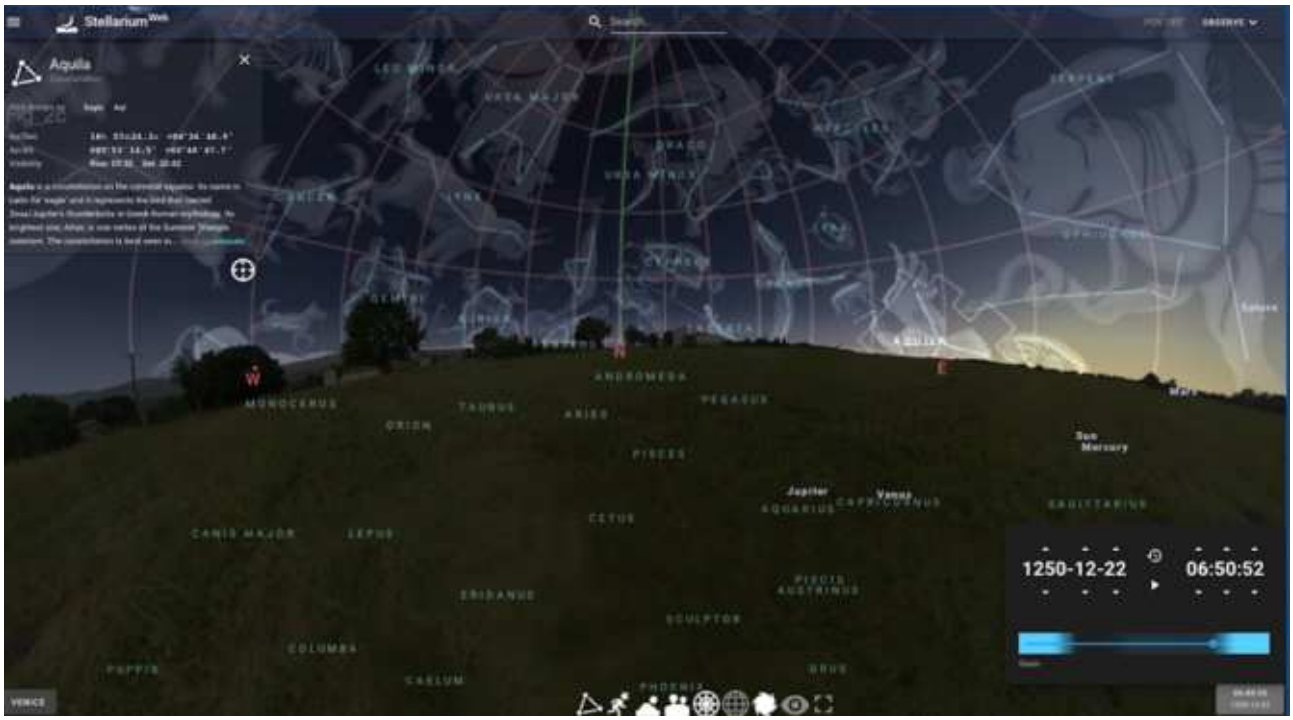

Fig. 15 *Stellarium*[78] map showing Venice, at dawn of the Winter Solstice, looking North.

As it has already been pointed out, the two Eagles (depending on their posture) represent two different constellations: Vega/*Lyra* and Altair/*Aquila* (Fig. 3). Furthermore, the Two Eagles can attack the constellation-prey at the head or at the rump, depending on if it is rising or declining.

In the patere vocabulary, there are some standardized positions that the animals take to indicate the state of the constellation. An ascending constellation is represented by the animal in profile, walking with a front paw raised (Fig. 16). When it's at its upper culmination, its figure is doubled and in symmetrical position, face-to-face (Fig. 17); or, it can be represented as a single animal, in frontal posture (Fig. 18). If, instead, the constellation is at its lower culmination we have the same set of animals (doubled and symmetrical) but back-to-back, with their heads turned backwards (Fig. 19). When in decline, the constellation is represented as an animal walking, with a front paw raised,

[78] https://stellarium.org/it/

like when ascending; but, this time, with its head turned back and biting its own rump in frustration and dismay (Fig. 20). [79]

As Vallese writes, in the patere "the postures are chosen from the collocation of the celestial objects in particular moments of the year (the equinoxes and solstices), at some key moments of the day: midday, twilight, midnight, and dawn. So, for example, the Eagle with the closed wings (i.e. Vega/*Lyra*), 'pivots' (i.e. culminates) at midnight/north at the time of the winter solstice; the Crane (i.e. Al Dhanab/*Grus*), 'pivots' at South at dawn, at the time of the Summer Solstice."[80]

Fig. 16 Ascending posture: Lion

Fig. 17 Upper culmination: Trampoliers

Fig. 18 Upper culmination: Peacock

Fig. 19 Lower culmination: Eagles

[79] Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference, September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

[80] *Ibidem*

Fig. 20 Declining constellation: Dog

Patere can be found in groups and alignments on the facades of private houses, and in this case, they work like puzzles about the Rose of the Winds: to a common passer-by, they indicate the approximate direction that he is facing when facing the house, but to an expert navigator they can tell the precise orientation of the façade with the approximation of one or two degrees. This level of precision was not important to move about in town, but it was fundamental to navigate by sea as well as in the sand deserts, and it showcased the navigational skills of the family that put that patere on the façade of their house.
There was also a hint to the far lands that the family had visited, or had interests in, by means of the iconography: if, for exemple, a constellation was denoted according to a Near-Eastern iconography, that meant that the family owning the house had travelled that far (provided that the onlooker, in turn, was able to note the reference).

