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Nooks and Crannies in Visible Cities: 3D Re-imagining Techniques for Archaeology and Architecture in Film

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Abstract

With the success of the BBC and PBS series such as *Italy's Invisible Cities* (2017), *Ancient Invisible Cities* (2018), and *Pompeii: New Secrets Revealed* (2016), made in collaboration with ScanLab and employing LiDAR scanning and 3D imaging techniques extensively, popular television programmes grasped the aesthetics of spectral 3D mapping. Visualizing urban topographies previously hidden away from view, these shows put on display technological prowess as means to explore veritably ancient vistas. This article sets out to investigate cinematographic devices and strategies – oscillating between perspectives on built heritage championed by two figures central to the 19th-century discourse on architecture: Eugène Emmanuel Viollet-le-Duc and John Ruskin – manipulating the image in a rivalry for the fullest immersion into a traversable facsimile of past spatialities.

By the waving of the skeletal trees, closer and closer
Through the doors and through the walls and...
Justin Sullivan

In contemporary 'moving pictures', any flight of fancy can be executed by means of digital cinematography and other actions involved in the process of image processing. Companies such as Double Negative, Uncharted Territory, Scanline VFX, Method Studios, Legacy Effects, or Rodeo are well into their second, third decades even, utterly devoted to the task of placing unwieldy creatures and settings in effects-driven spectacles, while an 'arms race' between these actors in the image-making industry escalates in ever higher levels of photographic verisimilitude.

This article, however, looks into cases where these proportions of accuracy and aestheticization are inverted by the scientific paradigm, with the reconstruction of digital objects pushed to the limits of archaeological expertise. There is more to visualization than the eye is expected to meet, at least when inspecting the area in question. While cinema accustomed us to seeing only that which is presented to the camera, archaeological restoration – employing LiDAR scanning as an increasingly resourceful technology of environmental data acquisition – allows imagination to epistemically complete the lacunae in the findings. Reconstructing material objects (stage props and pieces of set design in film; artifacts in archaeology and heritage conservation) as digital props on screen can be followed through in the narrative itinerary of the BBC and PBS series: *Italy's Invisible Cities* (2017), *Ancient Invisible Cities* (2018), as well as their 'predecessors' – *Rome's Invisible City* (2015) and *Pompeii: New Secrets Revealed* (2016). Their popularity brought in a surge of sibling TV specials, each incorporating segments of 3D visual modeling employed for architectural surveying, showcased in their plots as cutting-edge techniques to retrieve information on antiquity. Among the basic premises of these shows we can discern the assumption that even long forgotten past(s) can be accessed through 'light detection and ranging', yet the degree of artistic interpretation involved in the process testifies to another side to the story. The limits of our retrospection are defined by our competences in interpreting the finds; more importantly, by an awareness of the technological framing these limits – a 'ground truth' for heritage reconstruction since the 19th century.

This is far from suggesting that cinematic period pieces do not involve historical accuracy and credibility when recreating digital ornaments and historical set extensions, enshrouding them with the patina of the age. The digital age simply took set dressing to a new level by blurring distinctions between matte paintings and real buildings; moreover, it provided novel solutions to sweeping camera moves, capable of gluing together footage shot in geographically distant locations, as if we were viewing rooms of the same apartment. To a certain extent, the tasks of preparing a complete virtual scale model of a city, along with its past strata – equivalent for an advertising slogan for the series – can be compared to designing a virtual set for a feature film. Each is a navigable illusion, presented for (temporally) limited scrutiny. Both are precise when it comes to details, but far from objective in terms of arbitrary decisions involved in manipulating source materials. This study aims at understanding how – by means of cinematography, 3D visualizations, and narrative – the technology of LiDAR scanning, combined with pho-

togrammetry[1] and 3D modeling, transforms the viewing experience (for the shows, and – by affinity – multiple other film projects), challenging our reading of the filmic space. All examples picked for the case studies employ complex digital reconstructions of archaeological, mainly subterranean infrastructures, as shown in the aforementioned BBC and PBS series. Here, long lost or previously unseen layers are mapped, and rendered into scaleless 3D models, revealing the past's 'untold secrets'.

Introduction: magnetism of the underworld

The Underworld has always had its sickly allure, and not just for Dante. Centuries of subterranean speculative fiction writings on Etidorhpa, Vril, or Symzonia[2] have established a rich tradition of locating forgotten or unknown utopian communities deep below ground, which are often unaware of the march of progress above. The narrative threads of the BBC and PBS series with "Invisible Cities" in their titles also boldly reaffirm aspects of secrecy, lost memories and their digital retrieval, underwriting each episode. The subterranean world is put on virtual display, referred to by names associated with childhood memories – a tabletop train set, a dollhouse digital diorama. In Mary Beard's words, all this is executed with the aid of technology which helps produce the most accurate and detailed 3D map of a city composed of so many layers that history has to reappear as sinkholes, disrupting the fabric of the everyday, in order to draw attention.

