

Tecnologie per i Beni Culturali

ARCHEOMATICA



ROME REBORN 4.0

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ROME REBORN 4.0: A VIRTUAL TOUR INTO THE HEART OF THE ETERNAL CITY

Interview to Bernard Frischer by Michele Fasolo



Bernard Frischer (at his young age) on front of the model of Imperial Rome in the Museum of Roman Civilization.

The concept of *instaurare Romam* has a noble origin: the Renaissance historian and humanist, Blondus Flavius (1392-1463). Today, we recognize the modernity and relevance of his intention not to confine himself to a static reconstruction, but rather to offer an insight into the development of the city and the functions of its buildings.

A persistent effort to identify the remnants of ancient monuments amid the successive transformations of the urban fabric, achieved through continuous comparison of written sources with on-site observations of places and monuments.

This idea, this method, far from being forgotten, sees, about six centuries later, a visionary professor - who has taught at various American universities (UCLA, Virginia, Indiana) - proposing a reconstruction of ancient Rome. This is Bernard Frischer, a digital archaeologist, and the 4.0 version of Rome Reborn, his captivating digital recreation of ancient Rome within the Aurelian Walls, was unveiled a few weeks ago in Rome. Frischer is the founder and president of Flyover Zone Productions (established in 2016), a company based in Bloomington, Indiana, with a mission to market products and services utilizing 3D

digital technologies to present cultural heritage sites and monuments to the general public. Twenty-seven years of uninterrupted work through the significant and rapid technological transformations of recent years, Frischer has invested in data collection and acquisition, databases, increasingly innovative services, the realm of networks, wearable computing, and much more.

The digital reconstruction of ancient Rome faces significant challenges and difficulties in the accurate rebuilding of its monuments. Some proposals inevitably spark controversies; however, compared to Gismondi's traditional model, Rome Reborn 4.0 stands out as a three-dimensional, navigable, dynamic, and versatile model, thereby stimulating the opinions of those who consult and utilize it.

Its use does not necessarily demand an uncritical acceptance of the proposed reconstructions; rather, it predominantly provides a fertile ground to explore and discuss history from new perspectives. In this way, it configures itself as an educational and tourist resource that goes beyond a mere reproduction of the past, making it accessible and engaging for anyone ap-

proaching it. An adaptable tool that evolves with the progress of research, updating whenever convincing and widely accepted solutions are reached for each individual monument.

Affectionately known as Bernie among friends, thanks to his warmth and amiability, Frischer has honored us with his presence for years as a member of the Scientific Committee of Archeomatica. With pleasure and openness, he now shares reflections and details of his work over these years in this interview with us and our readers, responding to our questions.

OVERALL

What was the overall timeline of the Rome Reborn project, broken down by versions?

The idea for the project goes back to October 1974, when I first saw the *Plastico di Roma Antica* of Italo Gismondi. The moment I saw it, I had the idea that it would be wonderful to find some technical solution that would allow people to have the impression of walking down the streets of ancient Rome. I published a paper proposing the project (at first called “Project Cicero”) in 1988. I got funding from two philanthropists in Los Angeles in 1995 to start the planning. The project was officially launched at a conference held at the American Academy in Rome on December 1, 1996. To understand the evolution of the project, I need to tell you that we divide the features of the ancient city into two classes. Class I are those features about which we know the name, location, phasing,

design, and function. As examples, I can cite the Colosseum and Pantheon. Class II features are all the features about which we are less certain about one or more of those details. Our best sources for Class II are the two late-antique regionary catalogues. They give us quantitative

data about the distribution of buildings by type in the 14 regions of the city, but they do not give us exact information about location and design.

Version 1.0 included the Class I features in the Roman Forum. Everything else derived from a laser scan of the *Plastico di*



Aerial view of the city from the southeast. In the foreground are the Baths of Caracalla. In the middle ground can be made out the Circus Maximus (the 600-meter-long racetrack in the center of the image) and the Colosseum (to the right). In the distance is the Tiber River.



Aerial view of ancient Rome in AD 320. Similar view to what is seen on page 03, except we are positioned to the west of the Circus Maximus.

Roma Antica of Gismondi. This version was launched at a press conference I held with Rome's mayor Walter Veltroni in June 2007.

Version 2.0 added several more Class I features (e.g., the Colosseum) and also replaced all the scan data from the Gismondi model with new, procedurally generated Class II buildings. The Class II features were shown in the highest level of detail. This version was launched on August 8, 2008 at SIGGRAPH 2008, where it was the featured project.