To understand how these alignments and groups work, we must imagine the house bearing the alignment superimposed to a gigantic Rose of the Winds, ideally extending to the horizon. The patere correspond to the points of the Rose are ideally projected on the façade, generating the alignment; so that we can understand how the façade is oriented according to the order of the points (Fig. 21).[81]

[81] Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference, September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

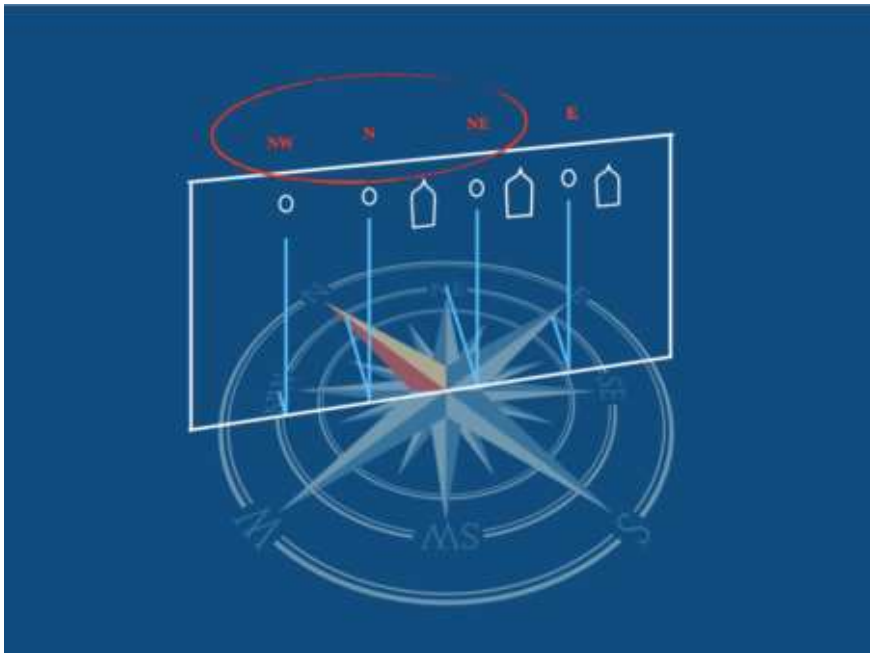

Fig. 21 Scheme showing how an alignment works with respect to the Rose of the Winds.
From: Vallese, 2022 (see above, note 78), Fig. 5. Courtesy of the Author.

Before proceeding with some concrete examples of patere in Venice and their use, it is useful at this point, since some basic notion has been given, to anticipate the idea that lays behind the project *Discovering Patere,* outlined in this dissertation. In fact, one of the main goals of our project is to divulge, with the help of the Augmented Reality technology, the lost functionality of the patere as road signs of the ancient Venice, international town of travellers. In this way, not only we suggest the user a new and interactive way to explore the city, but also, we guide our visitor into the less frequented corners of the town to rediscover this lost and most appealing world of symbols.

It is important to note a distinction in the collocation of the patere on the walls of Venice. As it will be seen in the next examples, the patere can be found both in groups on the facades of the buildings along the streets or at the cantonments, but also in alignments on the facades of the mercantile houses. In the former case, the patere have the use of the road signs today, namely, as it has already been pointed out before, to help the traveller get its bearings in the city. In the case of the alignments on the mercantile houses, instead, they were not only there to give orientation information, but they also showcased the navigational culture of the family that lived there. This is the case, for example, of Corte Seconda del Milion and Ca' Boldù.

Ca' Boldù

Ca' Boldù is a 16th century building in front of Chiesa di San Felice, on Strada Nova, in the sestiere of Cannaregio. It was constructed for the Boldù family, counted among the 'New Houses' of the Venetian Republic, it passed into the hands of the Ghisi family towards the end of the 17th century, who rebuilt it. It was later acquired by the Contarini family, owners of the adjacent Palazzo Contarini Pisani.

The patere are located on the Gothic street gate of the courtyard, facing the Strada Nova, which is the access by land to the house (Fig. 22). This portal, and therefore also the patere that are embedded in it, appears to be more ancient than the present-day building of Ca' Boldù, and therefore also the patere that are embedded in it. They are three disposed around the middle axis of the door, and they represent: the one on the left, a centaur (the constellation *Sagittarius*); the one on the right, again *Sagittarius* (in a different attitude, see below); and the one at the top in the middle, our by now familiar Eagle falling on a Hare and biting its head.

Fig. 22

The patera on our left (with the Centaur/*Sagittarius* riding towards right and holding a crown in its hands), represents the point on the horizon, a bit shifted to the South of East, where the Sun rises on the morning of the 21st of December (Fig. 23), in the "house" where also the constellation *Sagittarius* rises.

Conversely, the patera on the right denotes the point a little South of West, where the *Sagittarius* constellation sets on the same evening, on the day of the Winter Solstice (Fig. 24).
The third patera, the one on the top, represents the Eagle with the wings closed and the head down that is Vega/*Lyra*, or *Vultur Cadens* (as already seen for San Marco's portal) (Fig. 25).
Vega is located among the Northern constellations, and when represented alone it appears, in the patere context, to designate the geographical North. When catching a prey, however, Vega/*Vultur cadens* designates the point in which the prey is located. In this particular patera, the Eagle from its position in the North-East is biting the constellation *Lepus,* the Hare, which is located in the South-Western sky, therefore it designates "South-West", that is in fact the point I am facing when looking at Ca' Boldù's street door.

Fig. 23 Sagittarius holding a crown (left)

Fig. 24 Sagittarius playing the flute (right)

Fig. 25 Vega/Lyra biting a Hare (top)

Since I see this point of the Rose of the Winds exactly in the middle between South-South East (the Sagittarius with the crown or garland in his hand, on my left), and South-South West (the Sagittarius on my right, turned back, and playing a flute), then I, the traveller, am told with this that facing the gate I am not facing due South, but a point slightly shifted, namely, South-West; which is actually the case, if we check it with a compass.

Calle del Vento

The next group of patere taken into analysis can be found in the sestiere of Dorsoduro, at the end of Fondamenta delle Zattere, coming from Ponte dell'Accademia, at the corner with Calle del Vento. There is a building facing the lagoon and, on the façade, above the street name plate, there are two patere: the upper one, also the bigger, represents a frontal Eagle, standing on two Hares back-to-back; the second one, instead, is portrayed in profile biting the prey on the head, as the one in Ca' Boldù, and therefore represents Vega, but in a different location along the horizon (see below). At the middle height between them there is a formella, namely a bas-relief similar to the patera, but in a rectangular shape (Fig. 26).