Although the series' narrative does not break away from the generic standard into some unhinged structural detour, its finale confronts the spectator with an overlaying of visual planes – live action footage and 3D models – presenting an interplay between the two, as if we were taken back in time to a mid-1990s cyberspace adventure, which would have felt incomplete without a VR headset (nowadays, Oculus Rift). The show's presenters take us on tour through world-famous and myth-wealthy cities, promising to uncover their pasts by means of previously unavailable technology – that is, a FARO Focus3D Laser Scanner. Primarily devised for collecting topographic data, LiDAR, which stands for "light detection and ranging", uses pulsed laser light for a 'time of flight' measurement of distance (the emitted laser beam is reflected by the object's surface, and returns to the sensor). As hundreds of thousands of such light pulses can be emitted per second, the apparatus maps the surrounding environment (in its on-the-ground, i.e. terrestrial applications, as opposed to traditional aerial photography/scanning) with utmost precision, becoming an invaluable aid in land surveying, as well as spatial documentation in a constantly increasing number of fields: archaeological excavation, architectural preservation, film set design, and even crime scene forensics. At the tail end of the process, we receive an image of the mapped terrain resembling a 'nebula' of topographically accurate points, delineating three-dimensional silhouettes of every object that found itself on laser beam's path. The outcome resembles a digital descendant of a plaster cast, ready for further modeling. Guided by the itinerary of a travel show, while resting on the premise of 3D scanning technology, we are taken on a tour around the city, while 'at the same time' a team of surveyors works on site, gathering image data from subterranean levels. Not simply exploring, but comprehensively imaging its hellish shafts, caves and under-

ground mazes, the enterprise concludes in the creation of a full stratigraphic representation of the city. What instantly captures attention is not just the point-cloud model's spectral look, but the possibilities at hand in manipulating the resultant 'cast' – it can be rotated, zoomed in on, re-scaled to human size, or shrunk, while remaining suspended in black void. Consequently, the entire scanned infrastructure becomes exposed.

Visuals are meant to dematerialize the landscape on screen, being evocative of a language that evidences an unprecedented treatment of the filmic space – an expandable afterimage superimposed on the footage. These can be glimpsed at in subsequent previsualization inserts, in each episode. At the end of the day, *Invisible Cities* series serve as a demonstration of the intricacies of image-processing in contemporary pipelines for 3D visualization and cinematic digital post-production, precisely because we can look into the process, collating placeholder renders embedded in the footage with further stages of digital environment creation. Unlike big budget productions, however, scanning, masking, photogrammetry and compositing are presented as open-ended. Instead of a technological showcase in its final stage, we can inspect the 'magic' at work. After typical VFX feasts we are usually less likely to question the algorithms behind the visuals.

In one great swipe, a virtual camera glides over the reconstructed landscape, assuming perspectives impossible to achieve in real life – from architecture's every nook and cranny, down to a darkened niche. Another advantage comes with the newly discovered interconnectedness of finds that are scattered temporally as well as spatially – an aqueduct is revealed to run in parallel to a metro line, next to labyrinths, catacombs, cellars, water tanks, or air-raid bunkers, together spanning not decades but centuries in the urban timeline. We can inspect the landscape in a myriad of improbable ways, looking at the city from below, where we plunge to obtain a reversed bird's eye view on the infrastructure of underground tunnels, streets, and hollowed out buildings.[3] Located on the outside, we notice the contents of chambers and catacombs projected onto semi-transparent walls as mirror images. From a worm's perspective, each floor plan is mirrored, every room is lit up like a frosted glass lamp. A sensation of the uncanny is reinforced by a perforation of black holes or circle-shaped voids delineating tripod positions of the FARO Focus X HDR.[4] Netherworldly as it is, the shows' presenters do not seem to mind such cognitive dissonance, walking in VR headsets upon reconstructed streets, crawling in previously inaccessible tunnels of the Great Pyramid, or themselves resorting to childhood games, when pasted into an amalgam of film footage and 3D renderings.

When on set...

