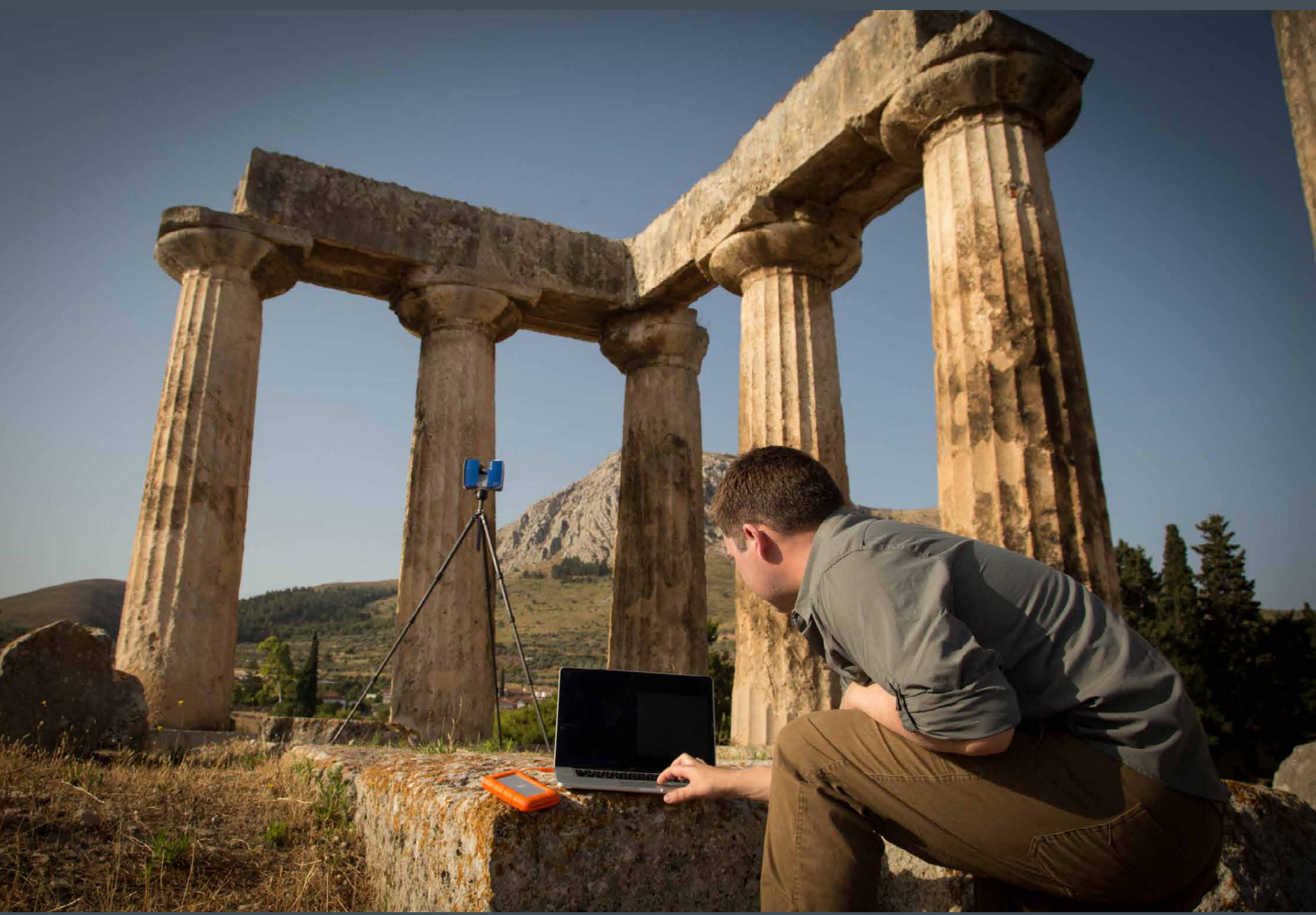

Figure 1: Scanning in the field, Temple of Apollo at Corinth: a laser scanner (blue, on tripod) detects surfaces that face it and registers these surfaces as a series of points in coordinate space. Data can subsequently be reviewed on a laptop in the field, and multiple scans can be pieced together (registered) to form a composite of the site.

In Conversation with CyArk

Digital Heritage in the 21st Century

Justin Underhill

Abstract: CyArk is a California-based nonprofit dedicated to digitally documenting and preserving world heritage. Since 2003, they have used photogrammetry and laser scanning to capture 3D data for over 200 sites; most recently, they have partnered with Google Arts & Culture to create an open-access platform for these sites (https://artsandculture.google.com/partner/cyark). Here, two members of the CyArk team, John Ristevski (Chairman and CEO) and Elizabeth Lee (Vice President of Programs and Development) sit down with Justin Underhill to discuss the past and present of digital cultural heritage.