Fig. 26

The frontal Eagle standing on the two Hares back-to-back represents the axis South-North (Fig. 27), which is confirmed by the formella below. There, the two Lions facing at the bottom and the two Eagles facing each other at the top means that they are at their midday position with respect to the axis of the word, and they tell us that we are facing the direction North-South (Fig. 28).
The last patera, instead, is Vega biting the Hare, the same iconography of the one in Ca' Boldù, and therefore stands for SouthWest-NorthWest direction (Fig. 29).

Fig. 27 Frontal Eagle

Fig. 28 Formella: Lions

Fig. 29 Vega biting a Hare

If I were facing due North, I could not see this latter point aligned on the same vertical with the two previous ones; his disposition indicates, as seen in Ca' Boldù, that my point of view (and the facade I am facing), is slightly rotated with respect to the main axis: facing this wall, I am not facing due North, but North-NorthEast.
This can be verified by looking at the map and the compass.

Fondamenta dei Cereri

Not far from Calle del Vento, at the border between sestiere of Dorsoduro and sestiere di Santa Croce, there is a group of interesting patere that are disposed on different houses at the corner of Fondamenta dei Cereri with Fondamenta de la Cazziola.
Facing the houses in Fondamenta dei Cereri, from left to right, the observer can see: the first two patere, identical, representing two Eagles back-to-back, with the head turned back, their beaks touching and their tails entwining (Fig. 30); then, in the upper part of the next building, a Lion biting the wing of a downed Eagle (Fig. 31); and lastly a formella with a winged Lion with a book, namely the symbol of San Marco (Fig. 32).

Fig. 30 Eagles

Fig. 31 Lion biting an Eagle

Fig. 32 Lion of St. Mark

The figure of the first two patere, namely two birds with lowered wings, touching each other with their beaks and entwining their tails, mean that the star Vega is at its lower culmination, therefore at midnight, North. This patera is therefore telling the passer-by that he's facing North.
Since the second patera has the same iconography of the first one, it is also telling us that after several paces, we're still with North on the same side, and that therefore we are walking along the East-West direction.
The third patera depicting a Lion biting the Eagle is the graphic rendering of the constellation Aquila/*Altair* showing only one wing above the horizon, with the light of the Sun, namely the Lion, "biting" it. This constellation in this disposition can be seen at North-East, at dawn, on the Winter Solstice. This patera therefore means North-East.

The nearby formella with the Lion of San Marco, it has no geolocal meaning; it can be devotional, or, more likely, a jurisdictional symbol, of the kind that we find elsewhere Venice to signal the boundaries between monasteries, confraternities, and such.

Reaching the end of Fondamenta dei Cereri and turning left on Fondamenta de la Cazziola, the passer-by can find another set composed by a patera and a formella up high on the wall. The fact that they can't be seen well from the street, but better from the canal, suggests that they were possibly meant mainly for the water navigation.

The formella shows two ranges of figures: below, a couple of Lions face-to-face, mid-height, a couple of Eagles (closed wings, therefore Vega), as well face-to-face (Fig. 33). They appear at the sides of the trunk and among the branches of the celestial tree, the latter being an intuitive visual device alluding to the axis of the world. The Lions sitting at the basis of the trunk mean that the Sun is at its lower culmination. However, the fact that the Lions are not perfectly symmetrical, but one is more shifted on the left, means that we are seeing the celestial axis from the side, therefore from West to East (or viceversa). Moreover, since the Lion on our right is nearer to the trunk, that side is where the Sun makes its shorter tour around the trunk itself, that is, midnight on Summer Solstice; therefore, Midday-South is on our left. The constellation of Vega at mid-height along the celestial axis, as it is represented in the formella, can be seen on the Summer Solstice either at dawn, facing West, or at twilight, facing East. The next patera is there to clarify if whether the observer is facing West or East. As a matter of fact, it represents again the two Eagles back-to-back, so it's saying that the North is that way (on our right facing the wall), and therefore we're facing West (Fig. 34).

Fig. 33 Formella Fig. 34 Eagles

Continuing across Fondamenta de la Cazziola, the passer-by reaches two crossroads. Turning left at the first one, in Fondamenta Procuratie, he finds another beautiful patera right on the door of the building, almost at eye level. It is the representation of a frontal Peacock displaying its tail in a fan and it means the culmination of a star, in this case one of the two *Gemini*, *Pollux* (Fig. 35). As a matter of fact, for the Venetians, as for Bedouin Arabs, the *Gemini* constellation was often represented not by two human beings, as in the classical tradition, but by two Peacocks. Since the culmination *Pollux*/Peacock is standing on two Lions face-to-face, which means upper culmination of the Sun, this patera denotes "midday-South". Facing this wall, the traveller is therefore facing South.

Fig. 35 Peacock standing on two Lions face-to-face

In the second crossroad with Rio de la Cazziola, there is a set of three interesting patere, two on the wall facing South and one on the wall facing West.

The first patera, up high on the wall in Rio de la Cazziola, shows two Trampoliers entwining their necks (Fig. 36), and this means “Summer Solstice”, while the patera at its right shows Vega, namely the Eagle with closed wings, and it converges towards the first one (Fig. 37). This set represents a celestial event that can be seen at North-East, in the evening of Summer Solstice, looking from South-West to North-East. Since Vega is at my right when I am facing the wall, it means that I am looking towards North. However, this celestial constellation could be seen in this position also at dawn during the Winter Solstice, looking from North to South. Therefore, to understand whether I am facing North or South, a third patera, that we find at right angle on the the next wall along Fondamenta della Cazziola, comes to help.

It shows the celestial Dog (the constellation *Sirius*/*Canis Major*), facing towards my right (Fig. 38). The Dog is represented walking, not rampant; this is his posture during his descending travel towards North. This tells me that, facing this new wall, I am facing West, and North is at my right.