The above should not come as a striking revelation, given the fact that 3D scanning technology's intended application is terrestrial mapping, which strives for a seamless representation of the terrain. Thus, on film sets LiDAR scanners are an increasingly welcomed nuisance, which takes over some of the competences from the proverbial 'continuity girl'. Historically, the role of a female secretary was to carry around an annotated shooting script, in order to step in whenever necessary, providing insight into narrative sequentiality, checking prop setups down to intri-

cate details – for example determining which side of a coffee mug was previously visible to the camera, in a scene filmed weeks before. Mistakes would happen anyway, so nitpicking could evolve without much constraint. On 21st century sound-stages, changes far more radical than revising this profession's gender bias have been implemented. Carrying a digital camera (smartphone) remains a life saver, yet the amount of post-production work outsourced from art departments to maverick visualization companies requires excessive data gathering and documentation during production. A LiDAR scanner mounted on a tripod in the exact position where the camera executes a 360-degree pan in the scene does not just survey the entire set, but also registers the dimensions between interacting objects and structural elements, creating a 'holographic Polaroid' of the scene. At later stages of film production, this 3D freeze frame will come in handy in transitions between scenes – substituting a hard cut with a smooth 'crane shot' that would link an exterior view of the street with the apartment's interior, dematerializing the wall in a complex, dynamic VFX shot, employing both virtual and actual cinematography. What formerly necessitated a wild wall or a soft dissolve, in contemporary films can be visualized as an illusion of the cine-eye penetrating through walls and solid objects. In fact, such transformations are almost always instances of 3D animated film segments, where computer algorithms approximate the scene in between 'neighbouring' key frames. Both the apartment interior and the street scene have to be reproduced as 3D doppelgangers. By matchmoving[5] the transitions of the camera in live action footage are now stitched with wireframe models under graphic software – like Maya, 3ds Max, Houdini, or Sketchup – in order for the 3D model of the scene to align perfectly with the rushes (in terms of angles, sight lines, etc.). As the LIDAR scan resembles a 3D game environment, refurbished as a film set, the practice of 3D scanning in the pandemonic universe of big budget productions is thus ideal reference material at later stages of production – an 'on call' continuity girl who can save the day even when the shooting has already been wrapped.

Towards the great unraveling – the narrative structure

In Naples we explore the Bourbon Tunnels, in Venice we do not refrain from *scanning the entire length of the Grand Canal and the naval might of the Arsenale*.[6] We take a walk along the Vasari corridor, the construction of Brunelleschi's Dome. Among all these upcoming attractions hides the narrative structure of the show, which embeds state-of-the-art 3D sequences into a travel show/historical documentary. Exploring the oldest continuously inhabited cities in the world, we are turned into VIP visual tourists, 'granted special access' to closed-off districts, tunnels, places. As the main premise of *Invisible Cities* states, there is an explicit resurrectionist storyline, because the technology at hand, while uncovering forgotten facts, recreates and establishes new connections, previously only speculated on. Just as in non-virtual guided tours, a linkage between attractions needs to be established, shedding light on their distinct histories. *Narrative construction, a key element in exhibiting heritage, forms the content for the curator and charting the route of the tour becomes the central activity of the cultural display. However, what really makes the walking tour a "living exhibit" is the performance of the narrative. It is the art of constructing a narrative, executing, and*

performing it that functions to link the audience with the culturalscape, such that the nar-
rative is the medium by which the presenter acts as a catalyst between the viewer and the
viewed.[7]
When in the finale the presenters enter into a virtual reconstruction of the scenery,
they go through moments of revelation, for example by targeting the location of
a robbers' tunnel in relation to the entrance to the pharaoh's burial chamber in the
Great Pyramid. Complete 3D models of eponymous cities are superimposed on
the presenters' personal space. They interact with models, while at the same time
attempting to explore these settings 'stitched from thousands of images'. Lost
memory of the ancient world is being retrieved and superimposed on an enclosed
projection space, like Myron Krueger's *Videoplace* (1975), although conceived as an
objectivized mental map. The goal has been reached, because the border between
a mock-up and a landscape frozen in time is constantly trespassed by optical
explorers, being at once traversed and gazed at. All this happens on screen, despite
evident 'lacunae' visible in the photographically accurate picture. Dregs of noise
and production marks draw our attention to the technique employed – the
proverbial 'stitches'. The animated fly-throughs and table-top cities therefore act
in the series as a cognitive aid. They reveal 'true secrets', while positioned in an
ambiguous relation to the presenters – at times, a scaled model, at others, a life-
sized virtual facsimile. However, this polarity is only the latest, 'digital'
manifestation of a centuries-long dispute over the adherence to either conservation
of a dilapidated state of the artifact, or an artistic rejuvenation thereof – no less
controversial in relation to immaterial objects, especially wherever 3D printing is
involved.

