CAA2015

KEEP THE REVOLUTION GOING >>>

Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods In Archaeology

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Stefano Campana, Roberto Scopigno,
Gabriella Carpentiero and Marianna Cirillo

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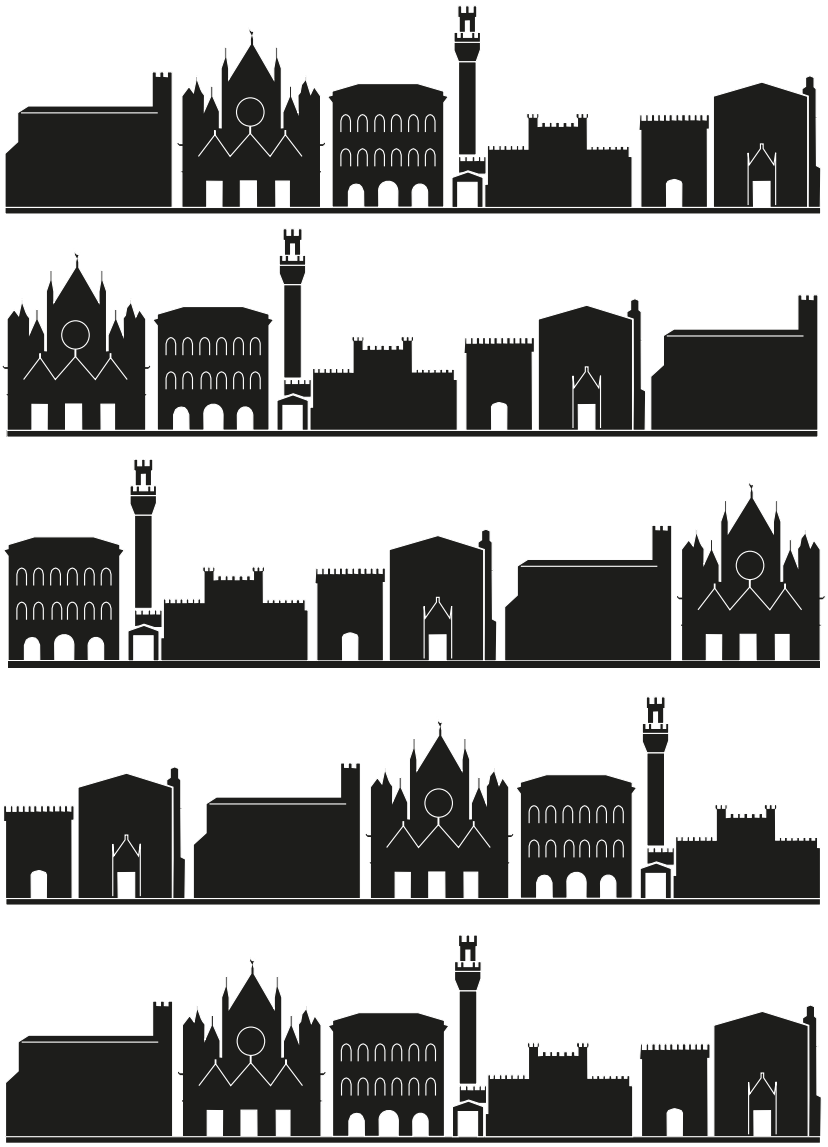

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Interactive Communication and Cultural Heritage

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Abstract: The advent of digital technology and new media has changed the expectations of visitors, driving the use of new solutions and technologies to deliver content that meets their demands. Cultural heritage visits are no longer solely information-based, but have now become all-round multisensory experiences.

The study proposed here aims to communicate further information about the nature and state of cultural objects, by means of the spontaneous and natural interaction of visitors physically pointing at the parts they are interested in.

A practical application of the procedure has been designed for the Forum of Nerva in Rome. The experiment was conducted with a Kinect sensor and Leap Motion 3D. A small-scale 3D print of the Colonnacce was made for the laboratory tests so that the results would be as realistic as possible.

Keywords: Interaction, Virtual reality, Communication view, 3D modelling, 3D simulation

Introduction

The new forms of communication for cultural heritage have seen an increase in methods of interaction between visitors and exhibits. Visitors are no longer the traditionally passive recipients of information, but are now more active in the exploring and learning process and are able to decide which forms of delivery they prefer. This new approach has led to more and more museum structures presenting their scientific and educational content in such a way as to be experienced 'subjectively' by visitors through the use of instruments that can detect their intentions/actions/movements and turn them into human-machine interactions. In turn, computer-developed applications enable multiple variations in the way a single object can be explored, thus improving our understanding of it.