Fig. 36 Trampoliers

Fig. 37 Vega biting a Hare

Fig. 38 Celestial Dog

Campo dei Mori

In the Sestiere of Cannaregio there is a group of buildings that, according to the tradition, once hosted a Fondaco degli Arabi. In the 13th century, these houses belonged to the Mastelli, a family of long-travelling merchants of Arab descent, but naturalized Venetians. Some statues which are likely their sculptural effigies, popularly called "Mori", can still be found along the perimetral walls of the group of houses.
Above the Gothic courtyard door, opening on Calle dei Mori, two patere can be seen, symmetrically disposed at the two sides of the gate: a couple of Trampoliers entwined in their wedding dance (on my right facing the wall), and a Sun/Lion catching a downed Trampolier (at my left) (Fig. 39).

Fig. 39

The two Trampoliers on the right (Fig. 40), depicted with the heads extended and the necks entwined, represents the culmination of the star Al Dhanab, also known as Gamma *Gruis*, namely the head of the constellation *Grus*. This is a Constellation of the Southern Skies, that is visible from Venice's latitude only as she culminates at the cardinal point South, at dawn, on the Summer Solstice.

On the left, instead, we find the Lion that grabs a single Trampolier, again *Grus*, by the neck, at its back (Fig. 41). This happens at twilight during the Winter Solstice.
The iconography of these patere and their disposition say that the decline of the Sun is on my left when facing the wall, while its culmination, denoted by the dancing Cranes on the dawn of the Summer Solstice, appears at my right; therefore, I am facing East.

Fig. 40 Trampoliers (right) Fig. 41 Lion grabbing Grus (left)

Chiesa dei Carmini

Chiesa di Santa Maria dei Carmini is a 13th century church located in the sestiere of Dorsoduro and it faces Campo dei Carmini.

On the porch of this church there are some patere, one on the front and five on the side (Fig 42 and 43).

Talking about the main group, namely the ones on the side, the patera in the middle represents once again Vega biting a Hare, and therefore means South-West. The four patere around it give information about the degree of obliquity of the façade, with respect to the main cardinal directions.

Fig. 42 Porch: frontal view

Fig. 43 Porch: side view

This interesting system of five patere is almost unique; two systems of four are present on the Northern Façade of San Marco and will be discussed below.

Particularly interesting is the patera on the bottom left, which represents *Grus* the Crane biting the tail of the nearby constellation *Piscis Austrinus* (Fig.44). It is the graphical depiction of Grus' short travel in the sky: *Grus* rises at dawn in the Summer Solstice, a few degrees East from South, at Venice's latitude, only the head and neck are visible. After it rises, it catches the fat big *Piscis Austrinus* constellation by the tail; then culminates at the cardinal point South (performing its wedding dance, as seen in the Calle dei Mori and Fondamenta de la Cazziola examples). But a few moments after, the Sun rises and makes it disappear (or, in the patere language, "devours" it; as seen, again, in Calle dei Mori).

Grus catching the Fish stands for a point a little before South; the couple of *Grus* entwining their necks and dancing (not present here) stands for due South.

Fig. 44 Grus biting the Piscis Austrinus (bottom left)

In the porch of the Chiesa dei Carmini, *Grus* catching the Fish forms the lower-left corner of a perfect square with three other patere (two of them representing Vega, in different postures, catching *Aries* the Lamb (Fig. 45 and 46), and one *Pegasus*/Griffin, again catching *Aries* (Fig. 47)). If seen on a Rose of the Winds, this square appears a little askew, rotated of some degrees clockwise with respect to the main four points.

In the middle of the square formed by the four patere, as already noted, we have a fifth patera with Vega facing left, and catching a Hare (Fig. 48) (= i.e., South-West, as seen in the Ca' Boldù and Calle del Vento alignments).

Fig. 45 Vega biting *Aries* the Lamb (top left)

Fig. 46 Vega biting *Aries* the Lamb (bottom right)

Fig. 47 *Pegasus* biting the Lamb (top right) Fig. 48 Vega biting the Hare (middle)

To see South-West in this location with respect to the other points, the observer needs to ideally shift himself, turning his position of some degrees anti-clockwise. This movement gives him the idea of how the Church of the Carmini is rotated with respect of the main points of the Rose of the Winds, allowing him to get his bearings and to go on navigating the town.

To the expert navigator, this can give a more precise indication: on a Rose of the Winds of sixteenth points, he is shifted exactly two points, which means 11.5° x 2= 23 degrees.

Corte Seconda del Milion

Corte Seconda del Milion is near Ponte di Rialto, in the sestiere of Cannaregio, and is surrounded by a group of buildings which an ancient tradition refers to the Polo family, a dynasty of long-distance travellers, well known to the public because of Marco Polo's diary of travel to China, *Il Milione*, written towards the end of the 13th century.

Facing one of these houses, at the second floor, the visitor can observe a set of five equidistant patere in line above the windows of a 13th century Gothic polyphora (Fig. 49).

Fig. 49

The reading of this elegant alignment begins from the two extremes, which can give a first general idea of how the facade is oriented. The patere at both ends are identical and represent a Peacock showing its tail in a fan, the culminating *Pollux* (one of the two *Gemini*, as seen in Fondamenta de le Procuratie) (Fig. 50). But this time the Peacock is not standing on the couple of Lions, which would tell us at first sight if it is meant to indicate the upper or lower culmination of the Sun, and therefore North or South.
This time, the two identical Peacocks are standing on a little globe; in this way we can't tell which one is the North and which is the South at first sight. But, since they are two culminations, it means that the line between them is a longitude, the Meridian, and therefore I must be facing East or West.

The second patera from the left depicts the decline of the celestial Griffin, namely *Pegasus*, that, in the night sky, has four different positions according to the cardinal points (Fig. 51). In this case, it is presented with the head turned back, and the wings touching by the tips; this means that he, in decline, is transiting the cardinal point West. Since West here is not represented exactly in the middle between North and South, but slightly displaced on the observer's left, then the latter knows that, facing the building, he is not facing directly West, but somewhere northwesterly.