John Ristevski

Elizabeth Lee

Justin Underhill (JU): To begin, I thought each of you might talk about how you joined the CyArk team, and more broadly, how you got interested in digital cultural heritage.

John Ristevksi (JR): I met Ben Kacyra [the founder of CyArk] in the early 2000s. He had invented the technique for 3D laser scanning, and wanted to apply that technology for good, for cultural heritage. I was doing my PhD at Berkeley, at the time. Looking at digital documentation techniques for architecture and archeology.

Someone said, you should come talk to this guy; he's got an idea. So we met, and he explained his vision for CyArk. It didn't even have a name yet. We decided to work together for a couple of years, and I helped him get the initial concept off the ground. Some of the first projects in the archive were my research projects from Berkeley.

Elizabeth Lee (EL): I had done archaeology, field work, at Berkeley, and with another university, as well. Doing mostly neolithic sites and documenting them with photography. What initially

drew me to these new forms of documentation was this idea that you're out at these incredible places, uncovering these amazing secrets, and there's not a really good way to record that.

And more importantly to me personally, was the ability to share that with a broader audience. As I was getting familiar with CyArk, I was also getting more interested in taking documentation data and making it accessible. I remember when our preliminary website was launched—it was really exciting that you could pull up one of the sites in a web browser, and see where certain photos were taken. I think now is a more exciting a time than ever, because the technology for viewing and engaging with these data sets is rapidly evolving, making it much more meaningful for not only researchers, but also just enthusiasts.

Technology for viewing and engaging is rapidly evolving

JU: What do you think is the most exciting platform development?

EL: Well, we are doing a lot right now in virtual reality. As a medium, I think it is really exciting for the type of data that we collect. Because we're collecting photorealistic scaled data of these sites, that you can then recreate virtually, in a one-to-one kind of experience, in a way that was not possible just even a few years ago.

JU: When Kacey [Hadick, CyArk's Heritage and Conservation Program Manager] came to speak to my students, we got to do a virtual reality walkthrough. Do you see your digital content going more and more VR oriented?

EL: Yes. I think right now we have got to push. We're going to have our first public-facing app come out very soon. A free app to transport people to three different World Heritage sites, and let them learn about those places. I think we are optimistic about how that will be received, and hope that that will allow us to do a lot more within the medium.

JU: What are the three heritage sites?

EL: It is going to be Mesa Verde National Park, in Colorado, Ayutthaya in Thailand, and Chavín de Huántar in Peru.

JU: Wow. Nice spread!

JR: Yes; Interesting geographic spread, and interesting spread in terms of the manifestation of climate change of these places. You've got one where

3D laser scanning, terrestrial photogrammetry, and aerial photogrammetry, through drones [...] all those data sets come together

we are seeing the impact of wildfires on the site, in Mesa Verde, while at Ayutthaya it is more about flooding, at this juncture of three different rivers in this delta.

And then at Chavín de Huántar it is the glacial melts. You've got three different kind of manifestations of climate change impacting the sites, in pretty dramatic in catastrophic ways.

JU: I would imagine that at a site like Mesa Verde, some of the sightlines and the actual scale of a site like that could be very overwhelming in VR, relative to other VR experiences. Did you find that to be the case?

JR: In VR, Mesa Verde is actually the most interesting and compelling of the sites (fig. 2). We are just taking one of those little cliff alcoves and we are representing that. When you are inside that actually feels very immersive, and the scale's very human, versus, say Ayutthaya which is a much larger area, and the structures are very monumental. In person, the scale is hard to grasp, and in VR it is hard to grasp. I find that those alcove sites are actually perfect for virtually inhabiting the place, and experiencing it. It has the stronger sense of place, of the three. I think that has to do with the scale-

JU: ... The intimacy of the space?

JR: Yes. The intimacy of the space, and the scale.

JU: Can you take me through the typical process for a site, from start to finish?

EL: It starts, initially, with identifying sites where we can provide real impact. So we do a lot of work with UNESCO, and their regional offices have become good collaborators with us, because they understand the challenges within their region and can help identify needs.

So, we identify a site in need, and then we also have to find funding to support that work. We pair that need on the ground with a funding source that's interested in either that culture or that region.

Figure 2: Digital rendering of Mesa Verde, made available in Sketchfab by CyArk.

We then have to figure out a scope that makes sense, given the funding, and given the challenges on site. Usually we end up on site for about one to two weeks. We mobilize the team. They go out there with a suite of equipment; we use a combination of 3D laser scanning (fig. 1), terrestrial photogrammetry, and aerial photogrammetry, through drones (fig. 3). On site we capture hundreds of scans. Tens of thousands of photos. And then, all that data comes back with the team.