Following this direction we propose a research where is planned an interactive exploration of the archaeological area of the Forum of Nerva in Rome: visitors can get more advanced information, on the remaining columns, called 'Colonnacce', just pointing at the parts they are interested in.

1 Recent solutions

The advent of digital technology and new media has changed the expectations of visitors, driving the use of new solutions and technologies to deliver content that meets their demands. Cultural heritage visits are no longer solely information-based, but have now become all-round multisensory experiences (Neves 2002; Chamberlain 2014).

Several studies have been made in direction to meet visitor needs (Sheng 2012; O'Flaherty 2014) and strategies used to date can be placed into three categories:

- narrative approach: communication and language are designed to engage the visitors' emotions in their experience of the cultural object (Monaci 2006).
- interaction: visitors play an active role and are not mere passive targets of the message (Antinucci 2007).
- new media and innovative forms of communication (Salerno 2013): exploration of content with various devices on several platforms. Examples include augmented reality, mobile devices (tablets, smartphones), touch screens, projection mapping etc. (Shumaker 2014).

The 'active' engagement of users enables them to interact and change the message they receive. Technological progress now allows us to take interaction beyond the screen, moving away from hardware interfaces, such as keyboards and mice, to gesture, voice, proximity and touch detection systems.

We can see how this evolution might point to the idea of natural interaction: a simple, immediate and direct way of communicating with the digital medium (Pescarin 2013).

There are numerous initiatives that help us to understand the current state of research and experimentation.

For a brief look at how Italy shapes up in this field of study, we can assess the following recent exhibitions, chosen as examples, remaining in the field of archaeological sites, for understanding the purpose of the application proposed in the next section:

- 'Order and light. A virtual journey through evolution of interior space in the history of architecture from ancient Greece to the Renaissance' – Mantua 2013-2014.
- 'Keys to Rome. The City of Augustus' – Rome 2014-2015.
- 'The Forum of Augustus. 2000 years later' – Rome 2014-2015.
- 'Journeys into Ancient Rome' – Rome 2015.

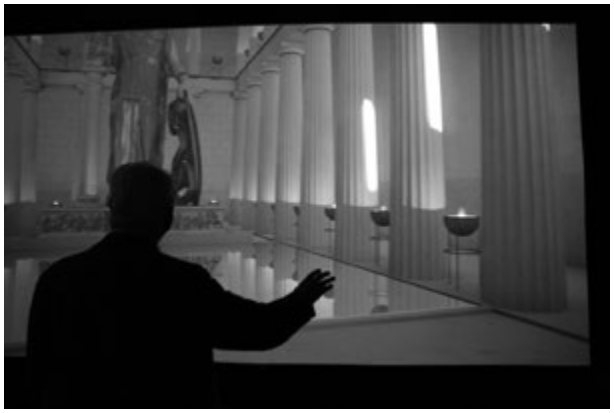

Fig. 1. Immersive/interactive reality, through body movement. Temple of Apollo Epicurius at Bassae in the exhibition/event 'The Order and the Light'.

Fig. 2. Virtual reality torch in the exhibition 'Keys' Rome. The City of Augustus'.

The exhibition/event 'The Order and the Light. A virtual journey through evolution of interior space in the history of architecture from ancient Greece to the Renaissance', held at the Centre for International Art and Culture, Palazzo Te in Mantua, from 15 December 2013 to 16 March 2014 (Centro Internazionale d'Arte di Cultura di Palazzo Te, 2013), relied on the use of 3D modelling/reconstruction of the great classic architectural monuments (such as the Parthenon, the Temple of Apollo Epicurius at Bassae (Fig. 1), the Temple of Apollo *Sosianus* in Rome, the *Domus Aurea* and the Trajan Spas) to provide visitors and scholars alike with a realistic insight in an immersive/interactive reality, through body movement.

The Museum of Imperial Fora, Trajan's Market, from 24 September 2014 to 10 May 2015 hosted 'Keys' Rome. The City of Augustus', an exhibition on the discovery of the Augustan Age centred on the use of new technology applications available to visitors (Ungaro 2014).

This museum experience consisted of films, interaction systems and interactive applications guiding the visitor through Roman history.