Of preservation and reconstruction

The nineteenth century saw the emergence of two radical positions concern-
ing the reconstruction of antiquity's image; they became a repository of ideas for ar-
chitecture, as well as constant reference point for archaeology. This discussion
between restoration and conservation of architectural legacy became the plinth on
which heritage discourse is based, yet in the light of digitalization of excavation sites,
artifacts, and buildings, it is being actively reinterpreted.

a) Viollet-le-Duc (reconstruction)
Originally, Eugène Emmanuel Viollet-le-Duc saw restoration as means *to re-*
establish a building to a complete state, which may actually never have existed at any given
time.[8] However, an 'updated' standpoint should recognize the advantageous position
of an expert in handling historical data, which summarizes issues central to restoring
ruins at any given time in the history of the field. This includes still recent contro-
versies around the digital reconstruction and 3D printing of the destroyed Arch of
Triumph in Palmyra. *Architectural reconstructions are the result of a selection process –*
not every building is supposed to be re-erected/recreated, not every layer of history preserved
– and they are a product of the construction of meaning with reference to historical events or
by singling out a particularly notable monument of a given period.[9] In 2016, a scaled replica
made it from Trafalgar Square into the headlines of archaeological magazines. Re-
constructed by the Institute for Digital Archaeology in Oxford, the traveling post-
digital monument unfortunately displayed a downgraded level of ornamental

details and simplified material texture. Given that the *usage of laser scanners is justified for objects, monuments, and sites with complex geometry, a lack of texture, and a lack of light. The quality of the results depends largely on the object's reflectivity*,[10] this successful technological reconstruction turned out to be a moderate failure for preservationists.

b) Ruskin (conservation/preservation)

Viollet-le-Duc's main opponent, John Ruskin, would have been against such interpretive efforts in the decision-making process. For him, *the greatest glory of a building is not in its stones, nor in its gold. Its glory is in its Age*,[11] and while we can agree with his flamboyant idealism, pure preservation is rare, however much we praise instances of ancient engineering, like the presenters calling Rome *crumbling ruins* that *were once the cutting edge of technology*. The pipeline of terrestrial laser scanning, photogrammetric reconstruction and modeling of digital artifacts updated the long debate on the approach to conservation of architectural heritage, as in its case both Ruskin's and Viollet-le-Duc's stances are given justice. Scanned objects are 'temporarily arrested'; their digital correlates immortalized through documentation, and subsequently turned into 3D models. Thus, they are reconstructed following a recipe that mixes expertise (data gathered on site, photographs and point-clouds) with artistic interpretation (retouching colours, correction of lighting, tone variations, reflections, correction of topological errors, cleaning up noise, generating textures for parts filled-in). Moreover, they juxtapose various strata of the past with modern interferences, because scanning is not selective. This becomes all the more apparent in the Istanbul episode of *Ancient Invisible Cities* (2018), where tourists visiting Hagia Sophia turn into statues.

c) authenticity/patina

Does digital reconstruction always have to stray from beautification when striving for authenticity? Where 19th-century reconstruction works often failed, modern-day algorithms confront issues of: veracity (authenticity of digital reconstructions), objectivity (the degree of alteration of the finds, data sets, cloud-points/meshes), and technological blind spots against the axiom of lacunae – missing fragments of structures, lost to erosion, natural disasters, aging of materials, and mechanical damage or destruction, always taken into consideration during contemporary preservation/reconstruction projects. Instead of purification, however, the models exhibit not just the age's 'patina', but scars, disfigurations and blemishes. 19th-century restoration practices aimed at resurrecting the fallen grandeur of Ancient Rome, in turn influencing the neo-historicist movement. Evidently biased and selective, this view of ancient days is now seen as a retort to progressive industrialization. Does contemporary practice of digitization display emphasis on the objects' material structure (surface, texture, discolouration, etc.) in equal degree? When the mystery of the past is threatened by total transparency, materiality becomes the holy grail. The geometry of the objects/finds and their textural aesthetics are put to the forefront in the absence of mass, tactility, and other features excluded from the protocols of graphic representation. *The material world carries weight – aura, evidence, passage of time, the signs of power through accumulation, authority, knowledge, and privilege. Replicas, on the other hand, are perceived as the opposite of all of these – immediate, surface, temporary, modern, popular, and democratic. In*

other words, this discussion emphasizes a dichotomy between original (authentic) artefacts and inauthentic replicas.[12] In addition, potential lacunae in scanned artifacts also derive from digital artifacts, when we reconsider digital documentation as a substitute for the original. *Current 3D digitization methods do not include the ability to capture the material information, and practitioners do not always take care to calibrate the color in their 3D captures. This becomes particularly dangerous when the public is led to believe that 3D digitization is actually preservation, and we cease to care for the monuments in the same way.*[13] Indeed, wonders are waiting to be performed in the area of resurrecting the past's comprehensive visual imaginary – as the creators of *Invisible Cities* convince us with each new episode – yet at this point a wholesale 'total recall' would have still suffered from 'episodic memory loss'.