Version 3.0 added many more Class I features (e.g., the Pantheon, imperial fora, and imperial palaces). The Class II features were shown in the lowest level of detail in order to facilitate use of the model on VR headsets like the Oculus GO. It was launched at a press conference in Rome on November 20, 2018.

Version 4.0 added many more Class I features (now numbering well over 150 urban features) and showed the Class II features

in the highest level of detail. It was launched at a press conference in Rome on November 8, 2023.

How many individuals contributed to the realization of this project, and what was their geographical distribution?

For the current version (4.0), the number of contributors is twelve. They live in Egypt, France, the Republic of Georgia, Italy, the United Kingdom, and the United States.

What specific skills and specializations were involved in the team? How many total working hours and hours per version?

I cannot tell you the exact number of hours it took to create version 4.0 if the model in the period November 2018 to November 2023. My estimate is that it took 1.5 times as many as the number of hours devoted to the project by our 3D modeling team. They spent 9600 hours working on version 4.0, so the total should be on the

order of 14,400 total hours by the entire team. The specialties are: Unity development, 3D modeling, 3D detailing, Roman archaeology, Roman architectural history, and classical art history.

What remote collaboration technologies were used to coordinate the work?

The team communicates using Google Meet.

An estimate of the overall costs and costs per version?

Version 4.0 cost an estimated \$650,000.

What is the overall size of the data?

Version 4.0 consists of 1.4 terabytes.

Considering its volume, what solutions were adopted for storage resource management and the creation of reliable backups?

For reliable backup, we use the LOCKSS approach. We have local backup using a 96 TB NAS formatted with RAID 10. We also backup all our files on Google Drive. As the project manager, one of my duties is to remind everyone to back up their data on a regular basis—no less than once a week.

Did you face ethical or cultural challenges during the creation of the virtual reconstruction?

Ethical concerns fall into three categories relating to the individual contributors to Rome Reborn, the third-party owners of resources we may need permission to use, and the end users. Regarding our contributors, we give them public recogni-



Aerial view of ancient Rome in AD 320. We are situated over the Aventine Hill and look toward the Circus Maximus and imperial palaces on the Palatine Hill. In the background (right) can be seen the Colosseum.

tion through the Credits which always are an integral part of a virtual tour on the Yorescape platform. Regarding third parties, we always obtain licenses for the use of their content or (in the case of archaeological authorities) their sites. We include a notice of such licenses in the Credits on Yorescape. As far as end users are concerned, we voluntarily adhere to the ICOMOS-approved Seville Principles of Virtual Archaeology, especially Principle 7 on scientific transparency.

COMPUTER SCIENTISTS AND ARCHAEOLOGISTS

How did the collaboration between computer scientists and archaeologists evolve during this project?

When the project started at UCLA in the mid 1990s, I naively assumed that as an archaeologist, I could bring my archaeological drawings to a 3D modeling lab at the university, come back several weeks later, and find a perfect 3D model awaiting me. That turned out to be naive. Technicians skilled at 3D modeling but with no background in Roman archaeology were not familiar with Roman building materials, construction techniques, and architectural styles, so they were unable to receive the plans, sections, and elevations and create an accurate 3D rendering. This quickly gave rise to the idea of close, collaborative work involving the 3D modeler and myself or another Roman archaeologist. It quickly became clear that as soon as you wanted to go from modeling an individual building with which I,

as a Roman archaeologist, was very familiar, to a complete city model, you would need the help of a scientific advisory committee of experts. As you say in Rome, “una vita non basta,” so one scholar is hardly likely to have all the knowledge needed to oversee the reconstruction of the entire ancient city. You also needed your own 3D lab if you wanted to ensure quality control. All of this happened rather fast. I raised my first gift from a philanthropic foundation in Los Angeles in 1995 to start my 3D lab and make our first 3D reconstruction: a model of the Temple of Antoninus and Faustina in the Roman Forum. By December 1, 1996, we had expanded the project to include the entire city and had succeeded in recruiting a prestigious scientific advisory committee including such experts as Paolo Liverani (then Curator of Antiquities at the Vatican Museums), Russell

Scott (the American professor who excavated in the Roman Forum for many years), and Adriano La Regina (then the Superintendent of the Colosseum, Forum, and Palatine). We also had sufficient funding to start bringing our American 3D modelers to Rome to study the ruins first-hand so that they could familiarize themselves with the styles, materials, and, above all, the monumental scale of Roman buildings, which is really beyond the ken of the average American.

Since 1996, I have continued the project with the same formula: my own 3D lab employing modelers who visit Rome as frequently as possible working under the supervision of expert scientific advisors. I’m happy to report that Professors Scott and Liverani are still serving after all these years, and we constantly add new advisors as our projects shift from site to site.