A map of the City in the museum great hall gave the visitor the sensation of 'walking' about in Rome some two thousand years ago, some of the rooms being equipped with interactive and multimedia aids including:

- Virtual reality torch - 'augmenting the reality of assets' (Fig. 2).
- Virtex – 'Touching the asset'.
- Matrix totem – 'Playing with the assets'.
- AR-tifac – 'Augmenting the reality of assets'.
- Admotum – 'Playing with the assets' (Fig. 3).
- Holobox – 'Augmenting the reality of assets'.

Celebrations for the bimillenary of Augustus's death (19th of August, 14 AD) helped valorise the Imperial Fora with project

Fig. 3. Use of Kinect interaction in the exhibition 'Keys' Rome. The City of Augustus'.

'Forum of Augustus. 2000 years ago', from 22 April to 21 October 2014 (Ministero dei beni e delle attività culturali e del turismo, 2014). Here, the communication tool was a multimedia installation with projection on the walls of the Forum of Augustus, representing the history of Augustus and the Forum with lights, films and projection mapping reconstructions.

The success of the 2014 edition of 'The Forum of Augustus. 2000 years later' led to the organisation of 'Journeys into

Ancient Rome' (Viaggio nei Fori, 2015), from 25 April to 1 November 2015.

Reconstructions and videos take visitors back through the history of the excavations carried out to build Via dei Fori Imperiali, when an army of 1,500 construction workers, labourers and other workers were enlisted in an operation unlike any before to raze an entire neighbourhood to the ground and dig down to ancient Roman street level.

The exhibition went right into narative, starting with the remains of the impressive Temple of Venus, whose construction was ordered by Julius Caesar after his victory over Pompey, reliving the emotional experience of life in Roman times, when officials, commoners, soldiers, matrons, consuls and senators walked beneath the arches of the Forum. Among the remaining colonnades can be seen the *tabernae*, which were offices and shops and, among these, a *nummularius*, a kind of currency exchange office. There was also a large public lavatory, some of whose remains are still in existence.

The visit tried to recapture the role of the Forum in the life of Romans, as well as the figure of Julius Caesar. To build this great public work, Caesar expropriated and demolished an entire neighbourhood and the overall cost was 100 million *aurei*, the equivalent today of at least 300 million Euros. He also wanted the new home of the Roman Senate, the *Curia*, to be built right next to his Forum. The *Curia* still exists and virtual reconstructions show us what it looked like in Roman times.

2 Proposed solution

The study proposed here aims to communicate further information about the nature and state of cultural objects, by means of the spontaneous and natural interaction of visitors physically pointing at the parts they are interested in.

The term 'natural interaction' (Alisi 2008) refers to the relationship between man and machine, where only the natural abilities of human beings are used to communicate with any system, therefore excluding mediation through artificial instruments. The aim is to find the easiest method of using digital media content.

When interfaces are included in the examination (Saffer 2008), we refer to them as Natural User Interfaces (NUI), which are practically invisible and need no training to be used. Everything in these systems has a counterpart in the real world to be certain that it is already part of the human experience. In other words, the basic idea is to apply to the interaction between humans and machines the natural instruments used in interpersonal communication such as the voice, posture, facial expressions and gestures (Pescarin 2013).

In the specific solution proposed, it was decided to use a gesture to select, choose, elements of the real world that can be activated. Pointing is a natural gesture, which we use from early childhood to indicate, obtain information and get to know. The interface thus becomes invisible as a device and part of reality, and hence is easy to interpret and does not need to be learned.

In 'natural design' (Norman 2013), information should be visible and convey the right message so that it can be understood without the need for awareness. All the restrictions and invitations expressed by the object help the user build a mental model, a subjective image of how the system works. This is in opposition to the conceptual model, where operating design is transferred from the mind of the designer to the system. The more the two models converge and overlap, the more users are able to seamlessly understand and interpret the object.

An example of invitation within the project can be observed in signage indicating the place/position the user should be. Icons, which have a strong semantic value in the mind, show users, with no effort on their part, what position they should be in in order to interact with the installation.

Two other elements that are important for creating a mental model are experience and feedback, which inform users what actions have already been completed and what the outcome is.

A laser pointer and the lighting of the area selected are, for example, ways of showing the person what action they are doing and what the purpose is.

By 'pointing' they receive feedback with information about the object they have selected (Saffer 2008).