This is enough to help him navigate the town. If, however, he is a navigationally skilled person, he may choose to examine the two other patere that compose the alignment and calculate his position exactly.

The third patera is a couple of Lions back-to-back, with their head turned back and facing us, which denotes the point on the horizon of the Summer Solstice setting (Fig. 52). The fourth patera is very similar to the previous one, but here one of the two Lions has its head frontal, the other in profile (Fig. 53); this can be translated as 'Sun/Lion at the half of his ascending travel', namely, cardinal point East.

Fig. 50 Peacock/*Pollux*

Fig. 51 *Pegasus*/Griffin

Fig. 53 Lions

Fig. 54 Lions

As already anticipated before, the patere in an alignment correspond to the points of the Rose ideally projected on the façade, so that I can understand how the façade is oriented according to the order in which the points appear.
In this case, since the distance between West (the Griffin patera) and the Summer setting of the Sun (couple of identical Lions) appears, from the observer point of view, at the same distance as this and

East, and as East to the North, he may be able to infer that his point to view is shifted clockwise two points and half of the Rose of the Winds of sixteen points; therefore, he is facing WNW.[82]

Ponte de le Oche

Standing on the Ponte de le Oche, located in the middle between sestiere of San Polo and Cannaregio, on the façade of the building facing Rio de San Zan Degolà it can be seen a set of three patere (Fig. 55).

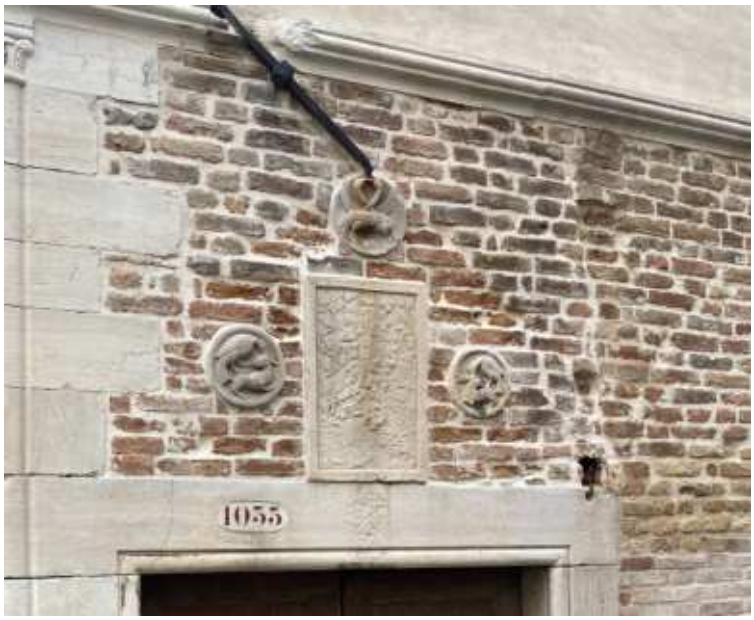

Fig. 55

The two patere at the bottom represent the same thing, namely Vega (the Eagle with closed wings), the one on the left means South-West and the one on the right North-West (Fig. 56 and 57). Instead, the patera on the top depicts a couple of Trampoliers with their necks entwined (Fig. 58) and, as it has already been seen in the case of Campo dei Mori, this represents the culmination of Al Dhanab,

[82] Vallese, G., 'Patere and formelle in Medieval Venice: towards an astronomical reading', Proceedings of the 11th INSAP Conference, September 20 - 23, 2022, held by the California Institute of Technology, Pasadena, CA; to be published in the next issue of Culture and Cosmos Journal, 2023.

that is visible on the South, at dawn of the Summer Solstice. This means I'm looking at West-South-West.

Fig. 56 Vega (left)

Fig. 57 Vega (right)

Fig. 58 Trampoliers (top)

San Trovaso

The next set of patere is above the door of the Taverna di San Trovaso, an historical taverna of Venice on the Fondamenta Priuli, close to the Squero di San Trovaso, in the sestiere of Dorsoduro (Fig. 59).

Fig. 59

The two patere are high up on the wall. The one on the left represents the Lion biting *Grus* and is the graphic representation of the "death" of the constellation *Grus*; we find the Lion that grabs a single Trampolier, again *Grus*, at the back of its neck. This happens at twilight during the Winter Solstice, as seen in Campo dei Mori.
The patera on the right instead represents Vega biting the Hare oriented towards right, this means that is rising and therefore indicates North-East. (Fig. 60)
The group indicates that, facing the wall, I am facing a North-NorthEast direction.

Fig. 60 Lion biting *Grus* (left); Vega biting the Hare (right).

San Marco

With this group of patere, we go back to where we started, namely to the Basilica di San Marco. This time the focus won't be on the portal, but on the Northern facade of the Basilica, where two groups of four patere each can be observed (Fig 61 and 62).

Fig. 61 First group

Fig. 62 Second group

When facing the Northern facade of the Basilica we are looking southwards, as the compass can confirm; but not exactly at the cardinal point South, as the wall appears slightly shifted. To know of how many degrees, I have to look at the two groups of patere above mentioned.
If I am a navigationally skilled person, I shall be able to say exactly of how many degrees the wall is rotated. As in the patrician houses of the merchant-explorers in Venice, some of the patere are unusual or original from an iconographical point of view, asking a little more to my skills and learning to solve the riddle.

The two sets, as already stated, consist of four patere each. In both of them, the patere are disposed in a rectangle, and in both cases they represent (but with two sets of different symbols), the cardinal points North and South, and the sunrise and sunset points at the two Solstices, Summer and Winter.

If I were looking exactly from North to South, I would see these points not one above the other, but slightly offset; since, instead, I see them lined up (exactly one above the other, two by two), it means that I am not facing exactly South, but I am slightly rotated, in fact, of about 23.5° degrees. Looking at the first group of patere (Fig. 61), for what concerns the iconography they represent: on the top left, the Lion turning on itself and reversing its course; it indicates the dawn of the Winter Solstice, and therefore East-SouthEast (Fig. 63). At the bottom left, Vega clawing the third coil of the Snake that represents the constellation *Eridanus*, at 102° degrees (Fig. 64); on the top right, we find Vega pecking *Lepus* among the ears and turned towards left, which means South-West (Fig. 65); and lastly, on the bottom right, the Griffin/*Pegasus* pecking on the head the lamb *Aries*, that stands for the summer sunset, namely West-NorthWest (Fig. 66).