Errors and lacunae

'Digital dust' is a hefty metaphor used by Dr Michael Scott in an episode of *Ancient Invisible Cities: Istanbul* to describe the process of data acquisition by the laser scanner, as if the laser beams settled like tiny specks on the facades, retaining their form. The distance is measured by the phase comparison method, obtaining a dense cloud of reference points. *Laser scanning, broadly, refers to the collection of tens of thousands to millions of data points through shooting lasers onto an object and recording its position in 3D space (relative to the scanner). Points from laser scanning, in addition to spatial coordinates, also can contain limited color values, originating from a camera often included in the laser scanner.*[14] Its applications in archaeology and heritage conservation is therefore broad, which does not mean that the process itself is free from potential errors occurring at scanning and model-making stages – the first coming from atmospheric conditions (temperature), reflectiveness of the object's surface (albedo), speckle noise. For this reason, glass and steel skyscrapers (reflectivity) are difficult to work with, when creating their 3D facsimiles in film; nonetheless, with their oversimplified geometry, they pose minor resistance to model makers. The second source of potential problems pertains to the degree of interpretation involved in digital fabrication process. Despite accuracy, the data gathered on site might be incomplete, or the artifact itself may contain lacunae. For example, *for very dark surfaces (black) which absorb most of the visible spectrum, the reflected signal will be very weak. Thus the point accuracy obtained from the measurements will be affected by errors (noises). High reflective surfaces (e.g. white surfaces) yield strong reflections. …* Also, *when the laser beam is dispersed on an irregular surface, the deflection results yields a random model known as speckle noise.*[15]

Nevertheless, the *reconstruction of archaeological fragments includes a high degree of uncertainty. Typically this task is taken up by archaeologists, who interpret available data and propose the initial state of an artifact based upon its type, structure, technologies, materials, ornaments, scale in comparison with other similar objects.*[16] The possibility to visit extinct sites is obviously alluring. By kind permission of 3D modeling, we are able to walk the main street of Pompeii before it disappeared beneath volcanic ash. There is a great difference between 'simple' yet spectacular visualizations created for TV/film and actual 3D reconstructions of historical buildings and urban scenes. In each of the episodes, the presenters and scanning crew put great emphasis on professional aspects of the undertaking – resolution, accuracy, comprehensiveness

in terms of creating a complete and first this detailed digital map-model of the site (Pompeii, Naples, Rome, etc.). Still, a *visualization is only an illustration of the past without a scientific basis; a digital 3D reconstruction is in contrast a detailed digital replica of such a Cultural Heritage site based on the respective scientific state of knowledge. The level of detail as well as the model structures of such digital 3D reconstruction ranges from an urban level as a general overview up to a detailed digital replica of a building or a building element.*[17] What the facsimile lacks is inaccessible, mutilated areas. While a historically accurate volume is the outcome of visualization processes, there is still room left to speculation.

What the TV documentary continuously reaffirms is that LiDAR allows one to fully appreciate the genius of ancient craftsmanship, the *jaw-dropping engineering achievements hidden underneath the city* (Rome). Each building acquires its spectral double, and while we are shown the 3D model for most of the time, the show's presenters – as well as its producers – are more than willing to playfully superimpose the virtual cast on material surroundings. Even though transitions from a buried chamber to cathedral catacombs unfold 'by proxy' of a comprehensive 3D model of the urban underworld, there is no overriding intent to beguile the viewers, fooling them into a 'willing suspension of disbelief'. As the show strives for fulfilling its scientific claim, visualization tools in operation are presented for what they are supposed to be – cognitive aids. Nevertheless, we can easily imagine how these would make spectacular money shots in a rebooted sequel of a spin-off of *Fast&Furious*' 25th installment.

The resolution of post–processuality and visualizing uncertainty

While the show displays a positivist, techno-fetishist processualism, the perspective of resolution studies urges us to inspect protocols of image creation with more rigour. Despite scientific scrutiny in scanning and modeling, the noise *is ubiquitous in measured data. Surface mesh models built using measurement data obtained using 3D range scanners necessarily contains some type of noise.*[18] Even if the process of 3D scanning is considered as indisputable because of high definition/accuracy involved in creating 'clouds' containing billions of reference points acquired by the terrestrial scanner, the pipeline of model preparation introduces a range of subjective opportunities, which the post-processual archaeology of the 1980s saw as interpretative.[19] For example, a *2.5D scanning rig (a rig with just one 3D scanner) can only provide the surface data for one side of a scanned object. As a result, the final scan of an object, or space, includes blind spots: the backs of the objects and the shadows cast by objects in front of an object which, depending on the display technology, may show up as empty white shells.*[20] Blind spots, where data is unavailable, make space for professional (academic) expertise and bring decision-making stages into the reconstruction pipeline. Especially when reconsidered in the context of an educative, yet simultaneously entertaining program's attempts to beautify or purify the virtual reconstructions, as they are enthusiastically embraced, bringing in clarity, communicativeness and appeal.