Aerial view of ancient Rome in AD 320. We are positioned to the east of the Colosseum (visible below the center of the picture). To the left is the Temple of the Divine Claudius on the Caelian Hill. Across the street from the Colosseum in the Temple of Venus and Rome, the largest of the sanctuaries of the state cult. To the left is the Palatine Hill; beyond can be seen the Roman Forum and imperial fora. In the distance can be made out the gilded dome of the Pantheon.

How did the archaeological community react over time to your virtual reconstruction?

We have been gratified by the positive response of the archaeological community as evidenced by countless invitations to lecture and present our work and also by the willingness of an increasing number of colleagues to adopt Yorescape in their teaching. Our next challenge is to get the archaeological journals to publish reviews of our virtual tours. Yorescape is an example of so-called “New Media,” and scientific journals tend to review only those archaic Gutenbergian productions called “books”. We hope that will change in the not-too-distant future!

Did you interact with academics and professionals? Did you benefit from their feedback during development? Was there any form of peer review? Effectiveness of these interactions?
Our workflow is based on a

constant interaction with academics and professionals. It is they who serve as our scientific advisors and who give us constant feedback. For example, the advisors for “Athens Reborn: Acropolis” were the Director of the American School of Classical Studies in Athens, a professor of Classical Art History at Princeton University, and a professor of Greek Art at King’s College, London. The advisors for “Baalbek Reborn: Temples” were members of the Oriental Department of the German Archaeological Institute, Berlin, which has been excavating the site since 1998.

In dealing with historical data and sensitive information, how did you address security and privacy challenges in integrating advanced technologies?

I cannot recall any instances where an issue of historical data has arisen. Regarding the privacy of our Yorescape users, our

Terms of Use prohibit us from selling or sharing their data to third parties. We try to keep to a bare minimum the private information we require from them—basically, we need just their name and email address for them to log into Yorescape. Finally, we have retained Pryor Cashman, one of the top law firms for US and EU privacy law, to ensure that we act responsibly and within the scope of the law.

FUTURE OF TECHNOLOGICAL INTEGRATION IN ARCHAEOLOGY

Do you anticipate the integration of technologies such as virtual reality and artificial intelligence becoming increasingly prevalent in future archaeological research? How might this relationship evolve?

Yes! VR we already support, at least for our institutional subscribers. Later this month or in February 2024 we will also make Yorescape available on Oculus (probably at first in the App Lab and later in the Store) for our individual subscribers. Our goal is to be “platform agnostic,” supporting everything from mobile devices (iOS/Android) to PCs (Macintosh/Windows), and those VR headsets using the OpenXR standard (Oculus, Vive, etc.).

Regarding AI, the answer is again “Yes!” We already have a prototype AI working code-named “Yorebot.” This is an addition to our user interface allowing our end users to pose their own questions during a virtual tour. We believe in giving our users maximum freedom to move through time and space



Aerial view of ancient Rome in AD 320. We are positioned over the valley between the Palatine Hill (left) and the Caelian Hill (right). In the middle ground is the Aqua Claudia, the aqueduct furnishing water to the imperial palaces on the Palatine. Right of the middle of the picture is the Colosseum.

as well as maximum freedom to satisfy their own curiosity about what they are experiencing.

In this connection, I like to speak of Virtual Tourism 1.0, 2.0, and 3.0. Version 1.0 is basically a live slide show on a service like Zoom. The audience just watches passively, at most posting a question at the end in the chat box. In Version 2.0, the end user is empowered to take the tour whenever she wants, to visit the points of interest in any order following only the dictates of her curiosity, and to toggle between the site as it appears today and the way it looked in antiquity before it was in ruins. So, version 2.0 gives the user with freedom of time and space. With the introduction of an AI like the Yorebot, we get to version 3.0. Now, the user has freedom of time, space, and content.

I would predict a version 4.0 that is built on the metaverse and gives the user the affordances of social interaction, from jointly touring with others to role playing in costume and competing (for example) to rise from low to high status in the culture being visited. Version 4.0 was already predicted in my 1986 conference paper at Apple Computer, which was published in 1988:

Frischer, B. "Project Cicero," a chapter in *Interactive Media. Visions of Multimedia for Developers, Educators, & Information Providers*, Microsoft CD-ROM Library, vol. 3 (1988) 145-156; available online at https://www.academia.edu/36446114/Cicero_a_framework_for_multimedia_projects_for_Classics.

Besides virtual access for the public, do you foresee other future uses of this technology specifically in archaeological research?

