Visualizing the smallest details: the digital replica of the Annunciation by Beato Angelico

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Abstract. Painted during the first thirty years of the XV century, the *Annunciation* by the Dominican friar Giovanni da Fiesole, best known as Beato Angelico, represents the ideal intersection of the Renaissance perspective with the medieval educational value reserved to art masterpieces. This paper introduces the techniques and the procedures specifically developed to display and interactively visualize a digital replica of the Annunciation, by means of *AnnunciatiOn App*, a custom Real-Time Rendering application that was officially presented during the opening of the exhibition "Masaccio and Angelico. Dialogue on truth in painting", at the Museo della Basilica di Santa Maria delle Grazie in San Giovanni Valdarno, last September 2022 and still open. *AnnunciatiOn App,* targeted to museum visitors but also to scholars and restorers, successfully performed at the museum as a didactic kiosk hosting a 4k touch screen and a desktop computer integrated by a custom soft touch keyboard, developed by the research team.

Keywords: Cultural Heritage Visualization, Digital Replicas, Museum Interaction.

1 The Annunciation and the research context

Preserved at the *Museo della Basilica di Santa Maria delle Grazie* in San Giovanni Valdarno, the *Annunciation* is the masterpiece by Giovanni da Fiesole, better known as Beato Angelico. The impressive painting, which dates to 1430-32, is a 195×158 cm wide tempera with some fine gold foil placed on a wooden support and surrounded by a frame recalling a classic architecture, where the Archangel Gabriel is in the act to visit the Virgin Mary. Fra Angelico's masterpiece is enriched by many symbolic details, often difficult to appreciate in photographic reproductions as well as from direct vision, due to the distance from which the painting can be observed. Also, *Annunciation's* colors are vibrant due to the use of lapis lazuli to paint the Virgin's blue mantle or gold foil for halos. Last September 17, 2022, "*Masaccio e Angelico. Dialogo sulla verità nella pittura*" opened at the *Museo della Basilica*, promoted by the Municipality of San Giovanni Valdarno and included in the "*Terre degli Uffizi*", a project by the Uffizi Galleries and the CR Firenze Foundation. The exhibition was curated by Michela

Martini, Daniela Parenti, Carl Brandon Strehlke and Valentina Zucchi, presenting a shortlist of masterpieces by Masaccio in dialogue with Beato Angelico. Taking the opportunity of such an interesting initiative, the research group from the Department of Architecture at the Alma Mater Studiorum - University of Bologna developed a workflow to digitally acquire, replicate and visualize the *Annunciation*, to generate a digital surrogate perceptually indistinguishable from the original. In this contribution the final stage of this system, focused on the interaction with the digital replica, is introduced; *AnnunciatiOn App* (this is the name given to the framework) is the result of experiences in cultural dissemination for museums, such as *Anatomia dei disegni* (a successful exhibit on Leonardo da Vinci's drawings held in Bologna and Vinci) and *Mente et Malleo. Da Ulisse Aldrovandi a Giovanni Capellini: storie dal primo museo geologico in Bologna,* organized to celebrate the naturalist Ulisse Aldrovandi (1522-1605) and the first professor of geology at the University of Bologna, Giovanni Capellini (1833-1922).

2 *AnnunciatiOn App* and the interactive kiosk

The 3D model of the *Annunciation* was produced adopting combined photometric stereo and photogrammetric techniques for the painting panels and their wooden frame.

To faithfully reproduce the shape of the original altarpiece, a completely 3D solution was developed, relying on the concept of "*total appearance*". This solution guarantees the necessary perceived fidelity, and it requires an acquisition workflow that is simpler and less harmful than other schemes, though producing excellent results (Figure 1, left).

Fig. 1. From left, the digital replica authored, the original *Annunciation* close to the custom-developed kiosk installation and the interaction with museum visitors on the right.

A custom-made interaction environment was developed in the Unity3D graphic engine, a videogame design platform originally released in 2005 consisting in a *graphical user interface* (GUI) and an advanced render engine, which was also exploited to replicate accurately all the materials. The interactive GUI of *AnnunciatiOn App* is represented by a vertical virtual space, with 9:16 proportions, in which the 3D model can be explored, choosing from a guided tour on specific points of interests (POIs) or opting for a free navigation (Figure 1, right). Very few commands were placed over a digital canvas upon which touch buttons were layered. *AnnunciatiOn App*, in fact, was optimized to run on a 55 inches touchscreen with a supported maximum resolution of 3840x2160 pixels. A couple of on-screen GUI buttons, represented by arrows on a

semi-transparent circle in the size of a finger, let the users navigate the model, moving back-and-forth to specific details on the painting, with commentaries grouped into specific sections of interest (as reported in table 1). By lightly touching other two buttons, the users may activate an automatic guided tour, during which the most important details are automatically visualized in sequence or start over.