Fig. 63 Lion (top left)

Fig. 64 Vega (bottom left)

Fig. 65 Vega biting a Hare (top right)

Fig. 66 *Pegasus*/Griffin biting *Aries* (bottom right)

As said before, to see these point aligned as they are presented there, I must be watching from a point slightly West of North, towards a point slightly East of South; as it is the case, if we check it with a compass.
This approximate information was enough for everyday displacements about town; a skilled navigator by land or by sea, however, knew exactly the azimuth of the celestial events described in the patere, and consequently would have been able to read the exact orientation of this wall within the range of a few degrees.

As for the second group of patere that can be found on the northern façade of the Basilica (Fig. 62), the concept is the same, though the symbols employed are different. On the top left, we find the Peacock/*Pollux* frontal, and displaying its tail in a fan, so this is the culmination of *Pollux* at midday, therefore it means, as already seen in Calle delle Procuratie and Corte Seconda del Milion, due South (Fig. 67); on the bottom left, there is Hercules pushing back the Sun (Lion), and it stands for the dawn of the Summer Solstice, so North-NorthEast (Fig. 68). On the top right, *Sagittarius* is running away riding a Lion and playing the fife, this represents the point where the Sun sets at the Winter Solstice, namely South-SouthWest (see the similar representation at Ca' Boldù) (Fig. 69). Finally, on the bottom right, we find Orion riding the rising *Sirius* (the wolfdog) and beating the declining *Taurus*, this means midnight and therefore North (Fig. 70).

Fig. 67 Peacock/*Pollux* (top left)

Fig. 68 Hercules fighting the Lion (bottom left)

Fig. 69 *Sagittarius* riding the Lion (top right)

Fig. 70 Orion riding *Sirius* (bottom right)

So, in this asset the patera on the top left is the South and that on the bottom right is the North, whereas the other two are the “Summer Sunrise” (bottom left), and the “Winter Sunset” (top right). Since South and North are not perfectly overlapping, it means that I’m not looking exactly from North to South, but I’m rotated, in this case from North-NorthWest to South-SouthEast.

Chapter 3 Discovering Patere in Venice - An Augmented Reality project for Cultural Heritage

Chapter 3.1 - Conceptual proposal

This chapter describes the development of *Discovering Patere*, a Digital and Public Humanities project for Cultural Heritage of Venice. It is a project on an urban scale, which uses Augmented Reality to create a path for the discovery of Venice's patere, that have been presented in the previous chapter.

In this paragraph, the conceptual idea that lies under this project will be described, where it came from, and the steps undertaken for the actuation of it.

The AR project *Discovering Patere in Venice - An Augmented Reality project for Cultural Heritage* is an on-going research project shaped in the context of the Master in Digital and Public Humanities of Ca' Foscari University of Venice, under the coordination of Professor Fabio Pittarello and Professor Gloria Vallese. This dissertation is a contribution to this AR project that has been undertaken in the previous months and that will proceed with further study and implementations.

The initial idea for this project came from the research conducted by Professor Gloria Vallese on the patere, namely *Stelle e Viaggi*[83]*,* that has already been exposed in the previous chapter. As a matter of fact, this AR project is strictly connected to *Stelle e Viaggi,* since it draws the theoretical information on the patere stemming from Gloria Vallese's study on the iconography and astronomical meaning of them for presenting it to the general public. It could be intended as a further implementation of *Stelle e Viaggi,* with the goal of spreading further the knowledge about patere to a wider public, thanks to the use of AR technologies.

The AR technology adopted for this project gives the users detailed information about the patera they are facing, its astronomical reading, and their orientation in relation to the Rose of the Winds.

[83] Vallese, G., *Stelle e viaggi. Un ciclo astronomico del XIII secolo nel portale della Basilica di San Marco a Venezia*, Antiga Edizioni, 2017, p. 26-27.

The AR paradigm was selected because of its capability to connect, in a perceivable way, multimedia content to the real world. Moreover, thanks to the availability of the AR platform for common mobile devices, it is possible to reach a wider and younger audience, providing an intuitive and interactive interface that doesn't require advanced technological skills.

This approach resulted successful in a previous AR project for CH already cited in this dissertation, namely *Remembering the city,* conducted as well in the context of the Master in Digital Humanities at Ca' Foscari University of Venice. This project, already outlined in the first chapter of this thesis, was taken as a reference to *Discovering Patere* since it was conducted as well on the Venice urban scale, and it faced similar technical challenges related to the recognition of bi-dimensional urban objects, namely the stumbling stones, in a context subject to wide changes of light and weather conditions.

The ideation of *Discovering Patere* included different phases, starting from the historical research to the content creation, design, implementation of the AR experience and testing of the prototype. The historical accuracy of the content was guaranteed by Professor Gloria Vallese and her research conducted on the patere of Venice, which was one of the main references and that has been outlined in the previous chapter. The study of the patere and their astronomical meaning was a core part of *Discovering Patere*. As a matter of fact, the concept of the patere themselves, namely their astronomical and orientation reading, is the key to this project: a different way of orienting in an intricate city like Venice where it's easy to lose the way, and of exploring the patere not only to admire them as cultural artifacts and acquire knowledge, but also to use them as a mean to navigate through Venice, as it was done in the ancient times.

The name *Discovering Patere* suggests both the act of walking around the city to find these artifacts on the walls of Venice, and the discovery of a piece of Cultural Heritage that is not widely known.

The idea for this project was to create a set of small paths that the user could take to discover the patere while wandering around Venice. Every path is characterised by a set of patere in sequence, the user can decide to follow a path or discover the patere in autonomously by looking at the map on the interface of his or her mobile device. In this way, the visitor can explore a new and

alternative way of walking around the city and in the meantime discover an important piece of Venice Cultural Heritage that is the patere.