Yes, and this is something I theorized many years ago and started to put into practice in the last ten years in a series of publications. My basic idea is that interactive, scientifically valid models can be supports to empirical research allowing archaeologists to go back in time and make observations and run experiences that would be impossible in the real world without time travel. I call this use of computer simulations for empirical research "simpiricism," and I have written about how this is an approach that we can see utilized across the sciences, from Physics and Astronomy to Biology and Economics. Archaeology is rather late to the game, but I am convinced that as the simpirical approach generates

new insights and discoveries, more and more archaeologists will start to adopt it.

If your readers wish to read my simpirical publications, here are some titles and links where they can be downloaded at no cost:

Frischer, B., "From Digital Illustration to Digital Heuristics," in B. Frischer and A. Dakouri-Hild, editors. *Beyond Illustration. 2D and 3D Digital Technologies as Tools for Discovery in Archaeology*, BAR International Series 1805 (Oxford, 2008) pp. v-xxiv; available online at: http://frischer.org/wp-content/uploads/2016/03/Frischer_Heuristics.pdf.

Frischer, B., G. Zotti, Z. Mari and G. Capriotti, "Archaeoastronomical Experiments Supported by Virtual Simulation Environments: Celestial Ali-



Aerial view of ancient Rome in AD 320 In the mid-ground are the imperial fora. The one at the bottom is the biggest: the Forum of Trajan. We can see (starting at the bottom) the Temple of the Divine Trajan and Plotina, the sculpted and painted Column of Trajan flanked by the Greek and Latin libraries, the Basilica Ulpia, and the entrance plaza with an equestrian statue of Trajan. After Trajan's Forum are the Forum of Augustus, the Forum of Nerva, and the Forum of Peace.

gnments in the Antinoeion at Hadrian's Villa (Tivoli, Italy)," *Digital Applications in Archaeology and Cultural Heritage* 3 (2016) 55-79. Available online at: https://www.academia.edu/36445359/Archaeoastronomical_experiments_supported_by_virtual_simulation_environments_celestial_alignments_in_the_Antinoeion_at_Hadrians_Villa_Tivoli_Italy_.

Frischer, B., J. Pollini, G. Capriotti, D. Dearborn, J. Fillwalk, K. Galinsky, C. Hauber, J. Miller, J. Murray, M. Salzman, M. Swetnam-Burland, "New Light on the Horologium Augusti, the Montecitorio Obelisk, and the Ara Pacis," *Studies in Digital Heritage* 1 (2017) 18-119. Available online at: <https://scholarworks.iu.edu/journals/index.php/sdh/article/view/23331>
Frischer, B., with technical

appendices by P. Alberi Alber, D. Dearborn, and J. Fillwalk, "Edmund Buchner's Solarium Augusti: New Observations and Simpirical Studies," *Rendiconti della Pontificia Accademia Romana di Archeologia* (2018) 3-90. Available online at: https://www.academia.edu/38081245/Edmund_Buchners_Solarium_Augusti_New_Observations_and_Simpirical_Studies.

Frischer, B. and D. Massey. "Urban Models as Tools for Research and Discovery." In *Critical Archaeology in the Digital Age*, edited by Kevin Garstlki, *Cotsen Digital Archaeology Series 2* (UCLA, *Cotsen Institute of Archaeology*, 2022) 23-48. Available online at: https://www.academia.edu/74034923/3D_Urban_Models_as_Tools_for_Research_and_Discovery_Two_Case_Studies_of_the_Rostra_

[in_the_Roman_Forum_Utilizing_Rome_Reborn.](#)

What technologies were employed in virtual reconstruction, and how were they integrated?

If I understand your question aright, you are referring to my simpirical research. In that, in addition to VR for making observations and running experiments, I have used the planetarium software Stellarium for archaeoastronomical research investigating possible alignments between built monuments and astronomical features at Hadrian's Villa and in ancient Rome. I have used ESRI's CityEngine for 3D viewshed analysis of structures in the Roman Forum. My collaborator, Prof. Diego Gutierrez used AI and Hierarchical Fine State Machines (HFSM) to study the circulation of spectators in the Colosseum. And my student Julia Puglisi has used I-Simpa for 3D acoustic analysis of an enigmatic feature in the South Theater at Hadrian's Villa.

DIGITALIZATION OF HISTORICAL CONTEXT

How did you tackle the challenge of preserving historical accuracy in virtual reconstruction?