And in the office here, it all gets linked together. All the scans get registered. The photos get registered through common points, and all those data sets come together to form this photorealistic 3D surface model of the site (fig. 4). And then that model can be used to create a virtual reality environment, and it can also be used to create a number of conservation outputs—a base data set that we create, and that goes to those that are working on the site. And then, all the data is archived here, so that it's available for the future (fig. 5).

JU: Ten years ago, photogrammetry was nowhere near where it is today. That's been one of the most dramatic developments I have seen in the past five years. You mentioned drone photography, and you've integrated it in your workflow. Can you say a little more about that?

EL: The biggest advancement in terms of the photogrammetric workflow side has been the software. Camera sensors have also really improved, but the RealityCapture software that we have been able to process images with for the last

Figure 3: Drone at Bagan, Myanmar: aerial photographs captured by a remote-controlled drone provide images of surfaces, such as rooftops, that are inaccessible to the scanner; digital models of these features can be generated from the images and combined with laser scans using photogrammetry software. Photo by Kieran Kesner for CyArk.

Figure 4: Drone documentation of Ayutthaya: Hundreds of drone images are uploaded into RealityCapture photogrammetry software; when they are aligned, a point cloud of the site emerges. In the image above, each orange pyramid represents a different photograph that has been used to generate the model.