In the age of digital documentation, often the focus is primarily on geometry, particularly with the increased accessibility of photogrammetric digitization techniques. This has generated a buzz in the public mind that sees 3D documentation as preservation, even

though it only records one aspect of cultural heritage.[21] Resolution is the central issue. The reconstruction of the Palmyra Arch already strained the delicate membrane between scientific reconstruction and public bedazzlement, due to time constraints imposed on the creators, in turn spawning less adherence to details – a characteristic perpetually presented as prime feature of this emergent technology. What centuries of archaeology accustomed us to is that excavated finds are rarely complete. Already the magnificent remnants of the ancient Roman empire, when fantasized about in Piranesi's engravings, employed a tragic sublime aesthetics of fragmentation, incompleteness, ruin. Becoming accustomed to a sense of permanent lack, it might be a shock to instantly grasp the ontological shift that came with 3D visualization, terrestrial scanners, and GIS positioning, especially as presented in the *Invisible Cities*. There is an ardent agitation in the BBC and PBS series, an air of completeness, as presenters keep emphasizing the integrative capabilities of the technology. Constructing a comprehensive model of the historic city is thus presented as the final 'assignment' for each episode, although it is in generating amazing and unexpected spatial connections where the show really excels.

Ancient Invisible Cities: Athens is particularly rich in highlighting those areas of the city where antiquity appears as a next-door neighbour to contemporary hustle and bustle. On the bottom level of a parking lot (Klafthmonos Square Parking) we encounter a fragment of a fortification wall set up against Sparta. From there we jump into a 3D map of the area, which melds together the past and the present. Again, no fragment is left behind. The scene reconstruction is thus a multi-temporal layer cake. In visualizing previously unmapped infrastructures, these temporal juxtapositions emphasize stratigraphic connections. In Naples, the presenter draws our attention to the modern metro line, whose construction catalyzes the destruction of an ancient aqueduct. In Pompeii, Mary Beard studies functionality of adjacent buildings, measuring walking distances and describing how everyday life must have looked, according to the team's new findings. The past does not necessarily relate us to far antiquity in all of the cases. In Naples again, we explore a WWII air-raid shelter located in ancient tunnels, where – instead of Roman artifacts – we find perfume flasks and toys. Dispersed fragments, attributed to different epochs, inhabit a shared digitally carved space. This assembly arises from overlapping scans that have been tied together into a seamless environment.

As remarked previously, the imagery captured by terrestrial scanner is, first of all, a dense 'cloud' created out of billions of points. The resultant scan resembles a digital cast, an ephemeral plaster of Paris that holds the memory of forms the laser beam bounced off of. It interpolates discrete points into a continuous surface – from a swarm of points into a mesh, and then into complex textures photographically identical to the object retrieved. With flocks of minutiae this dense, human eye does not discern each single point separately. Even if it is still an illusion, we perceive a continuous surface – identifying patterns and branching structures. Regarding these facts about the process of image construction, one finds it hardly surprising that so many references to connectivity, continuity, and completeness are made. This way, a seamless vision of not just space (previously hidden infrastructures), but time (historical strata) is put forward. Such continuity seems like an ideal outcome of the scanning/modeling process, which can be interpolated into archaeological sense-making in general.

Somewhat puzzling, however, might be the bravery in employing this technology, alongside brevity with which the experts skim over the gray areas, if not its outright blind spots. As initially stated, for both Ruskin and Viollet-le-Duc preservation represented a conundrum that had to face the fact of irreversible loss of knowledge on the past; in fact, its contemporary absence. Despite disparate approaches, neither of them would consider the practice a true redemption. This would also be echoed in Antoine-Chrysostome Quatremère de Quincy's dichotomous strategy in the renovation of the Arch of Titus[22] – opting for restoring (thus reconstructing, completing) the ancient monument, while 'preserving' its contemporary state – as well as the visage of its decay – in the form of graphic illustrations. But what about instances in which the site of 'monument' reconstruction is located on screen, within filmic space? What about the cases in which it is decay that needs to be reconstructed in graphic form, along with the structure? *(Ancient) Invisible Cities* negotiate this vague territory, though doing so without pondering too long on the problematic aspects of the visualizations they employ. Nonetheless, this *terrain vague* is shared with hypothetical stage sets from past productions inhabiting not some Hollywood back lot, but a flash-drive kept in a safety deposit box, in RAW files.

Conclusion: in lieu of sense-making

The episodes of the *Invisible Cities* series created in 2018 were a step ahead in comparison to their 60-minute predecessor, *Rome's Invisible City* from 2015. Each ends with an immersive 'walk' in the visualized city, previously inspected via a laptop or tablet. This technological upgrade, turned into an explicit stance, shifts the show's emphasis from presentation of tech-geek trivia towards a virtual touristic attraction. Secrets are revealed, strata uncovered, and the audience is given a chance to see the city as never before. *Our scanning team begins the task of making sense of this labyrinth* – the presenter states in the Naples episode. Visualizations serve as cognitive aids, photorealistic illusions, and the opposites of scene-setters, the latter due to the show's narrative structure. Only then – as it seems – do the presenters orient themselves in regard to the places previously explored, (re)discovering their mutual positions (and relationships). Now, they can stand alongside caryatids and look forward to the black khôra, the space outside of the 3D model, inspecting it like lacunae to be filled in a not-so-distant future.