A full answer would fill a book about *ars antiquaria* (which I am writing at the moment!). A short answer is that, first of all, we always consult with our scientific advisors and other experts whom they recommend we contact. Here I should give particular thanks to Prof. Paolo Liverani and Prof. Russell Scott, whom I mentioned earlier. Secondly we divide the sources of data to be used into two classes: archaeo-



Aerial view of ancient Rome in AD 320. We are situated over Transtiberim (modern Trastevere) and look east toward the Tiber River, Tiber Island, and (left) the Campus Martius and (right) Capitoline Hill. On the Tiber Island can be seen (right) the Temple of Asclepius in front of which is an Egyptian obelisk.

logical and literary. The archaeological sources include autopsy (i.e., studying the remains today), pottery, brick stamps, coins, and inscriptions. The literary sources are numerous and have been assembled in various collections, including, notably the (unfortunately incomplete) *Fontes ad Topographiam Veteris Urbis Romae* by Giuseppe Lugli. We always consult the two major reference works in our field, the *Lexicon Topographicum Urbis Romae*, 6 volumes (Rome, 1993-2000) edited by Eva Margareta Steinby and *The Atlas of Ancient Rome*, 2 volumes, edited by Andrea Carandini with Paolo Carafa (Princeton and Oxford 2017). They contain extensive bibliography for the individual features of the city we model. The scientific advisors frequently alert us to new research not yet published. Volume 2 of Carandini-Carafa has been especially helpful to us in getting started with the plans, sections, and elevations of a great many Class I monuments that no earlier scholars have tried to reconstruct. We don't always agree with what they propose, but we find their work the sine qua non for starting the modeling process and thinking through all the issues of architectural restoration. Let me take this opportunity to give a shout out to these two great Roman topographers!

What was the main challenge in recreating accurate details, especially considering the effects of time?

Of course, the passage of time has meant that an enormous amount of information we

would ideally like to have has been destroyed or lies below still unexcavated ground. As I mentioned earlier, these features fall into our Class II. Even the features in Class I can very often not be reconstructed with a high degree of certainty. Our forthcoming final report, which I have already mentioned, will have catalogue entries for each Class I feature. This will allow those worried about accuracy to distinguish between those elements of our reconstruction that are highly certain and those that are less certain or purely hypothetical. In a recent publication I co-authored, I wrote the section about how we handle uncertainty in *Virtual Heritage*:

Stewart, A., B. Frischer and M. Abdelaziz. "Fear and Looting in the Hellenistic Agora. Antenor's Tyrannicides Return," *Hesperia* 91 (2022)

311-350 (my section is at pages 344-345).

I reported on two ways that practitioners in the field have learned to flag uncertainty: through non-photorealistic rendering (NPR), for example, if you make a restored arm on a statue semi-transparent to set it off from the well-preserved parts; and through metadata (MD), that is, through a written report. Given the enormity of the Rome Reborn urban model, NPR was not a plausible approach, so we inevitably adopted MD. As I mentioned, I am now writing a book giving a final report on the Rome Reborn project. A big part of the book (written by my co-author Dr. Alberto Prieto) will present the metadata of the Class I features.

Was machine learning used to analyze historical data during the research phase? What type



Aerial view of ancient Rome in AD 320. Aerial view of the central Campus Martius with (left to right) the Porticus Divorum, the Isaeum, Saepta Julia, Pantheon, Baths of Nero, and Stadium of Domitian. Also visible are the entertainment complexes of the Campus Martius, including (starting at the left along the river) the Theater of Marcellus, the Theater of Balbus, the Theater of Pompey, and the Odeon and Stadium of Domitian (modern-day Piazza Navona).

of data was provided?

No, this has not been possible (at least thus far!).

Let's talk about Oculus. What challenges did you face in optimizing the reconstruction for VR devices like Oculus, especially considering hardware limitations?

We use three approaches to optimizing the 3D data in our 3D reconstructions so that our users can have freedom of movement. The simplest is the creation of 360 panoramic images. Doing so results in a huge reduction of file size. It is appropriate for use in a virtual tour which is, basically, an recreation of real-world tourism which usually involves following a guide from Point of Interest (POI) to Point of Interest. Our users have freedom of movement on the macro scale: they can teleport as they wish from any POI to any other. Of course, once arrived at a POI, many users want to have some freedom to

move around at the micro scale. We offer this possibility in two ways. The first way is by using standard optimization techniques to allow the user to freely roam wherever he wishes in the 3D environment. The second way uses what we call “cinematic free roam” (acronym: CFR). This is the sort of thing you see when you use Google Street View: you can jump from one 360 panorama to the next. If these are close enough together, it can simulate an experience not far different from the first kind of free roaming, but it does so with a cinematic quality of the imagery.