The procedure behind this applied methodology involves a series of related operations:

1. detection of the object or the area of interest by 3D laser scan. This throws up a 3D model with the dual function of (self-) representation of the object and allowing the Cartesian coordinates (x, y, z) of each point of the model to manage the interaction of the person exploring it.

2. development of the interactive application and creation of an effective interface for interaction between humans and machines.

3. creation of interaction between humans and machines by using tools designed for video games, such as Kinect and Leap Motion 3D.

4. design of an app for portable devices where additional information can be obtained on the cultural object of interest.

5. design of the physical setting where the interactive information is delivered, sectioning off specific areas (boxes, corners, walls) and placing input/output tools within them (projectors, Kinect, Leap Motion 3D).

One concrete application of the procedure has been designed for the Forum of Nerva in Rome, east of Via dei Fori Imperiali, where a number of imperial Roman friezes and columns can still be found. From a given position, visitors can quite naturally point to the part of the object they are interested in, when they are in front of it. For visitors at the site, a spotlight shows what part the visitor is pointing at and Leap Motion 3D tracks their pointing finger.

On the app, Leap Motion 3D detects the position of the pointing finger on the 3D laser model that has been made 'invisible'. When visitors point for longer than five seconds at something

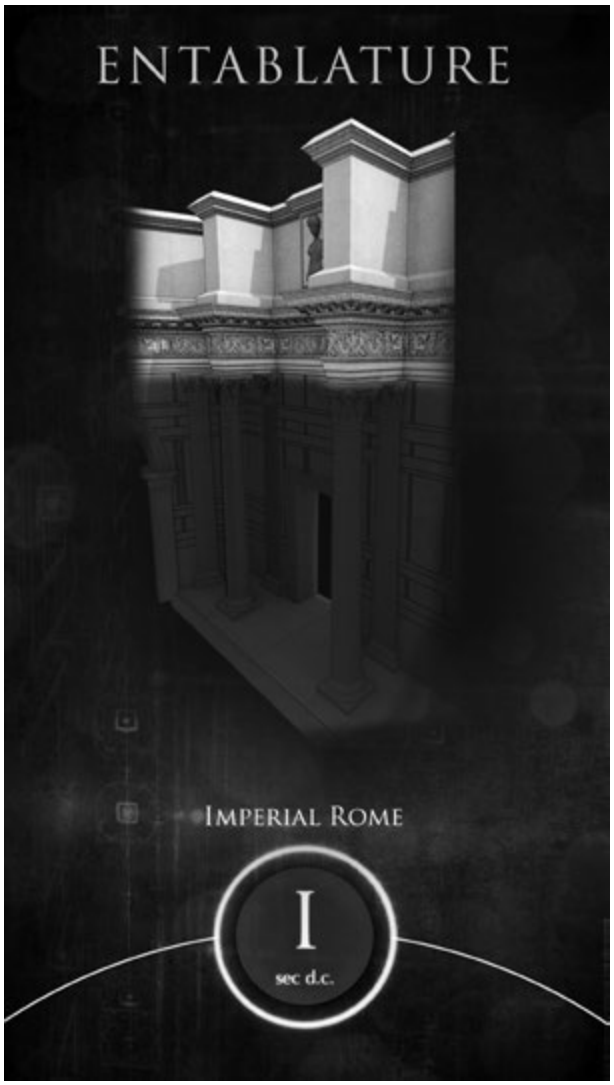

Fig. 4. Forum of Nerva: use of Leap Motion 3D. When visitors point for longer than five seconds at something they are interested in, a video starts illustrating the history or the nature of the object selected.

they are interested in, a video starts illustrating the history or the nature of the object selected (Fig. 4).

The video is projected onto a section of floor in front of the visitor if they are on site or on their iOS smart device if they have downloaded the 'Nervar' App (Empler 2014).

The same exploratory method can be used in the Forum of Nerva hall at the nearby Museum of the Imperial Fora.

3 Experimental results

The experiment was conducted with a Kinect sensor and Leap Motion 3D (Marin 2014). A small-scale 3D print of the *Colonnacce* was made for the laboratory tests so that the results would be as realistic as possible.