It is therefore a project intended not only for an audience of experts that already knows the patere, but it also and mainly addresses to the tourist that comes to Venice in search of an alternative tour of it, outside the most common and touristic paths.

The exploration of the patere in their original urban context can bring the tourists out of the more beaten paths, to discover these unexpected treasures in remote and less visited parts of the town, moving around in small, less massive groups. While many of the patere in Venice can be only seen by the canal, the patere selected for this project are outside the most touristic tours of Venice and are all accessible from the streets (calli) and squares (campi) of Venice, most of them at eye level to be more visible and enjoyable.

Chapter 3.2 – Prototyping

The Augmented Reality technical implementation for the project *Discovering Patere* was carried out thanks to the Wikitude AR platform.

Wikitude Studio is part of the Wikitude platform, "a commercial AR platform available for the major mobile operating systems, such as iOS and Android."[84] Thanks to this tool, an AR experience can be built starting from a set of 2D target images, augmenting them through different types of virtual contents like images, audio narration, video, 3D images and hypermedia. "This platform is characterized by the availability of an authoring environment accessible to content experts and a prototyping environment that permits implementing different technical solutions before the final app deployment."[85]

The Wikitude platform includes includes a mobile app that uses the smartphone's camera and sensors for showing the augmented view on the screen of the mobile device.

This is an interesting feature that permits to compose and check the results of the augmentations step by step during the development phase, without requiring advanced technological skill, showing the result of the augmented views for the final user.

Since *Discovering Patere* is a project designed for mobile users in an urban scenario, namely Venice, for the augmentations it was chosen a simple yet informative interface, in order to focus on the efficiency of the user experience (UX).

UX has different definitions and meanings but, referencing to Hassenzahl, it can be said that "User Experience is just a sub-category of experience, focusing on a particular mediator - namely

[84] Fenu, C., and Pittarello, F., "Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum" in *International Journal of Human-Computer Studies*, Volume 114, June 2918, pp. 20-35.

[85] Pittarello, F., Carrieri, A., Pellegrini, T., and Volo, A., "Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality" In *Proceedings of the 2022 International Conference on Advanced Visual Interfaces (AVI 2022), June 6–10, 2022, Frascati, Rome, Italy.* ACM, New York, NY, USA 9 Pages. **https://doi.org/10.1145/3531073.3531103**

interactive products."[86] As Fabio Pittarello reports in *Designing AR Enhanced Art Exhibitions: A Methodology and a Case Study, "*Hassenzahl et al. state that UX is a consequence of the user's internal state (needs, mood), the characteristics of the system (complexity, functionality, usability, etc.) and the con- text (time, space, etc.) within which the interaction occurs."[87]

In the project *Discovering Patere* the AR view is the most important interface and it activates the augmentation of the patere, the urban artifacts object of this project, when framed by the camera of the user's smartphone.

When the target image has been recognised, a short audio narration about the specific artifact framed is automatically triggered. Besides, a representation of the Rose of the Winds is added to the AR view, just above the patera, showing the orientation of the framed patera in relation to the cardinal points. Furthermore, on the top right of the screen, a menu permits to access to different functionalities appears. A unified graphic template for the menu buttons was defined in order to contribute to create a homogeneous user experience while wandering through the different patere. As a matter of fact, the menu is the main interface to contextual hypermedia information related to the framed patera, and it will remain the same for all the AR views. The menu buttons are three and they permit the user to access: the description of the project; a map showing the current location and the other patere available nearby; directions to reach the next patera according to the path that the user is following among the suggested ones.

Furthermore, on the left side of the screen, near to the patera, an "info" button has been placed. By clicking on it it's possible to access to the textual narration of the audio track with all the information related to the patera, to give an accessible alternative to audio impaired people (Fig. 71 and 72).

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[86] Hassenzahl, M., 'User experience and experience design' in *The encyclopedia of human-computer interaction 2,* 2013.

[87] Pittarello, F., "Designing AR Enhanced Art Exhibitions: A Methodology and a Case Study" in *Proceedings of the 13th Biannual Conference of the Italian SIGCHI*, Chapter: Designing the Next Interaction, ACM, pp. 19:1-19:5

Fig. 71 AR view

Fig. 72 Patera description (website)

The first prototype was based on the implementation, through Wikitude Studio, of a set of AR views, corresponding to the patere mapped in the project. As it has already been described, each view included the image of the patera, the audio narration, the three-buttons-menu, and a 3D Rose of the Winds.

These different widgets have been mapped to the pages of a hierarchically structured website, that was built using Wordpress to complement the augmentations with hypermedia information (Fig. 73). As Pittarello et al. point out, this method allows "a good balance, already experimented with other projects, between the emotional approach given by the augmentations and a structured approach compliant with the educational goals of the project."[88] The website has also the goal to provide a stable presence on the web of the project and enable the user to navigate all the information within a desktop interface. The goal and further implementation for the project will be to allow a bidirectional use of the AR views and the hypertextual information provided by the website.

On the website connected to the AR project the user can find: the description of the project and its goals (Fig. 74); the definition of the patera and its astronomical reading, fundamental to understand how patere were used in the Venice of the 13th and 14th century and how they can be used as an

[88] Pittarello, F., Carrieri, A., Pellegrini, T., and Volo, A., "Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality" In *Proceedings of the 2022 International Conference on Advanced Visual Interfaces (AVI 2022), June 6–10, 2022, Frascati, Rome, Italy.* ACM, New York, NY, USA 9 Pages. https://doi.org/10.1145/3531073.3531103

orientation means; the list of all the patere considered for this project, their description and their astronomical meaning; a map of Venice where all the patere of the project are placed and labelled (Fig. 75); a set of suggested paths to discover the patere while wandering around Venice (Fig. 76).

Fig. 73

Fig. 74 The Project

Fig. 75 The Map

Fig. 76 Paths

Goals and limitations

The goals for the project *Discovering Patere* are three: technical, cultural, and touristic.