How has the use of virtual reality devices enriched the experience for users?

I would say that there are two ways that VR has enriched our users' experience. First, the scale of presentation is 1:1 and the VR headset is immersive, that is, it completely fills the field of vision and thereby generates a

sense of presence, or of “being there.” The 1:1 scale and the fact that we set the camera height at 150 cm (the average adult male height of the eyes) means that our users can sense the relationship of the features of the scene in relation to their body. We also populate our scenes with avatars, which adds to the sense of human scale.

Secondly, VR helps our users because it has all the affordances needed to “remediate” the traditional ways used to communicate developed by ars antiquaria since the Renaissance, namely written descriptions, maps, and 2D illustrations. So, in addition to being immersed in a 3D scene showing you the site today or the site as it appeared in antiquity, our user interface includes: descriptions of what you are seeing developed in consultation with our scientific advisors (both written and oral); a site map showing you all the stops on a tour with a legend identifying them; and an information window in which we can show you relevant texts and 2D views providing background information you will find helpful in understanding what you are seeing. Our intention is to use this multimedia approach to make it as easy as possible for students new to the field or to the general public to understand how experts interpret the monuments.

How did you address design challenges to ensure an intuitive and accessible user interface, especially in a virtual reality context?

Yes. We have a UX expert on staff who ensures that our user



Aerial view of ancient Rome in AD 320 showing the Baths of Caracalla, one of the major public recreational facilities built by Emperor Caracalla (ruled AD 211-217).

interface is as intuitive to use as possible and that it takes advantage of the conventional solutions that have developed in this sector.

Does Rome Reborn allow specific user interactions?

The Yorescape user interface supports the following temporal features: taking a tour whenever you want; prompting you about what you have and have not yet seen (especially useful if a useful takes a tour in small chunks of time spread over several days, weeks, or longer), and toggling between our contemporary world and how the site appears today to the ancient world and how the site looked before it fell into ruin. It also supports the following spatial features: teleportation from point of interest to point of interest following your curiosity, and freely roaming around the site using “cinematic free roam” (CRF). In terms of content, Yorescape offers short audio clips (typically 1 to 4 minutes in length) in which an expert interprets what you are seeing. English is the base language for the audio, though on some tours we offer a variety of languages. On all tours, we also allow you to turn on or off the Closed Captions, and we strive to offer a selection of major languages ranging from Chinese, English, French, and German to Italian and Spanish. Often, the expert will reference pieces of evidence (such as an inscription) which you can display by clicking the “i” icon to open the Information Window. As I mentioned, in the next version of Yorescape, we will add even more content

freedom by implementing the Yorebot across all our tours and integrating the related icon into the user interface. Finally, we do support one key social feature: Group Tour. We have turned this off at the moment because we have found virtually no demand for it from our users, and it costs a lot of money for the company to support. But, we have this in case (perhaps as the metaverse takes off) it is ever needed.

Was there involvement of generative artificial intelligence in enriching the historical narrative or providing contextual information during the VR experience?

As I mentioned, our user interface will soon be enriched with the Yorebot, an AI solution built on OpenAI that makes it possible for the user to ask whatever question he wishes to pose while on one of our tours. The Yorebot is working quite well on

one of our shorter tours (Rome Reborn: Basilica of Maxentius). Now we simply need to apply it across all fifteen of our tours and work out the best way to add it to our user interface.

RECONSTRUCTION OF MISSING PARTS

How did you integrate photogrammetry into the detail acquisition process?

Yes, we have done lots of photogrammetry. Indeed, our company’s second streaming service (which I have not yet mentioned) is our Virtual Museum. It has over 700 interactive 3D models of classical sculpture and furniture almost all made by photogrammetry. The museum allows our users to study an individual work of art in isolation, taking advantage of the museum’s ability to let you pan, rotate, zoom, and change the lighting. We also provide standard metadata for the object



Aerial view of ancient Rome in AD 320 showing the Mausoleum of Augustus. Located near the banks of the Tiber River, the structure was due north of the Pantheon in the middle of a park laid out by Augustus in the Campus Martius. The tomb was topped by a colossal statue of Augustus. Inside were buried most of the emperors and imperial family members in the first century AD. The last emperor buried here was Nerva (ruled AD 96-98).

(name, material, dimensions, museum, inventory number, link to vetted scientific information, etc.). Yorescape then recontextualizes the individual work of art, showing you where it came from in antiquity. So, you can, for example, study the Hercules Farnese in the Virtual Museum, viewing it from all angles and under different lighting condition. You can see its current state in the MANN and also its restored state reflecting the polychromy research the “MANN in Colour” project. Then, in Yorescape, you can visit the Hercules Farnese in the Frigidarium of “Rome Reborn: Baths of Caracalla,” learning how the decorative program of

the Frigidarium revolved around the myth of Hercules.