The Kinect sensor (Borenstein 2012) can detect with sufficient precision joints and other points that are important in the

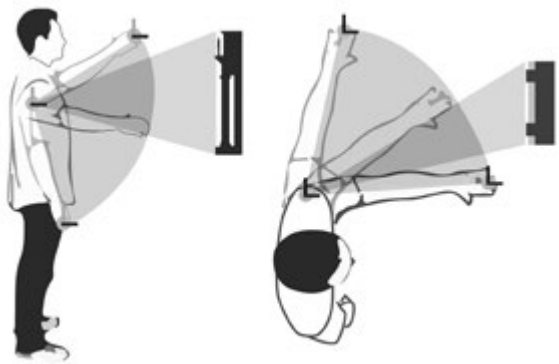

Fig. 5. Forum of Nerva: Kinect interactive working scheme.

movement of the body, thus reproducing a schematic model of the human skeleton.

In this particular project, Kinect is used to track two of these joints: the shoulder and the hand.

The sensor provides the spatial x, y and z coordinates of these points to draw a vector. The projections can be determined on the zx plane and on the zy plane. The angles formed by these two projections and by the z and y axes respectively provide a value for the rotations of the user's arm around the x and y axes.

Using a conditional structure, the values obtained can relate to the real world to virtual reality. With restrictions on the rotation values (measured on site) to highlight an area (Fig. 5), the hypothesised interactive effect can be achieved.

Leap Motion Sensor 3D (Leap Motion 2014) uses two IR cameras to return the spatial coordinates (in mm) of hands and fingers moving within a specific detectable area of approximately one cubic metre.

The Software Development Kit (SDK) distributed with the sensor orders the x, y, z coordinates and the vectors describing the skeleton of the hand so that these values can be used with leading development tools and platforms: Unity, Unreal, Javascript, C++.

Before focusing further on the development of the interaction with one of the two systems, some tests were conducted on the usability of the Kinect and the Leap Motion, involving 30 volunteers.

Though it's possible to integrate the two systems (Vinkler 2014), we decided to choose the one that provided best results in terms of usability (Marin 2014), compared to the place where the system was supposed to be located (open archaeological area just in front of the 'Colonnacce').

The test showed a greater usability and easiness of use of the Leap Motion 3D than the Kinect for the following reasons:

- Kinect, to be activated, requires a specific body posture (arms raised up), while the Leap Motion requires only that the hand (fingers) enters the range of action of the device;