Table 1. Captioned sections in which views are organized in the interactive interface.

Section ID	Section name	Contents
Section A	The Annunciation	The painter: Fra Angelico - The location: Montecarlo - The painting during World War II - The subject: The Annunciation - The Dove - The Virgin - The Virgin's book - The Prophet - Adam and Eve.
Section B	The *predella*	Predella - Scene 1: The Marriage of the Virgin - Scene 2: The Visitation - Scene 3: The Adoration of the Magi - Scene 4: Presentation of Jesus in the Temple - Scene 5: Burial of the Virgin.
Section C	The House and Garden	The *hortus Conclusus* - The rose - The lily - The palm - The loggia - Pentimenti in the arches - The Interior Room - The Flowers.
Section D	Technical Analysis	The wooden support – UVs - Infra-red reflectography – Lapis lazuli - Other Pigments – Gold.
Section E	Other Annunciations	The other Annunciation altarpieces - Museo Nacional del Prado, Madrid - Museo Diocesano, Cortona - Comparison of the Virgin's house in each altarpiece - Comparison of Adam and Eve in each altarpiece - Comparison of the Visitation Scene in each predella.

The robustness of the touch interaction system is guaranteed by some customized C# scripts written to avoid multiple buttons selections or to program the application to restart from the beginning if no activity is detected within a timed interval. However, the versatility of the application is also related to its ability to be targeted to scholars: in fact, some specific commands may be executed also via traditional devices. For example, pressing the space bar of a connected keyboard, the interface will change getting out from the kiosk mode to let the painting be explored with the use of a common pointer device. The video resolution, usually set to 4K during the exhibition, is also automatically set to the maximum values that can be guaranteed by the new connected if existing. This way, the application conforms to many possible hardware requirements in different exhibition contexts. The comparison between the real *Annunciation* and the one replicated in *AnnunciatiOn App* is particularly effective, since visitors can get in touch with the masterpiece in a personal way, "touching" its virtual replica to establish a more intimate relationship with the artefact. So, it was decided to run *AnnunciatioOn App* on a dedicated kiosk in form of a case made of wood, to recall the frame around the original painting: the kiosk was placed in the same room, close to the original work of art (Figure 1, center). It was conceived as a vertical frame to host the touch screen and to hold all the necessary hardware to run the app, including a workstation hidden behind a panel that can be removed to guarantee maintenance operations. Its dimensions were established in 110x220x49 cm considering ergonomic performances: a physical proximity keyboard was placed below the vertical screen (Figure 2, left) to

give users an easy and direct access to each one of the 5 sections of the guided tour. This physical interface was developed through the adaptation of a dedicated AT-mega32u4 microcontroller (*Leonardo*), which drives 5 illuminated soft-touch buttons that visually indicate the reference section through a flashing white light when activated. Each single button is made of a 3D printed ring, made of white PLA, around which is placed a NeoPixel strip with 5 RGB WS2812 LED diodes, to illuminate a transparent methacrylate disc (Figure 2, right). Below, some *vetronite* plates, a material often used for circuits boards, were soldered to two pins in the electronic controller to transform them into sensors able to perceive the electrical capacity of human hands. The buttons act as antennas and, through a correct calibration, it was possible to interact with the model when the palm of a hand was in the proximity of the circular element.
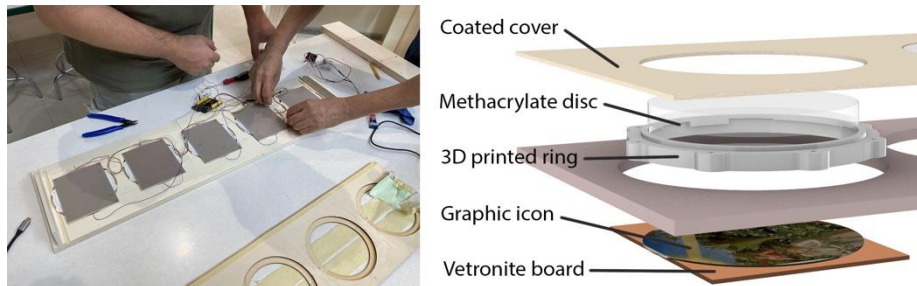

Fig. 2. From left, the physical capacitive keyboard, with customized proximity button with schematics on the right.

3   Conclusion

This contribution introduced some perspectives on the interaction with digital artifacts in museums referring to *AnnunciatiOn App*, the application designed to exhibit the *Annunciation* by Beato Angelico. Eventually, the introduced interaction paradigm is a novel way to spread and disseminate knowledge translating data into information for the particular purpose of Cultural Heritage dissemination.

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