Which programming languages were predominant in the development of Rome Reborn? Are there specific languages that proved particularly suitable for this challenge?

The main use of computer programming has been in the development of Yorescape (www.yorescape.com), our delivery platform for Rome Reborn and our other virtual tours. These are built on the Unity platform, so any unique features we have to create are programmed using C#.

Looking ahead, do you foresee

the development of interactive AI-based devices allowing users to verbally interact for exploration in specific ways and areas?

Yes, I already imagined this in the 1986 paper given at Apple Computer. As I mentioned, we have developed a prototype AI code-named “Yorebot” that has the function of allowing the users to pose their own questions during a virtual tour.

What were the testing and quality control methods for the virtual experience?

We have a UX specialist who is responsible for our in-house testing. Afterwards, our virtual tours are tested in classroom situations by the teachers whose



Aerial view of Rome Reborn 4.0, the 3D digital reconstruction of the entire city of ancient Rome within the Aurelian Walls as it appeared in the year AD 320.

institutions have subscriptions to Yorescape. Many of the early adopters are colleagues I know quite well, and they have been very forthcoming in providing feedback which our developers have taken to heart in making adjustments to Yorescape.

What are your future projects, and what improvements do you plan to pursue in the coming years?

If you read my Apple conference paper of 1986, you will see that what we have been able to achieve thus far is just the beginning of a much more elaborate simulation in which students can, for example, play the roles of ancient inhabitants of Rome and learn to speak Greek and Latin. In other words, I see the metaverse in the future of what we are doing. Virtual tourism is just a baby step toward that goal.

Some may fear that offering virtual experiences of historical places could negatively impact traditional tourism. How do you respond to this concern, and how do you see the coexistence of both experiences?

We always stress that the purpose of virtual tourism (at least as practiced at Flyover Zone) is not to replace real-world tourism but to enhance it. We think we accomplish this in several ways. First, virtual tourism can raise awareness of cultural heritage sites that are unknown to the general public but worth visiting. If we succeed, it should increase tourism to sites not visited as much as they merit. It can also help tourists to prepare for a trip before they leave

home so that they get more out of their visit to the actual site. Once arrived at your destination, a virtual tourism app like Yorescape can be useful as an AR app allowing you, for example, when you visit the Roman Forum to visualize how this complex site looked before all the monuments fell into ruin. Finally, when you return home, you can use Yorescape to keep your memories alive and to share them with your family and friends.

ADVANTAGES OF VIRTUAL REALITY OVER PHYSICAL TOURISM

Can you outline the unique advantages offered by virtual reality over physical tourism? How can the virtual experience enrich individuals' interaction with historical sites?

To the advantages I mentioned in the answer to the previous question, I would just add that virtual tourism is especially valuable in helping people with disabilities that prevent them from traveling great distances. Likewise, people who simply cannot afford the time or money to travel can at least have a virtual experience of sites they would otherwise like to visit.

EMOTIONAL ENGAGEMENT

Virtual reality can evoke deeper emotional engagement compared to a physical visit. How did you work to create an emotional connection between users and Rome?

I think that both real-world and virtual tourism can (and, ideally, should) arouse positive emotions. Real-world tourism

has the advantage over virtual tourism of engaging the visitor with the place, people, and culture they are experiencing. New friendships can be formed, new food preferences can be developed, you can shop, and, when the sun starts to set in the late afternoon of a day with a clear sky, you can see why Rome is called "aurea." In short, virtual tourism will never be able to replace the experiences that simply require your physical presence in a place.

In contrast, virtual tourism can take you to the Rome of 1,700 years ago, something a visit to today's Rome cannot compete with. We find that when our virtual tourists use our time warps to toggle from the "now" to the "then" view of an archaeological site, they often feel a sense of awe when they see the ruins spring to life. Here one can think of the "Stendhal Effect" as an extreme case of the emotions that can be aroused when a tourist sees something they have been thinking about for many years and thought (because time travel is impossible) you would never actually be able to experience.

FUTURE PERSPECTIVES AND DEVELOPMENTS

Looking to the future, what developments do you anticipate in the use of virtual reality in the tourism sector, and how do you plan to address the challenges and opportunities that may arise?