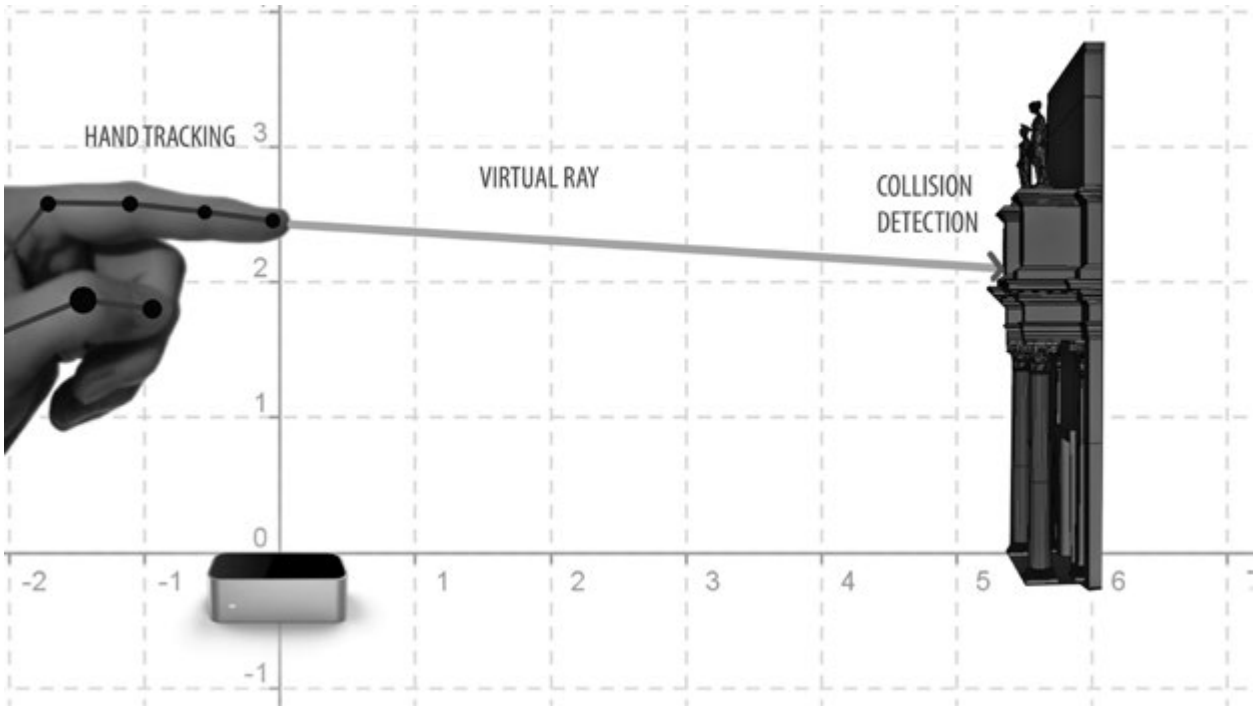

Fig. 6. Forum of Nerva: Leap Motion 3D working scheme.

Leap Motion facilitates an immediate interaction without the users were previously instructed on how to use the instrument (85% of the volunteers preferred the use of the Leap Motion, 15% were still satisfied also with the use of the Kinect).

- Kinect requires that nobody else or nothing stands in the sensor area of action (up to 3.5 meters from the device), otherwise can occur some tracking errors, while the Leap Motion uses a limited space of detection, in close proximity to the sensor (1 cubic meter). The Leap Motion excels at reading minute movements. It was designed to be accurate to within 1/100 of a millimetre in order to be useful for applications that require precision, such as 3D-modeling.

At the end of the tests we decided to choose the Leap Motion 3D. In order to recreate virtually the actual location and shape of objects and relate them to the data collected from the hand, a special C++ language software has been developed which integrates with the SDK and open source Cinder ++ libraries. This script defines the functions for importing 3D models into the relevant space, management of events, control of selections and the uploading and launch of multimedia files.

After the experiment with the software program and the sensor, it was found that data from the hand and the object (detected as described above) matched, provided the following are true:

- both are expressed using the same scale (1:1) and units of measurement (mm).

- the distance and the height difference between the sensor and at least one point on the detected object are known.

This means everything within one reference space originating at (0,0,0) in the centre of the device (Fig. 6).

Once the skeleton of the hand has been translated into virtual space, rendered by the ray casting procedure often used in video game programming, the application creates a ray from the tip of the finger depending on which direction it is pointing. The system then calculates the intersections of this ray with the 3D elements in the scene.

This makes it possible to associate collisions with certain parts of the object with a number of events, such as playing specific multimedia content, confirming to the user that they have made the required selection.

These instruments were used to build the installation that describes the *Colonnacce* of the Forum of Nerva.

Once the original state of the colonnade has been printed in 3D, it is placed on a plane 30cm away from the sensor (Fig. 7). The 3D model of the same area of the Forum was divided into two parts, columns and entablature, which have been made sensitive by the program. The computer running the application is connected to a projector positioned so that users can see the videos.

Users can select one of the two parts of the object by pointing at it while their hand is near the sensor. This input is recognised instantly and the data sheet with basic information (name, period, 3D reconstruction) on the selected part is projected (Fig. 7). A 5-second timer is also launched, after which, if the finger has not moved during this time, multimedia content about the selected part is played of its history and peculiarities. As an alternative to projection, the output can be transferred to the user's mobile device.

At the end of the video, the installation returns to waiting mode ready for the user to select another part.

Fig. 7. Forum of Nerva: simulating the Leap Motion 3D use on the small-scale 3D print of the Colonnacce.

This approach means the software can interface with objects of any size, moving easily from scale models (e.g. the 3D printing of the *Colonnacce*) to actual-sized objects.

4 Conclusion

In order to have a more effective interactive communication in cultural heritage, with particular regard to open archaeological sites and museums, we can suggest additional lines of research, where the proposed application provides three levels of use:

- implementation of the Nervar app for the Forum of Nerva (Empler 2013), where the *Colonnacce* were studied and analysed.
- creation of a fixed station near the *Colonnacce* as an extension of 'Journeys to Ancient Rome' or similar projects.
- exploration station to reconstruct the 3D printed model, set up in the Forum of Nerva hall at the nearby Museum of the Imperial Fora.

These instruments provide complete and correct information on several levels of communication and interaction in Cultural Heritage and engages as many target users as possible.

By keeping the focus on direct experience of the cultural object, their spatial and functional aspects can be understood better than from images and reconstructions alone.

The result has been to combine the technical data with modern forms of delivery and entertainment to develop procedures that can be replicated in different places and situations, even for difficult-to-access cultural objects.

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