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[1] This imaging technology *uses a set of 2D photographic images taken of a physical object to generate a 3D representation of the object: typically, a textured 3D mesh. Photogrammetry tools enable artists to bypass the digital mesh- and texture-creation process and to fall back on classical skills, working in a medium where realism is a natural by-product rather than a conscious effort* (R. Dunlop, *Production Pipeline Fundamentals for Film and Games*, Focal Press, New York – London 2014, p. 79).

[2] Jonathan Seymour's *Symzonia: A Voyage of Discovery* (1820), Edward Bulwer-Lytton's *The Coming Race* (1871), and John Uri Lloyd's *Etidorhpa; or, The End of Earth: The Strange History of a Mysterious Being and the Account of a Remarkable Journey* (1895) are 19th-century speculative fictions on communities living beneath the Earth's crust, where lost civilizations are supposed to have thrived, according to the Hollow Earth theory. Although hardly linkable to theosophical or alchemical pursuits, the

shows' subterranean theme is put on display, narratively reproducing the same sublime atmosphere of mystery upon executing the extensive mapping of the underworld.

[3] This representational convention apparently has a profound impact on the way we conceptualize space in the post-digital age, in a sense amounting to a cognitive displacement. In the narrative, the scientific crews behind the show's visuals present us with traditional documentation, encompassing urban maps, building plans and architectural drawings, which by nature differ from the material edifice, whereas the same edifices mapped and represented in navigable 3D environment will always be judged by their relationships to other architectural objects, thus forming a sprawling network. Abstraction, similarly to film editing, allowed us to focus on details, while this shift towards connectivity forces us to become much more attentive to infrastructural coexistence of the artifacts, even though many uncanny infrastructural semblances – as explored by this novel visualization technique – have little scientific merit, being more akin to chance encounters of agendas temporally apart.

[4] The information provided on the show's website expounds on 3D laser scanning application in diverse fields: *The FARO Focus X HDR scanners used by the ScanLAB Projects team for Invisible Cities are typically used for measuring large areas for building construction and planning. These 3D scanners operate using a high-precision laser-beam to read solid surfaces and, rather than building up an entire 3D model, it processes this image of an area as a series of points that make an overall cloud of how an area appears* (https://www.vi-mm.eu/project/invisible-cities-invisible-italy-360/; accessed: 9.01.2021).

[5] *The matchmover takes information from a real-life set, where the actors, director, and all the other crew members who make movies shoot a film, and recreates that camera, including the focal length of the lens, the height, the tilt, and the position and motion relative to the subject, in the CG environment. Then, when the CG world is created, it is "photographed," or rendered, with the virtual CG twin of the real-life camera: the same lens, the same position, and the same movement ... the CG elements created in the virtual world will have the same perspective, the same depth, and the same relationships to the moving camera that the live actors and set pieces had to the live camera, allowing them*

to be seamlessly integrated into the live plate for the final shot (E. Hornung, *The Art and Technique of Matchmoving Solutions for the VFX Artist*, Focal Press, Amsterdam – Boston 2010, pp. XIII-XV).

[6] https://scanlabprojects.co.uk/work/italys-invisible-cities/ (accessed: 24.03.2021).

[7] N. Jafa, *Performing Heritage: Art of Exhibit Walks*, SAGE Publications, New Delhi – London 2012, p. 41.

[8] E. E. Viollet-le-Duc, "Restoration," in: idem, *On Restoration*, Sampson Low, Marston Low, and Searle, London 1875, p. 14 (English translation of the 1859 edition of *Dictionnaire raisonné de l'architecture française du XIe au XVIe siècle*).

[9] A. Klei, "Architecture, Reconstruction, Memory: The Image of Tel Aviv's White City", in: *Architecture Re-Performed: The Politics of Reconstruction*, ed. T. Mager, Routledge, London – New York 2016, p. 139.

[10] M. Cabrelles, S. Blanco-Pons, J. L. Lerma, B. Carrión-Ruiz, "From Multispectral 3D Recording and Documentation to Development of Mobile Apps for Dissemination of Cultural Heritage", in: *Cyber-Archaeology and Grand Narratives: Digital Technology and Deep-Time Perspectives on Culture Change in the Middle East*, eds. T. E. Levy et al., Springer, New York 2018, p. 74.

[11] J. Ruskin, *Stones of Venice*, vol. I, Smith, Elder and Co., London 1858, p. 186.