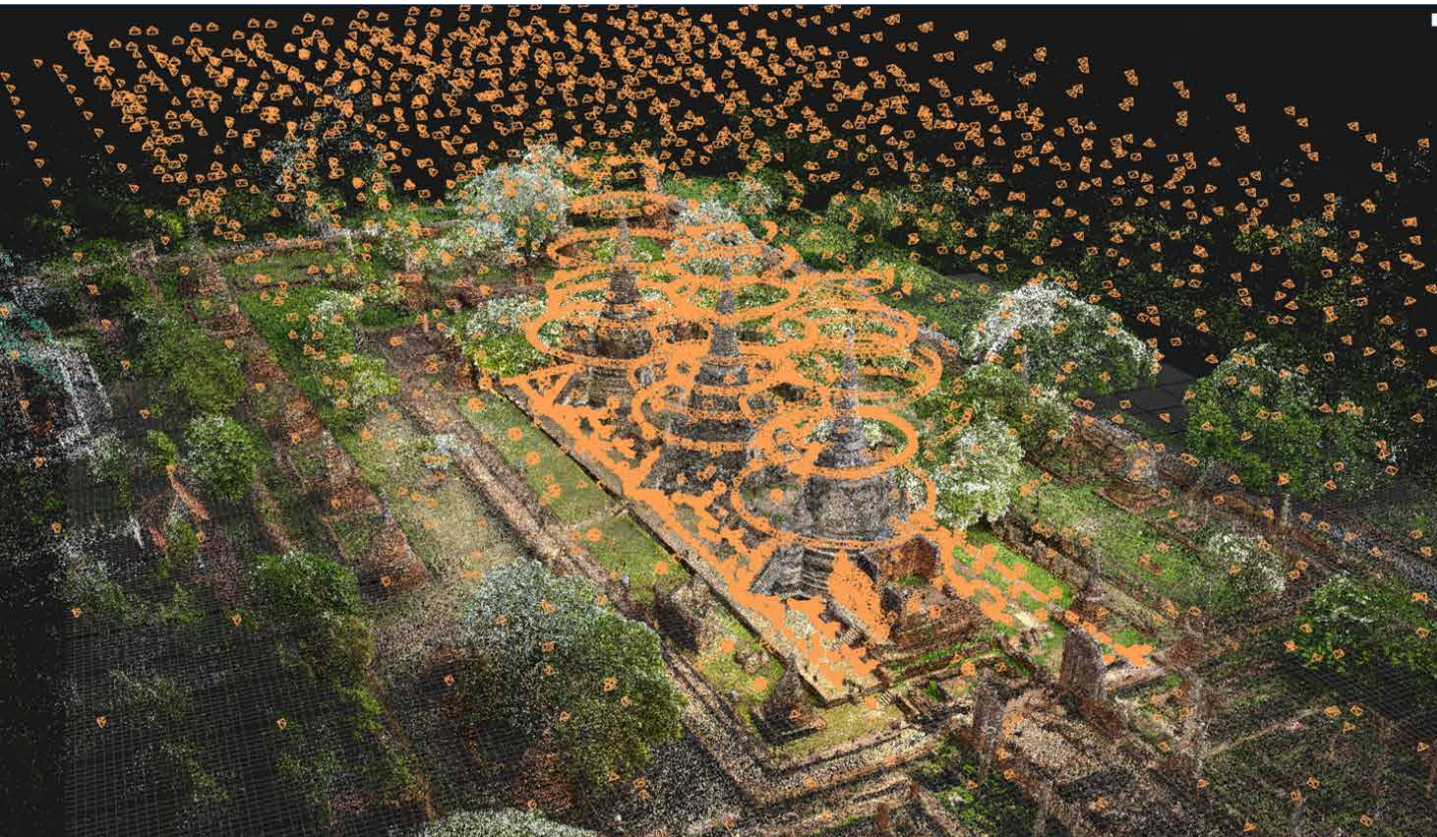

Figure 5: Exterior elevations (top) and clipped interior sections (bottom) of temples at Bagan. Center, (bottom and top): Eim Ya Kyaung temple. Left and Right (bottom and top): Khemingazedi temple.

18 months, allows us to combine the LIDAR with the photogrammetric data. That's been a game changer for us, in terms of the process, because before, we were using both [scanning and photogrammetry], but we didn't have a good way to bring them together.

Now, the software advances have really influenced our process, and we are still figuring out the best way to make sure all of that ties together in a repeatable way. Because the sites that we do end up being so different; some of the sites work quite well, because of the types of features, but at Chavín de Huántar for instance, there is a lot of grass, and it's very open.

It is not just collecting pixels

Parts of the site are a lot less structural than places like Ayutthaya which has very large, very unique lichen growing on the plaster. So you have these patterns that are just inherent, there.

JU: Beautiful reference points that we do not notice until we are back in the lab, and then we are so thankful.

EL: Yes. I think that the software has been a huge boon to our process. And the affordability of things like drones and the types of really high quality cameras that you can get for relatively cheap.

JU: Do you get a lot of requests to donate data?

JR: Occasionally, and one of the things we are trying to ensure is that we have a consistent data quality, across the sites. Especially now, as the methods get more integrated, combining drone imagery with scanning data, we want to ensure that the quality of the data and the archive is applicable to all the types of things we might want to build from it, whether it is a plan, section, or elevation, or VR experience. Texture data is especially tricky; capturing high quality texture data, that is evenly lit, that is a challenge.

JU: In our own backyard, here in the Bay Area, we are lucky to have many LGBT historic sites that remain engaged with their communities. And many of these sites go overlooked as sites for architectural preservation or archaeological investigation. Do you think CyArk will document any of those in the future?

EL: We have talked about a "Modern Social Movements" collection of sites, which I think is interesting.

JR: Especially with a site like Stonewall, which has become a national monument. Doing a site like that would be really interesting. It is complex. It is not just the bar. It is also that

landscape, and the neighborhood, and the course of events. There is also a lot of big opportunity to collect narrative information, too. From people that experienced it.

JU: ... Oral histories to collect before these people die.

JR: Exactly. I think that is the interesting thing about these modern movements; we are still living in the time where people can actually retell those stories. It is not just collecting pixels and points. It is also collecting the narratives, too, from people who are actually there. I think it is fascinating. I think we would love to do more in that vein, I think it would be an interesting challenge, and also an interesting opportunity would be to retell those stories in VR. It's hard to tell some of these stories and give people a sense of place. I think there is a unique opportunity to do that in VR.

John Ristevski is the Chairman of the Board and CEO of CyArk. John as formerly the Vice President of Reality Capture and Processing at Nokia's mapping company, HERE, where he led the company's initiative to index reality. John joined HERE in 2012 through the acquisition of his company, earthmine, which developed systems to capture and deliver highly accurate street level imagery and 3D data of cities. John is a Fellow of the Royal Institute of Chartered Surveyors and currently serves on the board of the non-profit CyArk. He has lectured at Stanford's Civil and Environmental Engineering Department and has a Master of Science degree from the University of California at Berkeley and degrees from the University of Melbourne in both Geomatic Engineering and Law.

Correspondence e-mail: john.ristevski@cyark.org

Elizabeth Lee serves as Vice President for Programs and Development for CyArk. Her expertise includes developing international partnerships in support of technology-driven solutions for cultural heritage protection, education, and appreciation. Originally trained as an archaeologist with excavation experience in Turkey and Hungary, Elizabeth has been applying 3D technologies to the cultural field for over a decade. She has extensive experience in working with foreign governments and local communities including cultural ministries and the United Nations Educational Cultural and Scientific Organization (UNESCO). Elizabeth is a graduate of the University of California, Berkeley and is a member of the US Chapter of the International Council on Monuments and Sites (ICOMOS). She is a past winner in the South by Southwest (SXSW) Eco Place by Design competition.

Correspondence e-mail: elizabeth.lee@cyark.org