As you know, XR is already being widely used in Rome. Think of the Vrbus, the AR/VR apps available at archaeological sites

such as the Domus Aurea, the Baths of Caracalla, and the Ara Pacis. What happens in Rome—one of the most important tourist destinations in the world—is noticed in many other places. So, I am very confident in predicting that in the near future VR and AR will increasingly become part of the global tourist ecosystem. As this happens, I like to think that serious adventure games will be developed that will be hybrid involving users at home and users on site (that is, at iconic tourist destinations). The two categories of users will be rewarded by meet challenges involving finding out-of-the-way features (for example, all the “talking statues” of Rome) and interpreting them. The work of finding can be done by the on-site tourist in the online game, and the work of interpretation by the player at home. One can imagine how this could even be commercialized by adding some challenges whereby a shop, snack bar, or restaurant is the place to be found. On-site players can be given a free drink in a snack bar or a meal at a restaurant. The at-home players can be given famous recipe from a restaurant or a gift certificate that can be used in a shop’s online store. There can be lots of posting of the avatars of the at-home and on-site player together at the place of the challenge. The goal of such a game is to convert tourism from a passive experience it usually is to an active (and fun!) adventure of learning and personal growth.

IMAGES NOTE

The phase of the city seen in these renderings occurred 1,700 years ago. The modern city sits an average of 7 meters above that seen in AD 320. Not surprisingly, over 99% of the ancient city has vanished, leaving behind only random ruins seen throughout the city today. Created from 2018 through 2023 under the supervision of an advisory committee of experts, Rome Reborn 4.0 is a scientific model based on the latest findings by Roman archaeologists and topographers.

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ABSTRACT

L'idea di instaurare Romam ha un padre nobile: lo storico e umanista rinascimentale Biondo Flavio (1392-1463). Oggi noi riconosciamo la modernità e l'attualità del suo proposito nel non limitarsi a una ricostruzione statica, ma nel voler offrire un'idea dello sviluppo della città e delle funzioni dei suoi edifici. Un lavoro tenace di riconoscimento dei resti dei monumenti antichi nelle trasformazioni successive del tessuto urbano, mediante il costante confronto delle fonti scritte con l'osservazione diretta dei luoghi e dei monumenti.

Quest'idea, questo metodo, lontani dall'essere dimenticati, vedono circa sei secoli dopo un professore visionario - ha insegnato in varie università statunitensi (UCLA, Virginia, Indiana) - proporre una ricostruzione dell'antica Roma. Si tratta di Bernard Frischer, archeologo digitale, e la versione 4.0 di Roma Reborn, la sua affascinante restituzione digitale dell'antica Roma all'interno delle Mura Aureliane, è stata presentata qualche settimana fa a Roma. Frischer è fondatore e presidente di Flyover Zone Productions (fondata nel 2016), una società con sede a Bloomington, Indiana, che ha come missione la commercializzazione di prodotti e servizi che utilizzano tecnologie digitali 3D per presentare al grande pubblico siti e monumenti del patrimonio culturale.

Ventisette anni di lavoro ininterrotto attraverso le grandi, veloci trasformazioni tecnologiche di questi anni, Frischer ha investito nella rilevazione e nell'acquisizione dei dati, nelle banche dati, nei servizi sempre più innovativi, nel mondo delle reti e del wearable computing, e molto altro ancora.

La ricostruzione digitale di Roma antica affronta notevoli sfide e difficoltà nell'accurata ricostruzione dei monumenti. Alcune proposte suscitano inevitabili controversie; tuttavia, in confronto al tradizionale plastico di Gismondi, Roma Reborn 4.0 si distingue come un modello tridimensionale percorribile, dinamico e versatile, stimolando per questo motivo l'opinione di chi lo consulta e lo utilizza.

Il suo utilizzo non richiede necessariamente un'accettazione acritica delle ricostruzioni proposte, ma, aspetto prevalente, piuttosto fornisce un terreno fertile per esplorare e discutere la storia da nuove prospettive. In questo modo, si configura come una risorsa educativa e turistica che va oltre la mera riproduzione del passato, rendendolo accessibile e coinvolgente per chiunque vi si avvicini. Uno strumento aggiornabile con il progredire della ricerca ogni qualvolta si raggiungano soluzioni convincenti e condivise per ogni singolo monumento.

Affettuosamente conosciuto come Bernie tra gli amici, grazie alla sua cordialità e affabilità, Frischer ci onora della sua presenza da anni tra i membri del Comitato scientifico di Archeomatica. Con piacere e disponibilità, condivide in questa intervista ora con noi e con i nostri lettori riflessioni e dettagli del suo lavoro di questi anni rispondendo alle nostre domande.

KEYWORDS

ROMA, VIRTUAL TOUR, YORESCAPE, AR, VR

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