[12] N. Gutschow, "Architectural Heritage Conservation in South and East Asia and in Europe: Contemporary Practices", in: *Authenticity in Architectural Heritage Conservation: Discourses, Opinions, Experiences in Europe, South and East Asia*, eds. K. Weiler et al., Springer, New York 2017, p. 2.

[13] M. L. Vincent "Crowdsourced Data for Cultural Heritage", in: *Heritage and Archaeology in the Digital Age: Acquisition, Curation, and Dissemination of Spatial Cultural Heritage Data*, eds. M. L. Vincent et al., Springer, New York 2017, p. 86.

[14] M. D. Howland, "3D Recording in the Field: Style Without Substance?", in: *Cyber-Archaeology and Grand Narratives: Digital Technology and Deep-Time Perspectives on Culture Change in the Middle East*, eds. T. E. Levy et al., Springer, New York 2018, p. 20.

[15] S. Xianfang, P. L. Rosin, R. R. Martin, F. C. Langbein, "Noise in 3D Laser Range Scanner Data", in: *2008 IEEE International Conference on Shape Modeling and Applications* (conference proceedings), Stony Brook University, Stony Brook 2008, p. 119.

[16] M. Mamoli, "Library Grammar: A Shape Grammar for the Reconstruction of Fragmentary Ancient Greek and Roman Libraries", in: *33rd eCAADe Conference, Vienna, Austria, 16-18 September 2015* (conference proceedings), Vienna University of Technology, Vienna 2015, p. 463.

[17] M. Pfarr-Harfst, "Practice – Research Challenges – Standards! A Reflection of Digital 3D Reconstructed Models for Urban Structures", in: *Digital Research and Education in Architectural Heritage (5th Conference, DECH 2017, and First Workshop, UHDL 2017, Dresden, Germany, March 30-31, 2017)*, eds. S. Münster et al., Springer, New York 2018, p. 159.

[18] S. Xianfang et al., op. cit., p. 1.

[19] There are a number of 'post-structuralist' assumptions to this pre-millennial turn in archaeology, which altogether erode the unchallenged authority of the archaeologists, stating that *there are no universal instruments of measurement, but it is possible to understand 'otherness'. Even the notions of the universality of meaning construction must be subject to critical evaluation … Post-processual archaeology, then, involves the breaking down of established, taken-for-granted dichotomies, and opens up study of the relationships between norm and individual, process and structure, material and ideal, object and subject* (I. Hodder, S. Hutson, *Reading the Past: Current Approaches to Interpretation in Archaeology*, Cambridge University Press, Cambridge – New York 2003, p. 235). This addresses both the actors in this complex network and measuring instruments of their expertise. Nevertheless, *norms and rules do exist. The argument here is rather that, in order to allow for change, innovation and agency, the relationships between norms, rules and individuals need to be examined more fully* (ibidem, p. 208).

[20] R. Menkman, *Beyond Resolution*, i.R.D. (institutions of Resolution Disputes) 2020, p. III (25).

[21] M. L. Vincent, T. E. Levy, "Introduction", in: *Heritage and Archaeology in the Digital Age…* op. cit., p. XI.

[22] *Quatremere distinguished between restoration and restitution, in order to differentiate the roles of the archaeologist and the architect, and direct the architect's thoughts away from the material exactitude of the "restoration a l'identique" needed by the archaeologist, toward a more instrumental use of tradition for contemporary practice* (S. Younés, *The True, The Fictive, and the Real: The Historical Dictionary of Architecture of Quatremère de Quincy*, Andreas Papadakis, London 1999, p. 45).

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Słowa kluczowe:
skanowanie 3D;
LiDAR;
wizualizacja 3D

Abstrakt
Maciej Stasiowski
Zakamarki (nie)widzialnych miast: Techniki obrazowania 3D na przecięciu archeologii, architektury i filmu
Sukces serii produkcji BBC i PBS zatytułowanych *Niewidzialne miasta Włoch* (2017), *Niewidzialne miasta starożytności* (2018) czy *Pompeje: Nowe tajemnice ujawnione* (2016) jest jednocześnie sukcesem współpracy twórców z grupą ScanLab, która wykorzystuje urządzenia typu LiDAR oraz technologie obrazowania trójwymiarowego do zobrazowania estetyki analizy przestrzennej. Wizualizowanie topografii miejskiej – wraz z jej podziemnymi formacjami, wcześniej niezarejestrowanymi w dokumentacji – stworzyło okazję do eksponowania sposobu działania zaawansowanej techniki w tworzeniu spójnego obrazu przeszłości. Autor koncentruje się na metodzie wizualizowania tych wcześniej niedostępnych przestrzeni oraz na strategiach zanurzania widza w tej reprezentacji/symulacji, a przy tym oscyluje między skrajnymi poglądami na problematykę zachowania/odtwarzania dziedzictwa materialnego, jakie wypracowali Eugène Emmanuel Viollet-le-Duc i John Ruskin.