For what concerns the first goal, this project aims at experimenting the AR tool in an urban scenario like the city of Venice, taking into account the characteristics of the streets (calli) that are narrow and intricate, where the GPS can happen to fail and the calle don't provide a good light-condition is not available in all the hours of the day.

As a matter of fact, the main limitation to the prototyping phase was related to technical issues with the augmentations based on the recognition of the patere. In fact, the outdoor light conditions in constant change and the varying weather didn't allow the augmentations to activate at every hour of the day. Particularly, the rain was problematic and the augmentations after sunset didn't work because of the low-light condition of this part of the day.

This problem, namely the failure of the activation of the augmentation, can be overcome by using the "map" button on the menu that appears on the interface. Through the map, the user can have access to all the patere taken into analysis for this project and can manually choose the one of interest and read all the related information, including the audio track.

For what regards the second goal of the project, the cultural one, *Discovering Patere* doesn't aim solely at creating a functioning AR outdoor application, but it is also finalised at spreading the knowledge about a not widely known piece of Cultural Heritage in Venice, the patere.

Thanks to the AR tool the process of knowledge is interactive and adaptable, through the choice of the different paths proposed to discover the patere, or, if the user prefers, the exploration of each of them in autonomy. The pace of the discovery of the patere is at everyone's choice, it could be intended as the main focus of a tour through Venice, or it can serve as an added-value, an alternative to the classical paths in Venice and a different way to look at the city. This is why the paths are just suggested, the "map" button on the app interface gives the possibility to look at all the patere in Venice and select in autonomy which one to explore.

To pursue the goal of a cultural experience, the AR interface connected to website was designed to provide a very accurate information about the patere, their astronomical reading and their use for orientation. In this way, the user can not only understand more about them, but also experience

them in first person by wandering around the city and learning how to use them to orientate, creating its personal patere experience.

The third goal, the touristic one, focuses on giving to the tourists comin g to Venice an interactive and unusual touring alternative to the classical and already beaten paths and tours. This also aims at moving the tourist engaged in the *Discovering Patere* experience away from the most crowded and touristic areas of Venice, giving the possibility to discover some more hidden parts of Venice while learning something new about its Cultural Heritage.

Chapter 4 Conclusions and future implementations

This dissertation has attempted to demonstrate that technologies like Augmented Reality can be very effective in increasing the historical and cultural engagement of citizens and tourists, and projects like *Remembering the City*[89] and *Svevo Tour*[90], that have been presented in the first chapter and that have been taken as reference to the project *Discovering Patere,* are examples of how this could be done.

The project *Discovering Patere* outlined in this dissertation follows the same path, proposing new modes of exploring the city and gaining knowledge about small but important cultural artifacts of Venice: the patere. The project is not intended only for a public of experts, but for each person that lives or comes to Venice and wants to wander through the city in an alternative and interactive way, knowing more about the patere and the celestial navigation.

This dissertation was developed in the context of the project *Discovering Patere* that is still ongoing and will see further implementations under the direction of Professor Fabio Pittarello and Professor Gloria Vallese.

The initial phase of it, as explained in the previous chapters, was focused on the historical research on the patere and their astronomical meaning, and it was conducted on the basis of the studies of Professor Gloria Vallese on the main portal of San Marco, the celestial navigation, the patere and the formelle.

The presentation and discussion of this research has been given in the second chapter of this dissertation, with a special focus on the patere that are the main topic of the project. In the beginning of this project, the exploration in first person of the patere in the city was important to understand the concept laying behind them and to transpose it into the project.

[89] Pittarello, F., Carrieri, A., Pellegrini, T., and Volo, A., "Remembering the City: Stumbling Stones, Memory Sites and Augmented Reality" In *Proceedings of the 2022 International Conference on Advanced Visual Interfaces (AVI 2022), June 6–10, 2022, Frascati, Rome, Italy.* ACM, New York, NY, USA 9 Pages. https://doi.org/10.1145/3531073.3531103

[90] Fenu, C., and Pittarello, F., "Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum" in *International Journal of Human-Computer Studies*, Volume 114, June 2918, pp. 20-35.

Then, the other fundamental complementary phase was the technical one. The implementation was based on the Wikitude tool, and it included several iterative phases, on site and remotely, for coming to the prototype and the AR views that were displayed in the previous chapter.
The AR views have been complemented by a hierarchically structured website that serves as informational support to the project, guarantees a permanent presence of the project on the web and complements the augmentations provided by the AR views with hypermedia content.
Both the AR views and the website are characterized by a simple yet informative design, immediate to understand and navigate for the user.
Since *Discovering Patere* is a project on an urban scale, Venice, it was necessary to consider the special features of this city. The changing conditions, the narrow streets, the varying strength of the GPS signal were considered during the prototyping phase of the project and led to some technical solutions for coping with these issues.

In creating the project *Discovering Patere*, we complied with a number of goals, including the goal of taking the tourist away from the most beaten paths of Venice. The choices operated during the different phases of the project were influenced by them, like the selection of the patere to explore: most of them are located in less touristic and crowded areas of the city.

Future implementations

As already pointed out before, this dissertation is a contribution to the digital project *Discovering Patere in Venice - An Augmented Reality project for Cultural Heritage,* that is still ongoing in the context of the Master in Digital and Public Humanities at Ca' Foscari University of Venice.
The steps undertaken to realise it are just the initial ones and led to a first version of the implementation, that will be developed and finalised with further work and study.

More paths, possibly connected, will be studied, taking into account the goal of leading the visitors into less beaten areas of Venice, making them wander around all the areas of the city and not only in the most touristic and crowded places.

Furthermore, the AR views and the website will be implemented to provide more and better functionalities (e.g. a carousel of miniatures showing the patere nearby in the AR view, that could be very useful in case the GPS fails or the low-light condition happens to stop the augmentation from activating).

Finally, the testing of the prototype will be carried in different times of the day and under various weather conditions, in order to have more accurate feedback about the environmental conditions that prevent the augmentation to work, in order to provide alternative, like a more robust target image.

Finally, a sample of people will be involved as volunteers to test the application and give feedback, that will be very important to understand the social engagement and for implementing a revised version of the project.

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